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Permaculture design in an ecovillage
In theory and practise

Figure 1. Made by Maria Martina Schmitt, Graphik Design, Wien, 2004.

By

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Summary

This essay presents guidelines how to approach a local ecosystem, taking into account biological, geological, chemical and hydrological assets in order to obtain a sustainable and self-sufficient farming system conserving and increasing local biodiversity. Biodiversity is a key factor in ecosystem structure and function. Conservation of biodiversity is now a legal obligation for the member states of the European Community. The guidelines will be presented both in general theory based on permaculture principles and with a specific case on a newly started ecovillage in Chozas, northwest Spain. The type of weed species found on a piece of land is an indicator of soil and above ground microclimate characteristics. Their indicator values have been used in the decision making of what species are suited for each specific field. The planting patterns suggested are designed to achieve a high yield with the use of as little labour as possible taking the observed parameters into account. There is a focus on perennial plants and plant combinations using different layers above and below the soil. Competition between species in mixed stands (*inter*specific competition) differs from that between plants within monocultures (*intra*specific competition) in that the component species of a multispecies design may impose different demands on the available resources. Competition may be more severe between similar species than between species with contrasting growth patterns and nutritional needs. Even so, all plants compete for the same resources (light, water and nutrients). There is an overlapping of resource requirement with nitrogen fixing plants as an exception.

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Introduction

This essay presents guidelines how to approach a local ecosystem, taking into account biological, geological, chemical and hydrological assets in order to obtain a sustainable and self-sufficient farming system while conserving and increasing local biodiversity. Biodiversity is a key factor in ecosystem structure and function. Conservation of biodiversity is now a legal obligation for the member states of the European Community (Baker, 2002; Barbercheck et.al. 1999).The guidelines will be presented in general theory based on permaculture principles and applied on a newly started ecovillage in Chozas, the province of Pontevedra in northwest Spain. The site has been chosen for various reasons;

- The 14 owners of the land and houses are interested in a design to obtain self sufficiency in organic vegetable and fruit production, culinary herbs and medicine plants. They are interested in commercialising the surplus production after their own needs are covered, but not as the only source of income.
- The persons are between 24-38 years old and most of them have experiences from agriculture, which makes the project viable.
- The area is generally affected by mild winters and abundance of water. The fields are spread out on quite a large area, which results in varying microclimates, and thereby supply growing conditions for a wide range of species.

The term permaculture is a derivate from ***perma**nent agri**culture*** and has its origin in Australia where the university teacher and researcher Bill Mollison from Tasmania university and his student at that time, David Holmgren, developed theories and practices. They observed how intensive monoculture drastically diminished the surrounding flora and fauna, how animal production was made into factory farming and how the local varieties of species disappeared. They wanted to facilitate a change in agricultural practices by uniting many disciplines, in order to achieve a truly sustainable practice that would function on the same site permanently without decreasing the fertility of the soil or the ecosystem. The guidelines were established 1972 (Mollison 1988) and Mollison received the "Right livelihood award" 1981, often called the alternative Nobel Prize, for his work on low-energy input and high yielding environmental design systems. (Right livelihood awards) There are now academies and learning centres established in many countries in Europe where courses are given.

The definition of permaculture design according to Mollison:
"Permaculture is the conscious design and maintenance of agriculturally productive ecosystems which have the diversity, stability and resilience of natural ecosystems".

Mollison, 1988

According to Holmgren:
"Consciously designed landscapes which mimic the patterns and relationships found in nature, while yielding an abundance of food, fibre and energy for provision of local needs."

Holmgren, 2002

Permaculture, as a strategic design system, attempts to integrate fabricated, natural, spatial, temporal, social and ethical components to achieve a sustainable lifestyle. To do so, it is focused on controlled, but to a large extent self sustained ecological systems for farming and living. Permaculture is based on a few principles that can be applied to any site no matter its geological position or size. The principles are based on observation of nature. (Mollison, 1988)

- Observe and interact
- Multifuncionality
- Relative positioning, energy efficiency (zones and sectors)
- Use and value renewable resources and services
- Use of natural succession and accelerating it
- Use and value diversity
- Border effect
- Intensive systems in small scale
- Catch and store energy
- Apply self regulation and feedback
- Creatively use and respond to change

(Mollison, 1988; Holmgren, 2002)

A literature study gives a background to different farming techniques, challenges and obstacles linked with these.

A glossary for the observed indicator plants can be found in appendix. It was written in an attempt to facilitate the reading of the report and the plant names are presented in Latin, English, Spanish, Galego and Swedish. A limit of three names per language has been set, as there is a great variety of local names for wild plants. Three general maps are included in the appendix to orientate the reader. A field map is also presented, in order to show the spread of the fields on the property.

Limitations/focus
Permaculture is an approach that takes many things into account; such as animal husbandry, material and bioclimatic design of buildings, renewable energy, alternative economy, community living, natural water purification and circulation of nutrients etc. As the bachelor report is done within a programme in horticultural science, the aim is to describe a method how to design a sustainable plant production system. The focus is set on how to make a permaculture design based on the goals of the landowners, including plant choices and crop combinations suitable for each field.

Six fields were chosen to represent the whole estate. After considering the different locations of the fields, the selection was made in order to present a large variation in growth conditions. Fields were excluded if to far away from the residences. On the contrary, if located very close, the usage of very small plots will also be taken into consideration, in order to present the possibilities of using the land in an optimal way. No indicator values will be presented for the forest since it is not within the scoop of this essay.

Sources of information
The information has been collected from literature, Internet and interviews with the North American permaculture teacher Richard Wade and the Spanish architect Inez Sanchez whom the author has been in contact with during a course in permaculture design in Montsant in the province of Tarragona in Spain. The information of specific growth site requirements of plant species is from the homepage of the University of

soilscience in Wienna, Austria and literature referred to in the text. Agatha Broeskamp-Gundin, board member of the Galician control organisation for organic agriculture and farmer, has translated the German information. When Mollison and Holmgren express the same idea in different terms, a compromise has been made. Some of the data has been collected by interviews with local farmers. This creates insecurity, but as the author can not be present to observe annual fluctuations in the weather/climate it is the most practical solution. It is clearly stated in the text where this is the source of information.

Botanical names used in the plant lists are taken from *Den virtuella floran*, *Anthos-Real Jardín Botánico* and *Termos esenciais de botánica*. General information concerning plant external growth factors has been achieved from Cheers, Plants for a future and Wiedermann.

All maps, including hand drawn illustrations, are oriented with north up.

Definitions
The term allelopathy is used to describe chemical substances released to the environment by an organism that acts as a germinator or growth inhibitor to another organism (Schlegel)

The abbrivation a.s.l. used in the text and meaning above sea level.

"Vermi-compost" refers to dry compost with worms.

1. Background

Permaculture uses a variety of cultivation techniques that are based on traditional methods combined with new results from research to optimize the efficiency in the use of land, water, nutrients, sunlight and working hours. There is a heavy emphasises on trees, shrubs and perennials, but there is also a natural place for annuals in some systems. There are several opportunities but also problems that need to be addressed when choosing the most suitable combination of techniques.

1.2. Intercropping

In agroecosystems pollinators, natural enemies, earthworms and soil microorganisms are all key components regulating nutrient cycling, decomposition and natural control of pests. The type and abundance of diversity will vary in different agroecosystems depending on age, structure and management. Systems that are more diverse, more permanent, isolated and managed with low input technology generally present an advantage in ecosystem services, compared to highly simplified, input-driven and disturbed systems (Altieri & Nicholls, 1999). Intercropping, or polyculture as it is sometimes called, is common in tropical agriculture but rarely found in modern agriculture in the western world. Experiments have shown that intercropping can yield more than sole crops if the choice of crops is suitable for the local ecosystem. Intercropping can be of four types:

1) mixed intercropping: growing two or more crops simultaneously with no distinct arrangement,
2) row intercropping: one or more of the crops are grown simultaneously in different rows,
3) strip intercropping: two or more crops are grown in strips wide enough to permit independent cultivation, but narrow enough for the crops to interact,
4) trap-cropping system: one species serves as a trap crop to trick the pest away from the major crop.

(Altieri, 1995; Dicke 2006)

Pest protection by biodiversity

It has been shown that it is possible to stabilize the insect communities of agroecosystems by designing and constructing the plantation in order to support populations of natural enemies or have direct deterrent effects on pest herbivores. (Altieri & Nicholls, 1999) A survey of published studies showed that 52 % of total herbivore species were found to be less abundant in polycultures than in monocultures (Andow, 1991). The planned biodiversity should aim at maximizing ecosystem processes and structural complexity, rather than just increasing the number of species. (Mooney, 1993) A well designed polyculture supplies parasitoids and predators with food (water, hosts, prey, pollen and nectar) and habitat (refuges, nesting and reproduction sites) (Altieri & Nicholls, 1999). The host plant may be protected from insect pests by the physical presence of other plants that may provide a camouflage or a physical barrier. It can also be the odour of some plants that disrupt the searching behaviour of pests or attract carnivorous insects (Dicke, 2006). The effect of these factors will vary according to the spatial and temporal arrangements of the crops and the intensity of crop management (Altieri & Nicholls, 1999).

Nutrient accumulation
The most obvious advantage in agriculture is the symbiosis between bacteria and many plant species, especially leguminous species. The nitrogen is available to other species as the plant dies, which make a combination of these plants and non-fixating very suitable (Hart & Sholto, 1976). Measurements have showed a higher content of organic matter, N, P, K and Ca concentrations under tree canopies compared to the surrounding soil. (Ong & Huxley, 1996)

Harvest
The combination of crops with a variety of temporal production cycles can result in a relatively uninterrupted food supply for humans, as well as the fauna, throughout the year. (Mollison, 1998; Ong & Huxley, 1996)

Microclimate
The most important effect of combining woody and non-woody species in mixtures is the result of changes in the microclimate which in turn influence the growth of all components in the system. A tree can transpire 450 L per day and thereby consumes 1000 MJ heat energy. The vegetation can in this way both lower the temperature and increase air humidity. (Borgström, 2005) The combined effect of these changes controls the energy balance of both the over storey and the under storey, thus influencing plant water and productivity. (Ong & Huxley, 1996)

Yield
An increased yield can be expected when one or more resources are limited, by using species mixtures if the component species capture more of the available resources or use them more efficiently for growth. In such instances, mixtures may provide a greater yield than the combined yield of the corresponding mono crops. Harvest in semiarid areas has been found to increase up to 50 % compared to outside the canopy. (Ong & Huxley, 1996)

Water use
Intercropping offers the opportunity for spatial and temporal complementary water use, resulting in an improved exploitation of available moisture relative to mono crop systems. Additional benefits may arise as annual runoff at rainfall, deep percolation and soil evaporation can be reduced. However, the opportunity for significant complementarities is likely to be limited unless the component species differ enough in their rooting patterns or duration. Intercropping with trees may increase the proportion of available soil moisture used for transpiration because of the more rapid canopy development that reduces soil evaporation. (Ong & Huxley, 1996)

1.2.1. Companion planting
Some plants grow better in the company of others than growing alone. Positive allelopathy might be one of the mechanisms by which companion planting works. Another one is by attracting beneficial insects into the garden, but many good companions fit together simply because their shapes are complementary, such as when tall, thin *Allium sativum* is planted with a short and wide one like *Lactuca sativa*. The shapes, annual cycles, shade tolerance etc. are all factors that influence if the plants will co-operate rather than compete. (Whitefield, 2002)

1.2.2. Perennials: Trees, shrubs and herbs

The introduction of perennial plants encourages planning and investment as they will take time to mature enough to be harvested. When the plants are established a relatively constant yield can be expected without much additional labour. The domination by perennials rather than annuals result in a relatively high ratio of nutrients stored in the vegetation compared to those stored in the soil. This ensures an effective nutrient cycle and relatively small hazard for leaching and erosion. (Whitefield, 2002) Annual leaf fall and the decomposition of fine roots provide significant organic matter to the soil. The C:N ratio of many shrub leaves provides a rapid decomposition that helps to rebuild surface soil quality. A higher earthworm activity and fungal/bacterial/actinomycetes counts have been observed in homegardens with a mixture of perennials and annuals compared to open areas. (Kumar et.al; 2004 & Colletti et.al. 2004) An effective nutrient status is further maintained by the uptake of minerals through deeply rooted perennials from the sub soil layers. *Symphytum officinale* and *S. x uplandicum* are claimed to contain higher levels of potassium than most plants and are therefore very suitable for adding to the compost, as direct mulch and in plant extracts. Potassium, phosphorous, bases such as calcium, magnesium and other micro nutrients are released by weathering rock in the deeper soil horizons that the roots penetrate. (Whitefield, 2002) The multilayered structure act as a defence against the impact of falling rain drops, resulting in lower rates of soil erosion (Kumar et.al. 2004). Multiple stem or branch system provides cover for wildlife, produces stored energy in its wood, building material, an addition of organic material, shelter for antagonist species, stabilize pH by addition of bases to the soil surface, reduces wind speed etc. All agroforestry systems produce more than one basic-need output, mainly because of the multipurpose nature of the associated woody perennial component. Therefore, all agroforestry systems have both productive and protective roles, though in varying degrees. (Whitefield, 2002; Colletti et.al. 2004)

Shrubs generally fruit best either on the edge of a forest or in the initial stage of a forest garden before the trees grow big. If the garden is to go on producing soft fruits once it has matured it must be designed with plenty of edges to let light in. (Whitefield, 2002)

1.2.3. Annuals

Most of the common vegetables are annuals and have to be reseeded every year as they do not propagate themselves.

Annual self-seeders

Garden plants vary greatly in their ability to self-seed. This group of plants often refers to annual or biennial plants that seed themselves easily if there is a suitable soil surface nearby for the seeds to germinate. The problem is that where the self seeders can grow so can weeds. Some weeding is therefore necessary and also a good thinning. Some of the species in this group i.e. *Cardamine hirsuta, Chenopodium bonus-henricus* and *Beta vulgari ssp. cicla* are suitable for a forest garden where no digging or planting is done on a regular basis. (Whitefield, 2002)

1.2.4. Climbers

Climbers can be trained up fruit-producing trees and give an attractive impression. The growing space is thereby used more efficiently and there will be a double harvest. The technique also has the advantage of saving the work of making climbing support. This arrangement is common and successful in the tropics, as the light intensity is sufficiently strong to penetrate the canopy of the tree and reach the climbing plant. In temperate regions there is a risk that the canopy of the trees does not dry up properly when it is accompanied with a climber, which makes it susceptible to diseases. *Humulus lupulus* and *Rosa spp*. give a good harvest in partial shade, while *Vitis vinifera* do not. (Whitefield, 2002) To assure a good harvest of *V.vinifera, Actinidia deliciosa* and evergreen climbers like *Passiflora spp*. it is advisable to train them on trellis with a southern sun exposure. (Fern, 2000) The shadow of such climbers can give a welcome relief in summer. (Wade, 2005)

1.2.5. Multilayer

The forest is often thought of as having only three layers: trees, shrubs and herbs. In reality there are many subdivisions as there are small trees and large shrubs. Sometimes the difference between a tree and a shrub may be more a matter of how well the plant tolerates shade than of its potential size when mature. The difference between the herb and shrub layer is easier to distinguish; shrubs and trees have woody parts, while herbs and vegetables do not. It is possible to prune a shade tolerant species i.e. *Corylus avellana* to grow under a small fruit tree, in order to achieve a high production on a small surface by using many layers of food plants (Whitefield, 2002). A major reason for a high productivity in a multilayer farming system is the increase of ecological niches. The lower herbs generally come into leaf earlier than the bushes and the bushes earlier than the trees. (Fern 2000; Whitefield, 2004)

The layered structure will of course not be static/permanent; the pool of replacement species results in a productive structure which is always dynamic while the overall structure and function of the system is maintained (Ramachandran, 1993).

1.3. Plant competition

Competition between species in mixed stands (*inter*specific competition) differs from that between plants within monocultures (*intra*specific competition) in that the component species of a multispecies design may impose different demands on the available resources. The intensity of competition is greatest when site requirements are similar, to the point where the species with overlapping niches may be unable to coexist within the same community. Competition may be more severe between species with similar morphology. All plants compete for the same resources (light, water, nutrients and CO_2) with nitrogen fixing plants as an exception. When resources are not limited, densely planted monocultures usually provide the most efficient resource capture systems. (Ong & Huxley, 1996)

85 % of the tree roots are found in the top 60 cm of the soil, where most of the soil micro-organisms, available nutrients and water are found. Some of the more competitive species can develop roots that extend three times the reach of its branches, if the soil is sandy. Many plants do have deep roots, but these tend to be not so finely divided, so that the total mass of roots in the deeper soil is much less. These roots seem to serve mainly for anchorage, though they do contribute to water supply especially in draught periods and contribute to some supply of plant nutrients from the subsoil. (Whitefield, 2002)

1.3.1. Intercropping and agroforestry

Intercropping with herbaceous crops and agroforestry both involves mixtures of species and seems to share many common processes including competition, environmental modification, transfer of nitrogen to nonlegume associates and resource utilisation. The first difference is that the woody perennial components of the agroforestry system have a well established root system, at least after the initial establishment period. The size and age further increase the advantage over the less developed annuals. (Ramachandran, 1993) The agroforestry systems need to be designed to optimize the use of spatial, temporal and physical resources by maximizing positive interactions and minimizing competition among the components. (Gillespie et.al. 2004)

1.3.2. Nutrients

The intercrop is usually the smaller component in the agrofrestry plantation and its root system will often be confined to soil horizons that are also availiable to the roots of the trees. As the trees can exploit soil volumes beyond reach of the crop, the effect of nutrient competition will most likely be more severe for the crop component. It is hard to conclude how severe nutrient competition affect the crop due to difficulties of separating it from competition for water, light and allelochemical interactions. (Ramachandran, 1993)

1.3.3. Shading

C_4 plants (i.e. *Zea mays* and *Amaranthus spp.*) build up a leaf area quickly if there is enough solar radiation. Minimal shading reduces assimilation due to a high light-saturated photosynthetic rate. In contrast, if there is a permanent canopy the C_3 plants (most dicotelydons) have a greater efficiency of CO_2 uptake at lower radiation levels than C_4 plants. (Ramachandran, 1993; Ong & Huxley, 1996) The different growth strategies of C_4 and C_3 crops make it possible to combine crops with different temporal need for solar radiation, as cereals and legumes. Both crops are only slightly affected by the competition because of different growing strategies. The faster growing cereal absorbs most of the radiation and the slower leguminous crop grows independently of a lower interception. The leguminous crop continues to grow as the cereals are harvested. As the crop duration of the field is increased compared to a monoculture of cereals the total absorption of solar radiation is more efficient. (Ong & Huxley, 1996)

1.3.4. Water use

There will be a considerable competition of water if it is a limited resource. The perennial plants will have an obvious advantage due to the extensive root system. (Ong & Huxley, 1996)

1.3.5. Allelopathy

Some plants reduce the vigour of other plants and sometimes their own species are receptive. Plants vary greatly in their sensitivity to allelopathic chemicals, so that the negative effects can be avoided by choosing suitable neighbours. Allelochemicals may be produced in various forms: root secretion, chemicals which are washed from the leaves of the plants to the soil, products of decomposition of the dead plant and volatile chemicals which are released into the atmosphere. Many common herbs are claimed to have a negative allelopathic strategy and interfere with the germination or growth of other garden plants. Most of them belong to three families: the Mint family (*Mentha spp., Thymus spp*. and *Salvia spp*.), the Carrot family (*Foeniculum vulgare, Angelica archangelica* and *Levisticum officinale*) and the Daisy family (*Tagetes spp*. and *Chamaemelum nobile*). *Juglans regia, Sambucus nigra* and *Salvia officinalis* are examples of forest plants which have negative allelopathic effects on other species. The chemicals involved in allelopathy are often the same as those which protect the plant from pests and diseases and they may in some cases have a positive effect of protecting the nearby plants as well as themselves. Aromatic herbs produce volatiles which mean that they can affect plants and animals which are not immediately adjacent to them. If their effects include positive ones as well as negative ones then they could have a significant effect on the health of the garden as a whole, even though it might be necessary to plant them in large quantities to have a significant effect. (Whitefield, 2002)

1.4. Planting patterns and techniques

It is very important to find a planting pattern that is suitable for the area and its local conditions. There are several techniques that can be used to maximize harvest, minimize work, loss of nutrients, water retention, slow down the wind etc. The beds or rows should be designed to follow the height curves of the topographic map, in order to slow down erosion and decrease surface run off by rain water (Jeavons, 1991). Where the field is flat there is an advantage of situating the beds in an east-west direction to decrease shadow effects.

A field trial in Sweden has showed that to supply one person with food for a vegan diet during a year a surface of 800 m^2 is needed. A focus was set on intensive, ecological farming methods, using as many perennials as possible (Ahnström, 2002). According to the trial results an area of 12000 m^2 would be needed to supply the members of the project with sufficient food for one year. Jeavons suggests that, a family of 4 persons, cultivating the fields during 6 months/year can achieve auto sufficiency of greens with approximately 30 m^2 of vegetable plantation for crops that are harvested frequently and 80 m^2 of staple food that are harvested late in the season. He refers to a intensive farming technique that use the addition of compost in raised beds, reseeding some crops up to 3 times per season. As there are 15 persons that will live of this land 4 times more surface will be needed i.e. 120 m^2 of the vegetables harvested frequently and 320 m^2 of the vegetables harvested at one occasion. (Jeavons, 1991)

1.4.1. Designing a forest garden

In any forest garden there will be a variety of quick and slow maturing plants with shorter and longer life spans. This means that the mix of produce from the garden will change from year to year. It also means that the structure will change, changing the internal microclimate, and this in turn will have an influence on which plants can be grown at different stages. There are three main ways to develop a forest garden that need to be assessed by the community.

1. *Planting all the layers at once***.** This method is the closest of the three to natural succession, in which light demanding herbs gradually give way to shrubs then to trees and shade-tolerant herbs, as the larger but slower-growing plants become dominant. In the first year the harvest will predominately be herbaceous, mainly from annuals. In the second year most perennial vegetables can be harvested and some fruit start to bear. As trees grow bigger and produce more shade the yield of the lower layer is reduced, and light demanding vegetables and shrubs may need to be moved to the edges.
2. *Planting in stages***.** Only trees are planted the first year, with shrubs and vegetables introduced a few years later, or trees and shrubs and than later on vegetables.

3. *Planting underneath existing fruit trees*. This kind of forest garden undergo changes such as old trees dying or loosing branches letting more light in which allows to grow more light demanding shrubs and vegetables. Dead trees may serve as trellis to climbers. In other parts of the garden the amount of shade may increase as trees continue to grow, or shrubs which were planted more recently grow thicker at the expense of the herbaceous layer. The disadvantage with this method is that you inherit the existing perennial weeds growing intermixed with the tree roots. Starting the establishment of the garden removing perennial weeds is an advantage.

(Whitefield, 2002)

1.4.2. Alley cropping/hedgerow intercropping

Alley cropping consists in growing food crops between hedgerows of planted shrubs and trees, preferably leguminous species. The technique can reduce nutrient leaching, act as wind break, suppress weeds and controls erosion on sloping land. (Ramachandran, 1993)

The use of windbreaks, composed of either evergreen or deciduous trees or shrubs control wind erosion and provide habitat for wildlife. It increases surface roughness and can provide large areas of reduced wind speed useful for agriculture. The effectiveness of a windbreak depends on its external structure, such as height, orientation, continuity, width and cross-section shape. It is also determined by its internal structure, which is characterised by vegetative surface area and the shape of individual plants. (Brandle et.al. 2004)

The hedges are pruned periodically during the growth of the crop to provide biomass and to prevent excessive shading of the crop. The addition of nutrient-rich mulch has a favourable effect on the physical and chemical properties of the soil, and hence the crop productivity. An additional supply of nitrogen might be necessary when seedlings are mulched as there is a risk of temporary immobilisation of nutrients. The provision of nutrients will depend on quantity, quality and time of application. If the ecological conditions do not favour the production of sufficient quantities of nutrient-rich mulch for timely application, then there are not enough advantages in using alley cropping. The additional labour that is required to maintain and prune the hedges is another limitation that needs to be considered. Alley cropping can not be a substitute for fertilisers if high levels of crop production are to be realised, but efficiency in the use of fertilisers can be substantially increased. Alley cropping may not be effective under moisture-stressed conditions as hedges and trees have deeper root system than the crop and will therefore have an advantage in absorbing water. The risk that hedgerow species become a weed or/and an alternate host for pest and pathogens need to be considered. (Ramachandran, 1993)

Figure 2. Raised bed made with the compost. Maria Martina Schmitt, Graphik Design, Wien, 2004.

1.4.2. Raised beds

By accumulating soil within a wall structure beds can be raised to 30-100 cm height from the ground in order to facilitate the work, as the bed requires minimal back-bending. One advantage is that the soil heats up fast in the

spring, but it can be a disadvantage that it dries fast in the summer and might require irrigation. (Mollison, 1988) A mature compost can be used as a raised bed, see figure 2. It is a method making it possible to achieve fertile soil quickly even in fields with low carbon and nutrient content. Cover
the compost with a thick layer of soil in order to protect the roots from humic acids (Holz, 2004).

1.4.3. Edge cropping

Edges of a forest, field or a pond that are notched or lobular provides a variation of micro-habitats for different species that have a variation of requirements, such as sun exposure, water access, wind shelter etc. This gives a great potential in designing plantation beds in polyculture, according to each species requirement. (Mollison, 1988)

1.4.4. Keyhole beds

Raised keyhole pattern allows access and provides a variation in micro habitats. The paths are permanent and compaction of the beds is limited. (Mollison, 1988) The maximum width of the beds should not exceed 170 cm, in order to facilitate weeding and harvesting. “Stepping stones” in the middle of the bed facilitate access to the plants, see figure 3. (Wade, 2005)

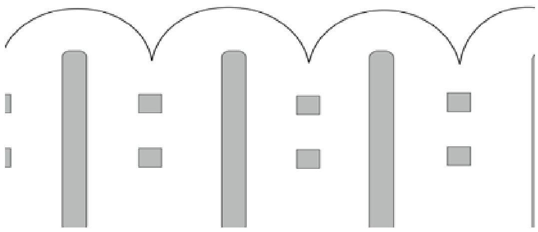

Figure 3. The keyhole beds with paths and stepping stones. Javier Palacios, 2006.

1.4.5. Herbal spiral

It is both beautiful and practical to design a raised spiral for an efficient use of land when establishing the culinary herb garden. It should be built as close to the kitchen door as possible to facilitate harvest. Mollison suggest a 200 cm wide base, ascending to 100-130 cm high. On the sunny side he suggests a combination of *Thymus spp, Rosmarinus officinalis* and *Salvia officinalis*. On the shade side he suggests *Mentha spp., Petroselenium crispum, Allium schoenoprasum* and *Coriandrum sativum*. The choice of the favourite herbs is of course up to the chef (Mollison, 1988)

1.4.6. Swales

The technique is used to stop water runoff on and increase water retention in the soil. It is therefore widely used in arid to sub-humid areas on both fairly steep slopes and flatlands and in both urban and rural areas. Long ditches, see figure 4, with a width that depends on available space, are dug in sequence following the height curves and the bottom filled with pine bark, saw dust or sand. If/when the top ditch gets filled up by water and the soil surrounding it is saturated, the second one is positioned to be able to receive the overflowing water. Water retention is improved and plants are supplied with water for a longer period. The soil/substrate will get saturated with water and it will be available to plants for a long time. Trees are essential

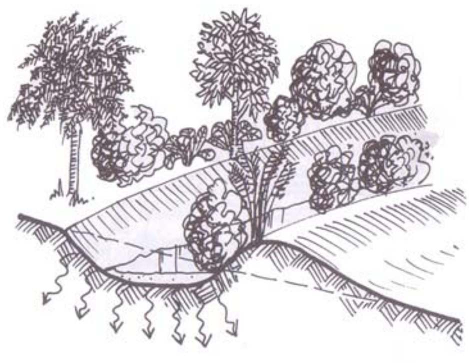

Figure 4. A swale where water is retained and used efficiently by the crop. Andrew Jeeves, 1988.

components of the swale planting system as they use large quantities of water, help to stop erosion and they cause minimal interference with the swales/beds.(Mollison, 1988)

1.4.7. Suntraps

By planting hedges in a U-shaped form on the edges of the field in an east-north-west direction a warmer microclimate is achieved, figure 5. Perennial and evergreen hedges are ideally chosen to achieve a year around sheltered from the strongest winds without missing out of much sunlight. (Mollison, 1988) Species such as the evergreen bush *Mahonia aquifolium* and *Mahonia japonica* shelter many insect eating species, produce edible fruits and serve as a nesting place for insect eating birds (Fern, 2000).

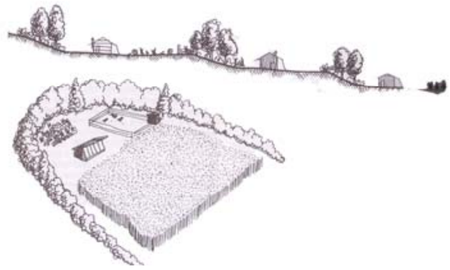

Figure 5. The bushes slow down the cooling winds and a warmer micro-climate is created. Andrew Jeeves, 1988.

1.4.8. Riparian forest buffer

To make a significant reduction of leaching nutrients from fields adjacent to nearby water bodies it is probably not enough with in-field management alone. A riparian forest buffer is a three zone system consisting of an unmanaged woody zone adjacent to the water body followed upslope by a zone of managed trees and bordered by a zone of grasses surrounding the crop field. The design has more advantages than only capturing of leaching nutrients and possible phytosanitarian compounds. The shade produced by the trees lowers water temperature at summer time, which can improve habitat for aquatic organisms. Production of large woody debris is also positive for aquatic organisms and terrestrial ecosystems. The buffer zone provides stream bank stabilization, moderate flooding damage and creates recreational opportunities. The managed zone of the buffer not only serves as a nutrient sink with systematic removal of trees, but can also produce fruit and nuts depending on choice of species. (Colletti et.al, 2004).

2. How to make a permaculture design

There are some general steps that are recommended to follow in order to achieve a sustainable design where several persons will be affected and a relatively large area is to be designed.

Step 1: Identification of planning problems, opportunities and goals
Step 2: Landscape analysis on a regional and local level
Step 3: Detailed studies
Step 4: Planning area concepts, options and choices
Step 5: Plan and design implementation
Step 6: Revaluation

(Steiner, 1999; Whitefield, 2002)

Step 1: Identification of planning problems, opportunities and goals

The goals should be identified and provide the basis for the planning process. Social, economical, political and environmental problems and opportunities need to be identified, as the goals present an idealized future situation. It is very important that the persons that will be affected by the goals are involved in the process. (Steiner, 1999)

Step 2: Landscape analysis on a regional and local level

This step involves making an inventory of the region, locality and the specific site. Processes that take place in the more specific planning area are studied. The major aim of local-level analysis is to obtain insight about the natural processes and human plans and activities. It involves information concerning geology, climate, groundwater quality and quantity, physiographic of the landscape, soil properties, vegetation and existing wildlife. Information concerning physical, biological and social elements that constitutes the planning area is collected. If budget and time allow, the inventory and analysis step may best be accomplished by an interdisciplinary team collecting data. (Steiner, 1999; Whitefield, 2002)

General observation
It is very important to make a thorough initial observation that should preferably be made through all of the four seasons. Neighbours can often be to a great help sharing their local knowledge on climatic issues and agricultural history of the region. Slopes that can be prone to erosion and produce frost pockets need to be addressed, as well as water sources. It should be consider if there is something of high ecological and horticultural value on the land. (Whitefield, 2002)

Some general questions concerning the present vegetation can be made at this stage.

1. What species of trees are growing on the land? Are they thriving or are their growth patterns indicating that something in their position is not optimal? Submerged roots, partial draught, lack of pruning or nutrients, wind, pests or diseases?
2. Are there many plants that thrive in wet soils? Can the growing pattern indicate an underground stream?
3. Are there plants with deep taproots or with a superficial root system? Could it be that the top soil is very shallow?
4. Are there plants that like acid soils or alkaline? Maybe a mix?

5. Are all the plants rather small and growing towards one direction? Maybe they are exposed to a lot of wind or are sun loving, but ended up in a site were there was too many shade hours per day.
6. Are there mainly leguminous species? Could it be that the nitrogen level is so low that other species can not compete? (Mollison, 1988)

Specific observation
Look for information concerning growth pattern of the plants that are to be included in the design, taking into account root depth, width, time and extensiveness of canopy emergence. Production of allelopathic compounds can affect the growth of nearby plants and is therefore very important to consider. (Mollison, 1988)

Indicator plants
The use of wild plant populations as indicator plants for the microclimate and soil status is based on the fact that they thrive where conditions are most favourable for their existence. It can also be the case that they have developed a unique strategy that makes them survive in a normally hostile environment. The Austrian botanist Wiederman has established a list of how to interpret the abundance of different species quantifying values for illumination, water access, nutrient status, pH and temperature of the growing site (2005). It should be emphasised that a large population of each species must occur for the diagnosis to be reliable. (Acquaag, 1999)

Step 3: Detailed studies

The information of the inventory is analysed and linked with problems and goals. It addresses the fitness of the specific place for the planned land use based on the thorough ecological inventories made in step 2. The design is adapted to the observed parameters, in order to choose the most suitable crop combinations. The purpose of the detailed studies is to reach an understanding about the complex relationship between human values, environmental opportunities and constraints. The traditional technique to record the analysis is the use of the “overlay technique” with various hand drawn maps. There are also computer programs, “geographic information systems” (GIS) that are used especially for large or complex planning projects. A topographic map is often available on the Internet and can serve as a base map to make sketches. (Mollison, 1988; Steiner, 1999)

Zones and sectors
It needs to be considered how frequently the species are used by the household and how often they need to be attended when making the decision of where to establish them. The area subjected to the design is divided into 5 zones and sectors for practical reasons.

Zone 0: the house where some pot plants and vines may grow.

Zone 1: close to the house are plants that need intensive maintenance such as frequent watering, fertilization, pruning or harvest, continuous protection from pests etc. These plants are often the annuals, culinary herbs and medicine plants. Seedlings, young trees for outer zone placement and water collecting devises are preferably placed in this area.

Zone 2: annual crops that have a limited harvesting season and a long growing period are grown with perennials. Fruit trees for auto consumption have a limited harvest season, need for pruning and fertilising and can also be planted in this zone.

Zone 3: plants produced in larger quantities as staple food or for commercialisation are suitable to establish in this area.

Zone 4: hardy trees that require low maintenance, such as trees used as timber can be planted on a larger distance from the house. On the borders of the land, where wild nature takes over it is possible to collect dead wood for fire, nuts and wild medicine plants. Irrigation dams may be built to lead water into the inner zones.

Zone 5: it is the location of natural unmanaged environment used for recreation and learning the rules of nature that are applied elsewhere. (Mollison, 1988)

The land is further divided into sectors where sun hours, chilling winter winds/cooling summer winds, noise or annoying views can affect the community. (Mollison, 1988)

Step 4: Planning area concepts, options and choices

It involves the development of concepts for the planning area. The concepts are based on combinations of the information gathered through the inventory and analysis step. A list of desirable crops and quantities is made and the microclimate for each field is mapped. The scenarios set possible directions for future management of the area and should therefore be discussed by the community in order to make choices. The community needs to decide what will be kept of existing vegetation and structures. The final plan suggests flexible guidelines on how to conserve, rehabilitate or develop the area. The final sketches should be drawn on a scale map that can be a simplification of the base map. The size of the land is the main factor that decide how detailed the design will be. Trees and shrubs may be drawn as individuals or blocks. It is important to valuate if the set goals will be achieved by the design. The success of the plan often depends on the extent of participation in its determination. (Steiner, 1999: Whitefield, 2002)

Step 5: Design implementation

This step concerns how the design will be implemented using the information in the earlier steps. It may include land purchase and a strategy for whom will implement the design in situ. (Steiner, 1999: Whitefield, 2002) This step will not be further discussed in this essay.

Step 6: Revaluation

It is important to revaluate the design after it has been implemented in order to introduce improvements. As the design is a system in evolution it can never be considered totally finished. It needs to evolve and mature with the settlers.
(Steiner, 2000 and Scotti, 2004)

3. The design

3.1. Identification of planning problems, opportunities and goals

Several elderly farmers living in the surroundings have given advices on local climatic and agricultural matters. The interchange of information, goods and favours is likely to continue in the future. As the area is marked by an aging population and young persons moving to the cities, there is political support for the establishment of new projects and habitants.

The community is divided into groups of interest, of which one is called the “agriculture commission”, where the goals are discussed and presented to the groups in the general meetings. The goal of the persons in the community is to achieve a multispecies production of fruit and vegetables on existing pasture, forest land and land adjacent to the buildings in field 885, see map 4 in appendix. The emphasis is on vegetable production and to conserve and enhance biodiversity. There is a wish to use organic and non-animal techniques in a sustainable way by applying the permaculture principles in the field designs. The proposal is to be low-cost orientated, but have the freedom to achieve high labour input to implement the design. There is an existing stand with ecological produce in the nearby town Pontevedra and an agreement to produce complimentary greens is feasible. A few organic cooperatives exist in various cities nearby, which present an economical opportunity. There is an increasing interest in organic produce from consumers, according to the cooperatives, which indicates a growing market. Local grocery stores in nearby villages have expressed an interest in purchasing goods produced by the project.

There is a high risk for leaching of nutrients in the sandy and humus-poor soils that need to be considered in the design.

3.2. Analysis of Chozas on a regional and local level

The village is situated 30 kilometers west wards from the city Pontevedra in north-west Spain, see map 1 and 2 in appendix.

The mean precipitation in November-March in Vigo is around 150 mm per month. June and July are the months with lowest rainfall, approximately 60 mm per month. The mean temperature does not go down to lower than 10 degrees or higher than 20 degrees in any month of the year (Gil, 2001). Chozas is situated inland, only one hour from Vigo that is found on the west coast of the Atlantic. The climate can therefore be expected to present slightly colder winters and warmer summers. There has been snow some winters, but it is not at all frequently occurring according to the local farmers. The strongest winds come from the north and east in wintertime according to local sources and the authors own observations. The fields are situated approximately 400-450 m a.s.l., see map 3 in appendix. The site consists of 2, 5 hectares divided on 16 fields and 2 apple orchards, see map 4 in appendix. Some fields are separated by stone walls, fences or without separation. There is a stream entering the land in the eastern orchard and another passing field 749, see map 4 in appendix. As the canals supplying the fields with water have not been properly looked after there have been severe water logging affecting the apple eastern orchard. The canals can be restored with a small effort. The water access is good even during long periods without precipitation. The soil is sandy loam with a generally low content of organic matter in the fields were no animal manure has been applied. Locals have during the last forty years harvested the wild plants growing on all of the fields for bedding and winter food for the cattle. As heavy rainfall is common during winter it is likely to expect a low nutrient content in the fields that are situated highest a.s.l. It is likely to expect a higher nutrient content in the fields that are situated in the bottom of the valley. Field 750, 816 and 839 present a clear risk for erosion due to the sharp slope, see map 3 and 4 in appendix. There is also some erosion risk in field 885 as it has a slight slope.

No rare species has been found on the fields that are addressed. There are several smaller lizards, Mantis religiosa, toads, bats and insect eating birds present.

The main mineral in the area is granite which is naturally acidic and the pH can therefore be expected to be rather low. Granite contains quartz (SiO_2), feltspa (Na, Al, Si. and sometimes K, Ca) and mica (K, Al, Si and sometimes Mg, Fe). Granite is generally of a very solid composition that does not crumble easily. Plants can not absorb silica from the granite in notable quantities except Equisetum species (Nordstedt, 1952).

3.2.1. Method

Observations of the flora in different fields have been recorded by photos and noted down on maps. A full list with wild species with plant names in five languages is presented in appendix as table 17. The identification of plant populations in the different fields has been performed with the assistance of two biologists and submitted to a scale for indicator plants,table 1. Plants have been considered a population when their presence has been considerable and the distribution on the field has been even. The following five parameters have been used; indication of light conditions (1-9), indication of temperature (1-9), indication of soil humidity (1-12), indication of pH of the soil (1-9) and nitrogen availability in the soil (1-9). An X indicates indifference to the specific parameter. A mean of the values from the plants growing in the field give the supposed assets of the land. Where an X is presented in table 1 it has been ignored in the calculations. In the cases of a wide span of preference values of the plant a rough mean value has been used to produce the approximate calculations. The plant populations observed have been divided and different means have been calculated to obtain the general profile, where the composition of plants differs drastically within a field. The general profiles of the fields will to a large extent influence the choice of species that will be planted on each site.

Table 1. Explanation of indicator values according to Wiedermann.

Light indication	**Temperature indication**	**Humidity indication**	**pH indication**	**Nitrogen indication**
1=Deep shadow plant	1=Cold, only in high latitudes	1=Very dry	1=Very low	1=Very low content
2=Between 1 & 3	2=Between 1 & 3	2=Between 1 & 3	2=Between 1 & 3	2= Between 1 & 3
3=Shadow plant	3=Chilly	3=Dry	3=Low	3= Low
4=Between 3 & 4	4=Between 3 & 5	4=Between 3 & 5	4=Between 3 & 5	4=Between 3 & 5
5=Moderate shadow	5=Moderately warm	5= Moderately humid	5=Slightly low	5=Medium rich
6= Between 5& 7	6= Between 5 & 7	6=Between 5 & 7	6=Between 5 & 7	6=Between 5 & 7
7= Medium light	7= Warm	7=Humidity indicator	7=Slightly low with tendency to alkaline	7=Rich
8=Light plant	8=Between 7 & 9	8=Between 7 & 9	8= Between 7 & 8	8=Pronounced N indicator
9= Strongly illuminated	9=Hot	9=Wet soil, often lacking oxygen	9=Alkaline	9=Oversupplied
X=Indifferent	X=Indifferent	10=Submerged roots at times, aquatic plants X=Indifferent	X=Indifferent	X=Indifferent

3.2.2. Specific traits for each field

The fields and their number can be found in appendix as map 4.

Field 1 (885)-600 m^2

The whole field is densely populated by grass. There are patches of fern in abundance in the field and none in the northern part. *Catsups scoparius* and *Ulex europeus*, which both have symbiosis with nitrogen fixating bacteria, are more common in the northern part of the field. *Genista hispanica* grows by the stone wall in the western part and some further north. The field is indicated to receive medium radiation, exposed to moderate heat and the soil is moderately humid, as can be seen in table 2. The soil tends to be acidic to slightly acidic and the nitrogen content is low.

A full sized oak tree is growing in the north western corner of the field. There are three apple trees growing along the western stone wall and two very small wild pears are situated in the northern part of the field. A young chestnut tree is growing by the stone wall on the eastern side. The western orchard and the houses shadows the land part of the day.

Table 2. Observed plants in field 1 and their indicator values

Species	**Light**	**Temperature**	**Humidity**	**pH**	**Nitrogen content**
Cytisus scoparius	7-8	5	4	3	3
Erica spp.	7-8	5-6	3-8	1-2-X	1-2-X
Centaurea nigra	6-9	2-7	3-5	3-8	2-6
Plantago lanceolata	6	X	X	X	X
Leontodon spp.	7-8	2-6-X	3-6	3-9	2-6
Spergularia spp.	7-9	5-6	5-8	3-9	4-8
Ulex europaeus	7	6	5	X	2
Genista hispanica	7-8	5-6	3-6	2-6	1-2
Pteridium aquilinum	6	5	5	3	3
General profile (μ)	(7,11) 7=Medium light	(5,13) 5=Moderately warm	(4,86) 5=Moderately humid	(4,14) 4=Low-slightly low	(3,13) 3=Low
Std (σ)	0,70	0,64	0,84	1,75	1,53

Field 2 (749)-1 206 m^2

The field is flat and has a low stone wall separating it from the neighbouring field in the south. The wall will not produce more than minimum shade as it is directed to the south where the sun stands relatively high even in winter in this geographical location.

The botanical composition was made up of the plants seen in table 3. Several of the plants species are indifferent to temperature and pH, but the tendency shows that this field receives medium light, which produce moderate warmth and dry to moderate humidity. The pH is indicated as low with a tendency to alkaline and the nitrogen level as medium rich.

Table 3. Observed plants in field 2 and their indicator values.

Species	**Light**	**Temperature**	**Humidity**	**pH**	**Nitrogen content**
Rumex acetosella	8	5	3	2	2
Dactylis glomerata	7	X	5	X	6
Plantago lanceolata	6	X	X	X	X
Ranunculus repens	6	X	7	X	7
Centaurea nigra	6-9	2-7	3-5	3-8	2-6
Conyza canadensis	8	6	4	X	5
Anthemis spp.	7-9	6-7	3-4	6-9	4-6
Arrhenatherum elatius	8	5	X	7	7
Lotus corniculatus	7	X	4	7	3
General profile (μ)	7 (7,28) = Medium light	5 (5,40) = Moderately warm	4 (4,36) = Dry-moderately humid	6 (5,80) = Slightly low with tendency to alkaline	5 (4,88) = Medium rich
Std (σ)	0,83	0,73	1,31	2,25	1,81

Field 3 (750)-707 m^2

The botanical composition is made up of plants that are to a high extent indifferent to many factors i.e. the species are very adaptable to varying conditions, see table 4. This makes it difficult to make a conclusion of the status of the field, but some approximation can still be made. The plants growing in this field indicate that the area receives medium strong radiation that makes it moderately humid to dry and the nitrogen content is moderately low to medium rich. The temperature seems to be moderately warm to warm and the pH slightly low with a tendency to alkaline. The field is oriented on a slight slope in a west direction. There are no obstacles that produce shadow, but eastern half of the field is protected from the northern winds by a house.

Table 4. Observed plants in field 3 and their indicator values.

Species	**Light**	**Temperature**	**Humidity**	**pH**	**Nitrogen content**
Anthemis spp.	7-9	6-7	3-4	6-9	4-6
Hypochoeris radicata	8	5	5	4	3
Centaurea nigra	6-9	2-7	3-5	3-8	2-6
Rumex acetosa	8	X	X	X	6
Lotus corniculatus	7	X	4	7	3
Potentilla erecta	6	X	X	X	2
Plantago lanceolata	6	X	X	X	X
General profile (μ)	(7,21) 7=Medium light	(5,33) 5=Moderately warm	(4,13) 4=Dry-moderately humid	(6,00) 6 =Slightly low with a tendency to alkaline	(3,83) 4=Low-medium rich
Std (σ)	0,91	1,04	0,63	1,58	1,47

Field 4 (839)-410 m^2

The field is situated in a slope directed to the west without any trees producing shadow. The southern part has a canal and a stone wall. The soil is very wet in the south east and is populated by species such as; *Iris pseudacarus, Cirsium palustre, Lythrom salicaria, Juncus effuses, Hypericum undulatum* and *Senecio aquaticus.* All other species were observed dispersed all over field. The general conditions have been calculated separately, as can be seen in table 5, for the drier part of the field and for the whole field. The drier part is indicated to receive medium illumination with moderate to warm conditions, moderately humid. It seems to have a slightly low pH with a tendency to alkaline and a rich to moderately low nitrogen content. The general profile of the field taking the wetter parts of the field into account indicate humid to moderately humid conditions and a slightly low pH. The local population claims that this field always used to be planted with potatoes.

Table 5. Observed plants in field 4 and their indicator values.

Species	Light	Temperature	Humidity	pH	Nitrogen content
Centaurea nigra	(6-9)	(2-7)	(3-5)	(3-8)	(2-6)
Hypochoeris radicata	8	5	5	4	3
Dachtylis glomerata	7	X	5	X	6
Plantago lanceolata	6	X	X	X	X
Cynodon dactylon	8	7	4	X	5
Lotus corniculatus	7	X	4	7	3
Potentilla erecta	6	X	X	X	2
Teucrium scordonia	6	5	4	2	3
Prunella vulgaris	7	X	5	7	X
Ranunculus repens	6	X	7	X	7
Mentha suaveolens	8	7	8	6	5
Crepis capillaris	7	6	5	6	4
Holcus lanatus	7	6	6	X	5
General profile (μ)	(6,96) 7=Medium light	(5,79) 6= Moderately warm-warm	(5,18) 5= Moderately humid	(5,36) 5=Slightly low	(4,27) 4=Low-medium rich
Std (σ)	0,78	0,99	1,33	1,80	1,49
Cirsium palustre	7	5	8	4	3
Lythrum salicaria	7	5	8	6	X
Juncus effusus	8	5	7	3	4
Senecio aquaticus	7	6	8	4	5
Iris pseudacorus	7	6	9	X	7
General profile (μ) with all values taken into account:	(7,03) 7=Medium light	(5,63) 6=Moderately warm-warm	(6,06) 6=Moderately humid-humidity indicator	(4,95) 5=Slightly low	(4,40) 4=Low-medium rich
Std (σ)	0,70	0,83	1,77	1,65	1,50

Field 5 (869)-400 m^2

It is a comparatively small field surrounded by stonewalls. The species in table 6 were observed with an even distribution in the field except for *Rumex acetosella* that was found in the western slope and *Cytisus scoparius* that was found in the northern part. As the field is very small the calculation will include the two species. The observed plants indicate that the field is exposed to medium light producing moderate heat. There is a moderate humidity and the pH is low to slightly low. The nitrogen level is medium rich, but might have a tendency to be low. The locals informed that the field always used to be planted with corn and has most likely been fertilized on a frequent basis in the past.

Table 6. Observed plants in field 5 and their indicator values

Species	**Light**	**Temperature**	**Humidity**	**pH**	**Nitrogen content**
Holcus lanatus	7	6	6	X	5
Dactylis glomerata	7	X	5	X	6
Ranunculus repens	6	X	7	X	7
Anthemis spp.	7-9	6-7	3-4	6-9	4-6
Rumex acetosa	8	X	X	X	6
Hypochoeris spp.	7-9	2-7	3-5	3-6	1-3
Plantago lanceolata	6	X	X	X	X
Rumex acetosella	8	5	3	2	2
Cytisus scoparius	7-8	5	4	3	3
General profile (μ)	(7,28) 7=Medium light	(5,40) 5=Moderately warm	(4,64) 5=Moderately humid	(4,25) 4=Low-slightly low	(4,50) 5=Medium rich
Std (σ)	0,83	0,82	1,44	2,40	1,93

Field 6 (816)-1 102m^2

The field is situated on a rather steep slope towards the river in the west. There are five large apple trees on the southern border expected to produce shadow to the crop in summertime, as well as the large oak trees on the lower side of the field towards the west. The soil is very wet at times.

There are some species that can only be found at the top of the sloping field, by the entrance in the east. As there is a house next to the gate it can be expected that some dung or household waste might have been applied in this area. The species growing in this location are *Lotus corniculatus, Stellaria media, Juncus effuses and Mentha suavolens.* The general average value is calculated, see table 7, with and without these species intending to distinguish the properties of the western part of the field separated from the eastern. The general indications for the western part of the field indicate that the field is exposed to moderate shadow to medium radiation which makes it moderately warm to warm. The plants indicate moderate humidity to clear humidity indication, pH slightly low and a nitrogen level that is medium high. The difference to the eastern part of the field is a less warmth and a lower nitrogen content.

Table 7. Observed plants in field 6 and their indicator values.

Species	Light	Temperature	Humidity	pH	Nitrogen content
Centaurea nigra	6-9	2-7	3-5	3-8	2-6
Potentilla erecta	6	X	X	X	2
Carum verticillatum	7	7	8	4	3
Plantago major	7-8	6-X	5-7	5-X	4-6
Dactylis glomerata	7	X	5	X	6
Brachypodium spp.	2-6	4-5	3-6	3-7	3-6
Ranunculus repens	6	X	7	X	7
General profile (μ), west	(6,36) 6= Moderate shadow-medium light	(5,50) 6= Moderately warm- warm	(5,75) 6=Moderately humid-humidity indicator	(4,88) 5=Slightly low	(4,50) 5=Medium rich
Std (σ)	1,18	1,22	1,54	0,63	1,71
Lotus corniculatus	7	X	4	7	3
Stellaria media	6	X	X	7	8
Mentha suaveolens	8	7	8	6	5
Juncus effusus	8	5	7	3	4
General profile (μ) with all indicator values taken into account, east	(6,22) 6= Moderate shadow-medium light	(5,08) 5=Moderately warm	(5,50) 6=Moderately humid-humidity indicator	(4,78) 5=Slightly low	(4,43) 4= Low-moderately rich
Std (σ)	1,93	1,89	2,09	2,05	1,91

3.2.3. Nutrients

Compost

Large parts of the land surrounding the buildings were covered with wild *Rubus fruticosus*, *Cytisus scoparius* and *Ulex europaeus* at the time when the ecovillage project started. A lot of them have been cut down and placed as a thick and woody layer at the bottom of the compost. Soil and very well decomposed animal manure has been removed from the old stables and placed on top of the woody layer in the compost. The third layer applied consists of household waste and mussel shells brought by the persons that are in the project. It is believed that the mixture will result in a nutrient rich soil that can be used when establishing the permanent beds.

Ash

The only heating system at the moment is woodburners that subsequently produce ash. It contains many essential minerals, such as potassium and calcium. It is known to have an alkaline pH (Wade, 2005).

Dry closet
There are plans to build several dry separation closets in order to save water and recycle nutrients. Urine is an interesting fertiliser due to its high content of plant available nutrients, see table 8, which can easily be applied in the desired concentration. The level of heavy metals, parasites, bacteria and viruses is extremely low. To assure maximum sanity level it should preferably be stored in a transparent container so that the UV light can sterilise it. As the urine is stored it forms mainly ammonium, NH_4-N, and reaches an approximate pH of 9. The high pH helps to kill any possible parasites or diseases and can produce a desired increase in soil pH when used as a fertilizer (Naturvardsverket). The risk of leaching to ground water is the same as for synthetic nitrogen fertiliser (Elmsquist, 1997). The faeces can be decomposed with a "vermi-compost" and may be spread, with permission, in the forest as there is a risk that they may contain heavy metals or parasites (Naturvardsverket).

Table 8. Ph, total ammonia content, ammonia nitrogen, phosphorous and potassium content in human urine in kg per tonnes. (Jönsson et.al, 1997)

Ph	**Total N (kg'*ton^{-1})**	**NH_4-N (kg'*ton^{-1})**	**Phosphor (kg'*ton^{-1})**	**Potassium (kg'*ton^{-1})**
8,9	3,7	3,4	3,7	1,0

3.2.4. Weed control
There is always a need to limit hand weeding. The use of mulching or surface composting is one way. As the climate is warm and humid in Chozas summertime, plants grow fast and there is a constant access to plant debris to use for mulching. Another approach is to cover the weeds with cardboard in order to out shadow them. It is important that oxygen can pass through the material in order to facilitate decomposing by micro organisms. A soil layer is placed on top of the material and the desired plants are seeded or planted. The soil can preferably be taken from the compost, were the temperature at decomposition hopefully will have killed most weed seeds. Plants establish their roots well as they can penetrate the material when it rapidly turns into humus. (Holz, 2004)

3.3. Detailed studies and planning options

The houses-zone 0
The function of the houses will not be discussed in this paper.

The gate-zone 1
A few plants of perennial *Passiflora edulis* is proposed to be trained on the stone vault surrounding the main gate, see table 9 for a detailed plant list. The flowers and their scent are magnificent and the fruit is very tasty. It is a climber with perennial leaves that produce shade even in winter. It will not be of disturbance in this location.

The stone square-zone 1
The square will need some shadowing trellies in summertime with for example *Vitis vinifera* and *Basella alba. B. alba* is a perennial that can reach 4 m, but as it is pruned and eaten as a vegetable it will be kept lower. To get some uplifting colours that make a contrast to the granite houses some large pots planted with *Calendula officinalis* and *Tagetes spp*. are suggested.

Table 9. Plants suggested to be preserved or introduced to the small surfaces surrounding the houses.

Latin	English	Spanish	Gallego	Swedish
Calendula officinalis	Pot marigold	Calendula	Calendula	Ringblomma
Basella alba	Malabar spinach, Ceylon spinach	Espinaca de Malabar		Malabar spenat
Eleocharis dulcis	Chinese water chestnut			Vattenkastanj
Helianthus annus	Sunflower	Girasol	Xirasol	Solros
Lavandula angustifolia	Common lavender	Lavanda	Lavanda	Lavendel
Lippia citriodora	Lemon verbena	Hierba Luisa	Herba Luisa	Citronverbena
Melissa officinalis	Lemon balm	Melisa	Herba abelleira	Citronmeliss
Nasturtium officinale	Watercress	Berro de agua	Agrión	Vattenkrasse
Origanum vulgare	Oregano	Orégano	Ourego	Oregano
Passiflora edulis	Passion fruit	Pasionaria	Pasiflora	Passionsfrukt
Physalis ixocarpa	Tomatillo	Tomatillo	Fisalis	Physalis, tomatillo
Rosmarinus officinalis	Rosemary	Romero	Romeu	Rosmarin
Salvia officinalis	Sage	Salvia	Xarxa	Kryddsalvia
Tagetes spp.	Marigold	Tagetes	Tagetes	Tagetes
Thymus spp..	Thyme	Tomillo	Tomiño	Timjan
Tropaeolum majus	Nasturtium	Capuchina	Capuchina	Blomsterkrasse
Vitis vinifera	Vine	Vid	Vide	Vinranka

The small garden-zone 2

This tiny garden of a few square meters is the first piece of land that the visitors will see. It is facing the south and is protected from wind and frost by a stone wall that have the property of accumulating heat during the day and releasing it in the night time, what is called a suntrap. A shrubbery of *Physalis ixocarpa*, can ideally be established in this spot as the plant is frost sensitive. As it thrives in acidic soil no change of pH is necessary. An establishment of the colourful perennial *Tropaeolum majus* surrounding the shrubbery will make a fine first impression and the whole plant can be enjoyed in salads for its peppery flavour. It is a self-seeding annual that flowers most of the year in this geographic location. *Lippia citriodora* is a plant with low demands on the soil and highly appreciated in the Galician kitchen. It would fit well in the innermost corner towards the stone wall.

The western orchard-zone 2

This orchard is situated just outside one of the biggest houses on the property, why it is convenient to establish plants that are harvested frequently and have a culinary value on an every day basis. Extensive pruning needs to be made and it might be necessary to remove the sickest individuals of existing *Malus domestica*. The existing *Ficus carica* need to be taken down as the roots are entering large areas of the basement and are found all over the orchard. Extensive pruning of the tree is suggested before cutting it down, in order to obtain cuttings that can be planted in a location further away from the houses. As the *F. carica* is removed plenty of light and space will be accessed from a southern direction. The remaining stubbles from the trees can be covered by soil and

Table 10. List of plants suggested to be preserved or introduced in the existing orchards.

Latin	English	Spanish	Gallego	Swedish
Actinidia deliciosa	Kiwi	Kivi	Kiwi	Kiwi
Citrus aurantiifolia	Lime	Limero	Limeiro	Lime
Citrus limon	Lemon	Limonero	Limoeiro	Citron
Citrus sinensis	Orange	Naranjo	Laranxa	Apelsin
Cryptotaenia japonica	Japanese wild parsley	Mitsuba		Mitsuba
Eruca sativa	Rocket, arugula	Oruga, rúcula	Eiruga	Senapsträd
Ficus carica	Fig	Higuera	Figueira	Fikonträd
Fragaria x ananassa	Garden strawberry	Fresa	Fresa	Jordgubbe
Fragaria vesca	Wild strawberrry	Agulles, fresal silvestre	Amarón, Freseira	Smultron
Lactuca sativa	Lettuce	Lechuga	Leituga	Sallad
Malus domesica	Apple	Manzano	Mazaira	Äppelträd, apel
Melissa officinalis	Lemon balm	Melissa	Herba abelleira	Citronmeliss
Mentha spp.	Mint	Menta	Menta	Mynta
Prunus avium	Sweet cherry	Cerezo	Cerdeira	Sötkörsbär
Pyrus communis	Pear	Peral	Pereira	Päron
Tetragonia expansa	New Zealand spinach	Espinaca de Nueva Zelandia	Espinafre de Nova Lezanda	Nya zeländsk spenat

make up round planting beds for vegetables that grow well in partial shade such i.e. *Tetragonia expansa, Fragaria x ananassa* and *F. vesca* . The southern part and the eastern peak of the western orchard is a suitable place for trees such as *Citrus sinensis, C. limon* and *C. aurantifolia*, which thrive in a southern location. A mixture of herbaceous medicine plants that tolerate partial shade i.e. *Mentha spp.* and *Melissa officinalis* can be introduced under the trees and the ones that are more dependants on sun along the southern edge.

The eastern orchard-zone 2

The canal is running through this orchard and need to be canalized in order to decrease the prevailing waterlogging. It is even so advisable to plant species that need plenty of water, ie. *Actinidia deliciosa* and some leaf vegetables that grow well in partial shade i.e. perennials such as *Cryptotaenia japonica, Eruca vesicaria sativa* or *Lactuca sativa* as can be seen in table 10. *A. deliciosa* is a monoik plant and at least one plant of each sex need to be planted in association to each other to produce fruit (Wade, 2005). If it is trimmed to the southern facing wall of the neighbouring house no shadow will fall on the fruit trees. Several of the apple trees are in a bad state and are better cut down to leave the few healthy ones more light.

The forest ponds-zone 4

There is running water entering into the ponds all year around, making it a suitable habitat for the edible *Nasturtium officinale.* It is perennial and can grow well in shade (Whitefield, 2002). The habitat is also suitable for establishing a population of *Eleocharis dulcis* that produce edible corms. Both ponds could be made slightly deeper without a large effort in order to get a bigger growing area.

The stone walls-various zones
The walls can be used for planting sun loving plants with small demands on the soil i.e. *Lavandula angustifolia, Melissa officinalis, Origanum vulgare, Rosmarinus officinalis, Salvia officinalis, Thymus spp.*.

Field 1 (885)-zone 2
The eastern part of the field has a slight slope and the beds are therefore suggested to be established in the direction north-south, see figure 6. There are several individuals of the leguminous species *Genista hispanica* growing in the field at the time of the inventory. These plants can be used for erosion control if they are moved to the middle of the planting beds to be used as hedgerow cropping. The other part of the field is almost flat and the beds should preferably be established in an east-west direction. Supplementary irrigation is feasible as the field is situated close to a stream in the eastern orchard. The illumination is quite strong on the whole field, except from the southern part where a stone wall and the trees of the western orchard produce shadow on the field in autumn, winter and spring when the angle of the sun is low. There is a large oak and three apple trees planted along the western border. By the main entrance to the field,the establishment of a culinary-herbal spiral is suggested, see table 11. The composition of the substrate should preferably be made up of a mixture of mature compost and soil from the field to increase humus, fertility and micro organism activity. The species selected for the northern direction could be the perennials *Mentha piperita*, *Melissa officinalis, Petroselenium crispum* (biannual) and *Allium schoenoprasum*. On the southern side and on the top it is suggested to plant perennials like *Origanum vulgare, Rosmarinus officinalis, Salvia officinalis and Thymus spp*. (Mollison, 1988; Whitefild, 2002)

An annual leguminous crop, as for example a local, yellow variety of *Lupinus spp.*, is suggested to sow the first year as the nitrogen level is low. It grows well on acidic soil and produce large quantities of organic matter both above and below ground. It should preferably be cut fine and worked into the soil at flowering, in order to increase nitrogen content and build up a humus rich structure. It is advisable to inoculate the seeds with compost soil to increase bacterial and fungal activity. Acid resistant plants such as the highly nutritious *Amaranthus spp.,* the medicine herbs *Rumex acetosa, Rumex acetosella* and the perennial *Vaccinum spp.* can be planted in beds were change in pH is in progress. *Phaseolus vulgaris, Vicia faba* and *Pisum sativum* are suggested to be combined with vegetables, spices and medicine plants for the following years. It is of great importance to be observant of crop rotation diseases as the species are very closely related. The plants may be used as green manure to increase soil health, or harvested as fresh or dry for storage. The size of the field makes it possible to produce a considerable amount of food to reach the needs of the land owners. The cultivation beds need to be well supplied with a calcium source to neutralize the indicated low pH, and thereby the risk of absorption of aluminium. Another possibility to increase nitrogen, pH and humus content that can be combined with the first one suggested, is to establish permanent raised beds from the composts. It is suggested to localize the subsequent compost in the northern end of the field in an eastern-western direction and continue establishing the future composts in the same pattern.

To capture nutrients leaking from the existing composts illustrated with green colour in figure 6, a couple of shadow resistant, perennial and deep rooted *Rheum* x *cultorum* is suggested.

A hedge made up of *Hippophae rhamnoides* and *Artemisia abrotanum* is suggested to frame the northern and the eastern extremes. It will function as a suntrap and protect the crop from the strongest winds. *H. rhamnoides* grows up to 6 m tall, grows well in windy sites and has symbiosis with soil bacteria that fixate nitrogen as well as producing tasty fruit. *A. abrotanum* grows up to 1, 2 m tall and both support temporary draught periods. The entire plant is claimed to function as an insect repellent (Fern, 2002) and is also an important plant in Chinese medicine (Luis, 2006). Even though this species is deciduous, it is probable that the growing pattern with many branches can alleviate the crop from some of the coldest winter winds.

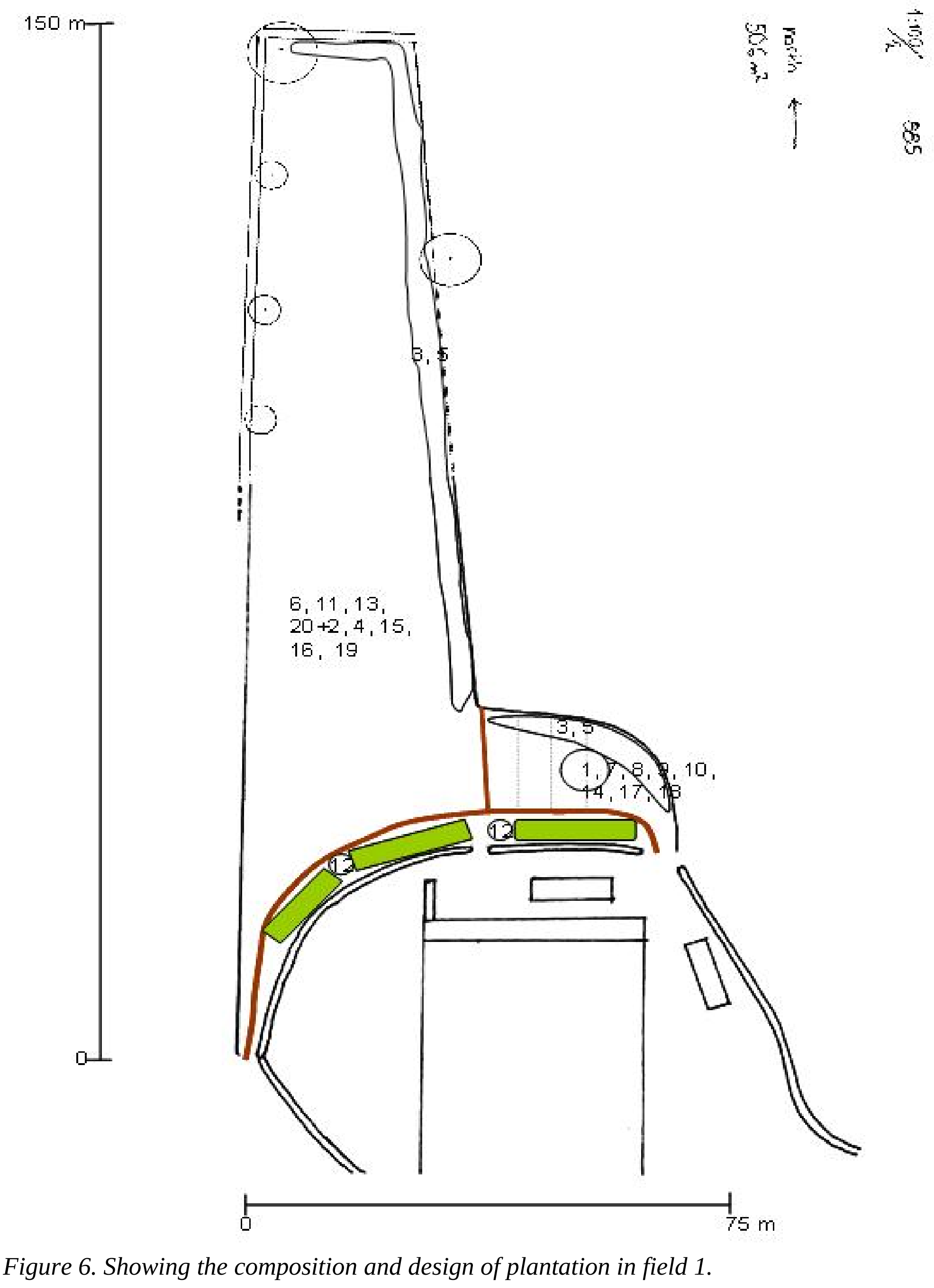

Figure 6. Showing the composition and design of plantation in field 1.

Table 11. Plants to be introduced to field 1.

Nr	Latin	English	Spanish	Gallego	Swedish
1	*Allium schoenoprasum*	Chive	Cebolliño común	Ceboliño	Gräslök
2	*Amaranthus spp.,*	Pigweed	Bledo, amaranto	Amaranto	Amarant
3	*Artemisia abrotanum*	Southernwood	Abrótano	Abrótano macho,	Åbrodd
4	*Genista hispanica*	Spanish greenweed	Abrojos, Abulaga		Ginst
5	*Hippophaë rhamnoides*	Sea buckthorn	Espino cerval de mar, bayas marítimas		Havtorn
6	*Lupinus spp.*	Lupine	Altramuz	Chícharo de raposo	Lupin
7	*Melissa officinalis*	Lemonbalm	Melisa, toronjil	Melisa	Citronmeliss
8	*Mentha piperita*	Peppermint	Menta piperita		Pepparmynta
9	*Origanum vulgare,*	Oregano	Orégano	Ourego	Oregano, Kungsmynta
10	*Petroselinum crispum*	Parsley	Perejil	Perexil	Perslja
11	*Phaseolus vulgaris*	Common bean	Alubia, frijol, judia	Faba	Böna
12	*Rheum x cultorum*	Rhubarb	Ruibarbo		Rabarber
13	*Pisum sativum*	Pea	Guisante	Chícharo	Ärta
14	*Rosmarinus officinalis,*	Rosemary	Romero	Romeu	Rosmarin
15	*Rumex acetosa*	Sorrel	Acedera, agrilla	Aceda	Ängssyra
16	*Rumex acetosella*	Sheep´s sorrel	Aceda, Acedera menor	Aceda	Bergssyra
17	*Salvia officinalis*	Sage	Salvia	Xarxa	Salvia
18	*Thymus spp.*	Thyme	Tomillo		Timjan
19	*Vaccinum spp.*	Bilberry	Arándano	Arandeira	Blåbär
20	*Vicia faba*	Broad bean	Haba	Faba loba	Åkerböna

Field 2 (749)-zone 2, 3

Since the field is flat, beds can be made with an east-west direction for optimal illumination of the crop as can be seen in figure 7. The stream passing at the top of the field can be used for irrigation of the crop if the field would dry out in the summer. As it is localised rather close to the cluster of houses a plantation of staple food is suggested. There is good access to the field from small paths, but also by the road at the west of the field. There is no border to a neighbouring house to the north; therefore it would be adequate to establish an area of high perennial plants in order to use the sunlight in the most efficient way.

Table 12 presents the complete plant list for the field. An area of perennial *Cynara scolymus* and self seeding *Chenopodium bonus-henricus* is suggested to be established in the north eastern part, adjacent to the road. It is further suggested to establish 20 plants of *Vitis vinifera* to the east of the former perennials with the approximate distance of 70 cm between them. It is a sufficient amount to make a small produce of grape juice or wine and there is space if there is a wish to expand the line with more vines in the future. The plants would not create any shadow to the crop growing underneath, but make a natural separation of the fields. To the south of the vines a row of *Beta vulgaris ssp. cicla* is proposed to be established. It has a long harvest period and will probably grow well with the perennials. It needs an extra supply of nitrogen and a neutral pH. It should therefore be supplied with woodash and easily assimilated nitrogen at various occasions during the growing season as the soil is prone to leaching. 4 structures for climbers of *Humulus lupulus* and *Hablitzia tamnoides* are placed at the eastern side of the line of vine. A perennial plantation of *Apium gravolens* intercropped with *Armoracia rusticana* is suggested to be established along the stream at the eastern border. They both thrive in humid conditions, but will need an extra supply of chalk to neutralize the slightly low pH.

The remaining surface of the field is suggested to be used for permanent vegetable beds with a crop rotation using fields with similar conditions i.e. field 776 that is not discussed in this paper. The suggested crop rotation for the two fields is as follows;

1) *Allium+Apiaceae*
2) *Brassica+ Vicia faba*
3) *Solanum+ Trifolium*
4) *Poaceae* (*Zea mays*)+*Cucurbitaceae*
5) *Fabaceae* (*Arachis hypogaea)*
6) *Chenopodiaceae (Chenopodium quinoa)*

Planting beds that are to be managed by hand and using the system of keyhole beds optimize land use and facilitate the work. Vegetables and fruit producing plants adapted to the microclimate are suggested to be planted on the field and grouped in families. Combining species from the same plant families and mixing them in row and strip intercropping with aromatic herbs can facilitate insect control. The species suggested from the *Solanaceae* family are *Lycopersicon esculentum*, *Capsicum annuum* and *Solanum tuberosus.* As the Colorado beetle is very common in the area, intercropping with *A. gravolens* is suggested. Local farmers claim that the intercropping combination has a protective effect on *S. tuberosum.* It has been seen in laboratory experiments that *L. esculentum* odour mixed with the odour of *S. tuberosum* makes it loose the attractiveness to the beetle (Thiéry & Visser, 1987). A combination of the three species can therefore be interesting. An over wintering ground cover of *Trifolium repens* or *T. pratense* helps to re-establish the nitrogen level of the soil for the next crop.

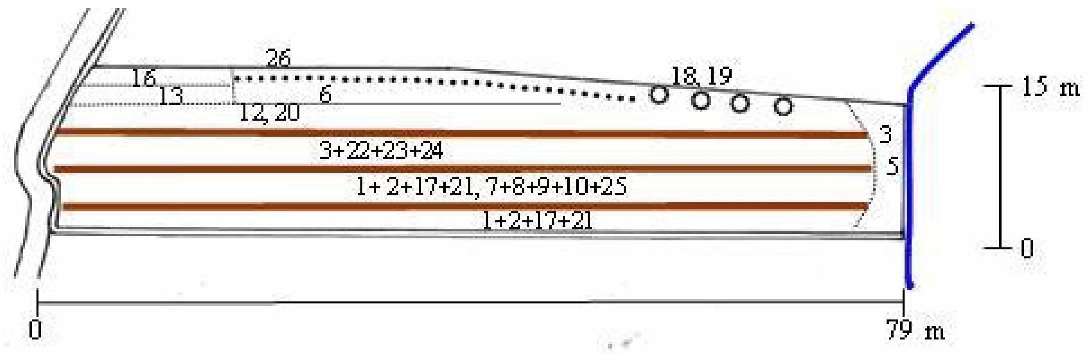

Figure 7. An illustration of the composition and design in field 2.

In the adjacent cultivation bed the family *Brassicaceae* and *Fabaceae* is suggested to be established. Species as *Brassica oleracea var. botrytis, Brassica oleracea var cymosa, Brassica oleracea var.gemmifera*, *Brassica oleracea var. acephala* or *var. viridis* and *Vicia faba* grows best when established during the cooler and more humid part of the year in this climate. It has been shown in experiments that intercropping with *Brassica spp.* and *Vicia spp.* results in lower herbivore damage on the former (Dicke, 2006).

The last cultivation beds are suggested to be seeded with *Daucus carota* and *Pastinaca sativa* from the *Apiaceae* family, in combination with *Allium cepa* and *A. sativum.* Their varying morphology over and below ground makes them compatible. They are expected to grow well in the prevailing soil conditions with a slight increase of the pH.

Table 12. Plants to be introduced to field 2.

Nr	Latin	English	Spanish	Gallego	Swedish
1	*Allium cepa*	Onion	Cebolla	Cebola	Lök
2	*Allium sativum*	Garlic	Ajo	Allo	Vitlök
3	*Apium gravolens*	Celery	Apio	Apio	Selleri
4	*Arachis hypogaea*	Peanut, groundnut	Cacahuete	Cacahuete	Jordnöt
5	*Armoracia rusticana*	Horseradish	Jaramago, mostaxa romana	Armoracia	Pepperrot
6	*Beta vulgaris ssp. cicla*	Chard	Acelga	Acelga	Mangold
7	*Brassica oleracea var. acephala or var. viridis*	Galega Kale	Col	Berza	Galisisk grönkål
8	*Brassica oleracea var. botrytis*	Cauliflower	Coliflor	Coliflor	Blomkål
9	*Brassica oleracea var cymosa*	Broccoli	Brécol	Brécol	Broccoli
10	*Brassica oleracea var.gemmifera*	Brussels sprouts	Col de Bruselas	Col de Bruxelas	Brysselkål
11	*Capsicum annuum*	Sweet pepper	Pimiento	Pementeira	Spansk peppar
12	*Chenopodium bonus-henricus*	Good king Henry	Buen Rey Enrique		Lungmålla
13	*Chenopodium quinoa*	Quinoa	Quinoa		Mjölmålla, Quinoa
14	*Cucurbita maxima*	Pumpkin	Calabaza	Cabaza	Pumpa
15	*Cynara scolymus*	Globe artichoke	Alcachofa	Alcachofra	Kronärtskocka
16	*Daucus carota*	Carrot	Zanahoria	Cenoura	Morot
17	*Hablitzia tamnoides*	Climbing spinach			Rankspenat
18	*Humulus lupulus*	Hops	Lúpolo	Lúpolo	Humle
19	*Lycopersicon esculentum*	Tomato	Tomate	Tomate	Tomat
20	*Pastinaca sativa*	Parsnip	Chirivia	Chirivia	Palsternacka
21	*Solanum tuberosum*	Potato	Patata	Pataca	Potatis
22	*Trifolium pratensis*	Red clover	Trebol violeta	Trevo rubio	Rödklöver
23	*Trifolium repens*	White clover	Trébol blanco	Trevo branco	Vitklöver
24	*Vicia faba*	Broad bean	Haba	Faba loba	Åkerböna
25	*Vitis vinifera*	Vine	Vid	Vide	Vinranka
26	*Zea mays*	Corn	Maiz	Millo	Majs

Field 3 (750)-zone 2, 3

Even though the mean of the indicator plants show a great variation there is a tendency that this field is one of the driest one. It is situated relatively high up on the hillside with a road behind the eastern stone wall, accompanied by ditches that lead the rainwater away. The slope of the field makes it necessary to situate the beds in a north-south direction, illustrated in figure 8, to avoid water run of and erosion.

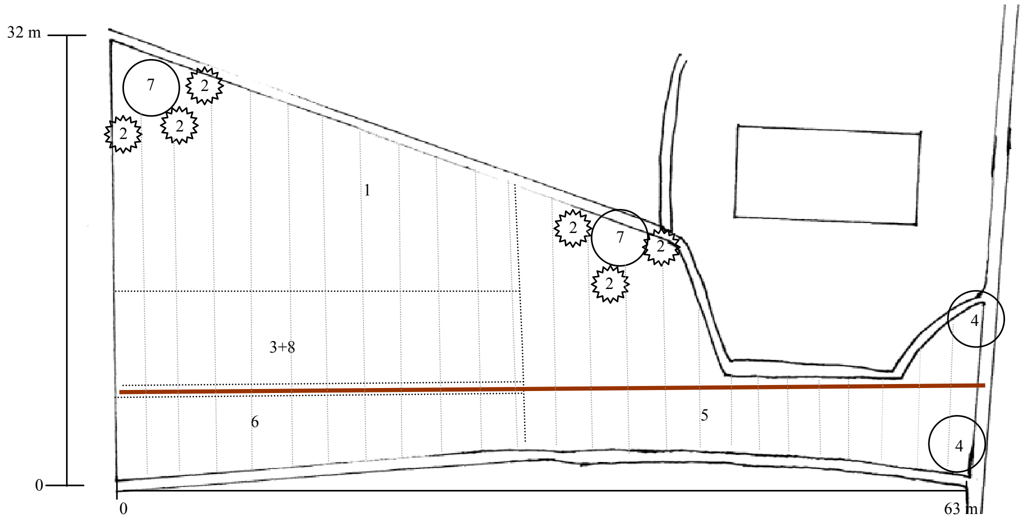

Figure 8. An illustration of the composition and design in field 3.

The plants suggested for the design of this field have the character of low maintenance and are presented in table 13. They will need normal weeding at establishment and during growth, but have limited harvest season.The medicinal tree *Ginkgo biloba* grows well in dry soils and it is suggested to introduce 2 individuals by the gate close to the road in the eastern part of the field where its shadow will not interfere with the crop. It produces tasty seeds with a high nutritional value and leaves with a medicinal use (Fern, 2000). *Laurus nobilis* is another tree that would thrive in the microclimate of this field, accompanied with the fruit shrub *Feijoa sellowiana*. They would preferably be planted in the northern part of the field, with the latter towards the south. It would be enough with the establishment of 2 individuals of *L. nobilis* and 6 of *F. sellowiana* to serve culinary purposes. The perennial *Asparagus officinalis* would also grow well with the properties of this field with an addition of a chalk source to increase the pH slightly. It is of great importance to supply a humus rich bed for the bushes. As it is a perennial crop that needs little attention, but has a high market price a large area could be established. The sun loving, annual plant *Helianthus annuus* is proposed to be seeded in large parts of the field as it is a popular seed plant for both humans and animals. A large planting bed of the self-seeder *Pastinaca sativa* is suggested to be established together with *Foeniculum vulgare* as under storey vegetation. They are of the *Apiaceae* family and are known to attract pollinators. *A. officinale* and *H. annus* are preferable to plant more north than the rest of the lower plants to avoid shadowing the other crops. *Hypochoeris radicata* is an annual medicine plant that is suggested for the lowermost plant layer facing the south.

Table 13. Plants to be introduced to field 3.

Nr	Latin	English	Spanish	Gallego	Swedish
1	*Asparagus officinalis*	Asparagus	Espárrago	Esparragueira	Sparris
2	*Feijoa sellowiana*	Pineaapple guava	Feijoa	Feixoa	Feijoa
3	*Foeniculum vulgare*	Fennel	Hinojo	Fiúncho	Fänkål
4	*Ginkgo biloba*	Maiden hair tree	Gingo	Xinkgo	Ginkgo
5	*Helianthus annuus*	Sunflower	Girasol	Xirasol	Solros
6	*Hypohcoeris radicata*	Cat´s ear	Hierba del halcón	Paciporcas	Rotfibbla
7	*Laurus nobilis*	Sweet bay	Laurel	Loureiro	Lagerblad
8	*Pastinaca sativa*	Parsnip	Chirivía, pastinaca	Charouvía	Palsternacka

Field 4 (839)-zone 3, 4

The conditions of rather strong radiation, good humidity, only slightly low pH and a fairly good supply of nitrogen would probably produce a good harvest of *Zea mays or Solanum tuberosum* and *Cucurbita maxim* as can be seen in figure 9 and table 14. The latter could be planted in the outskirts of the *Z. mays* or *S. tuberosum* plantation, towards all directions except north. The big leaves decrease the pressure from weeds by shadowing. The local population claims that this field used to be planted with *S. tuberosum*. The risk of disease due to poor crop rotation would be minimal, as the fields have been in fallow for many years. As *S. tuberosum* is already suggested to be introduced into field 2 it can be suitable to allocate *Z. maiz* in field 4 the first year. The mentioned plants have a limited harvesting period and that is another reason why suggesting them for this field that is situated slightly far away from the houses. It might be necessary to supply the crops with extra nitrogen during the growing season or well decomposed compost at the start of the cultivation period. The plants should preferably be oriented north-south in order to slow down erosion and increase water retention. An additional supply of calcium might be necessary.

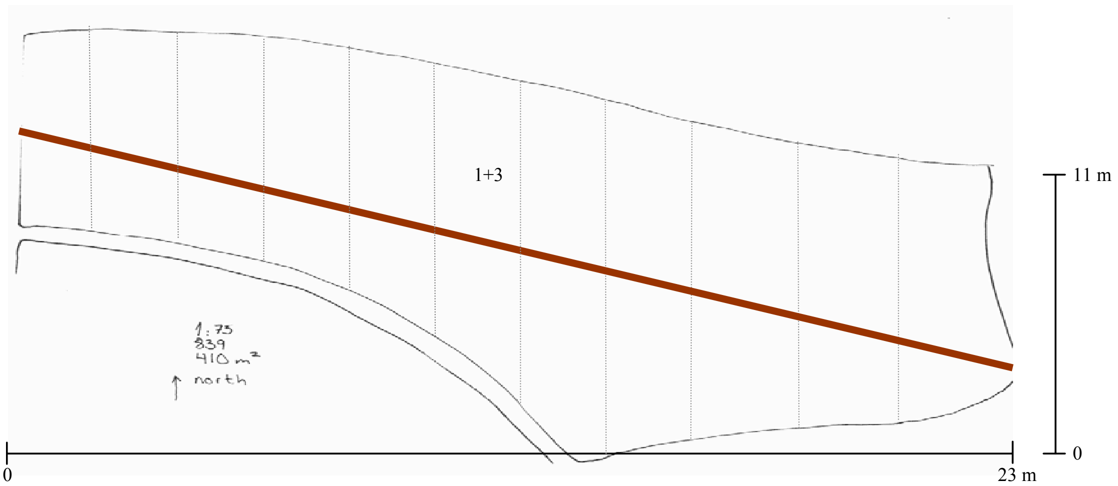

Figure 9. Showing the composition and design of plantation in field 4.

Table 14. Plants to be introduced to field 4.

Nr	Latin	English	Spanish	Gallego	Swedish
1	*Cucurbita maxima*	Pumpkin	Calabaza	Cabaceira	Pumpa
2	*Solanum tuberosum*	Potato	Patata	Pataca	Potatis
3	*Zea mays*	Corn	Maíz	Millo	Majs

Field 5 (869)-zone 3, 4

As the field is situated on a slight slope the orientation of the beds would preferably be north-south, see figure 10. The water access seems to be acceptable without supplied irrigation. There is a good access to light and a medium rich nitrogen content, which is suitable for plants such as the perennial *Helianthus tuberosus* accompanied with *Cucurbita pepo*, similar to field 839. They can be seen in table 15. A considerable amount of additional supply of a calcium source needs to be supplied however. H. tuberosum is a vigorous plant producing large quantity of biomass that could be used for improving the compost or as biofuel, when it starts to spread more than desired.

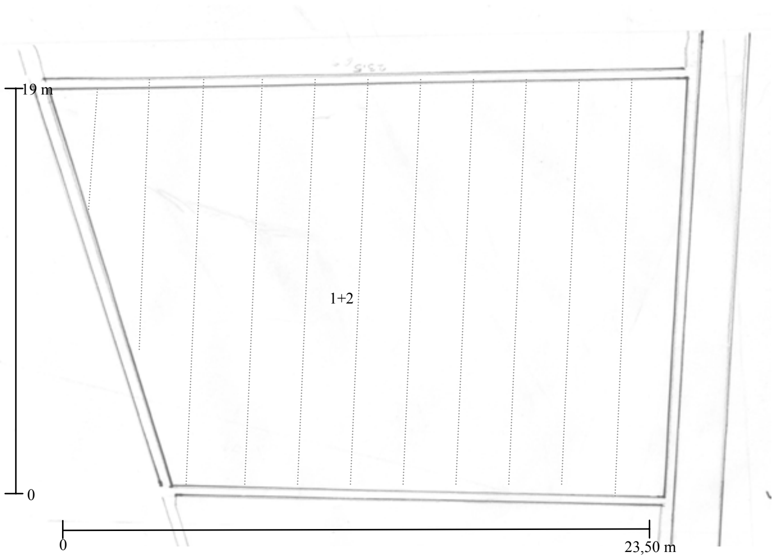

Figure 10. Showing the composition and design of plantation in field 5.

Table 15. Plants to be introduced to field 5.

Nr	Latin	English	Spanish	Gallego	Swedish
1	*Cucurbita pepo*	Pumpkin	Calabaza	Cabazeira	Pumpa
2	*Helianthus tuberosus*	Jerusalem artichoke	Aguaturma	Tupinambo	Jordärtskocka

Field 6 (816)-zone 4

The field is situated on a steep slope towards the west. As the valley is narrow, it is visually obvious that plants need to be more shadow resistant the further west they are situated. This fact can also be observed by the mean of the indicator plants. The establishment of swales directed north-south would slow down water and nutrient runoff and erosion, see figure 9. Plants are thereafter established, all layers at once, on the ridges between the ditches. Weeds growing on the field indicate a present status of medium rich nitrogen content in the soil, which is interpreted as there is a constant infiltration of nutrients from leaching fields situated higher up in the valley. If the assumption is correct there will low or no need for fertilizing the field for a long time. It is one of the fields with a larger distance to the house and it would therefore be practical to create an intercrop with shadow resistant annual groundcover with bushes and trees in a row arrangement that need low maintenance. All plants suggested for field 816 can be seen in table 16. The bottom of the field (1/4th) is suggested to be planted with *Salix spp.* species and *Cydonia oblonga* that withstands flooding very well and have a need for fertile soil. The aggressive root system of *Salix spp.* is very suitable to slow down erosion and serve as the managed part of a riparian buffer zone. The present oaks act as the unmanaged woody zone and the under storey vegetation, such as *Mentha spp*. and *Melissa officinalis,* spread all over the rest of the field represents the normally used grass zone. *Salix spp.* is known to be the second host that supports most number of insect species and also provides the most abundant source of nectar in early spring, which has a very positive effect on the biodiversity (Whitefield, 2002). The persons of the ecovillage have contact with a handicraft school were large quantities of *Salix spp*. is needed. *C. oblonga* produces a fruit that is used in traditional cooking in this part of Spain. It is further suggested to introduce shadow resistant bushes in between the coppice and trees to encourage biodiversity, species such as *Ribes uva-crispa, Ribes nigrum, Ribes rubrum* and *Sambucus nigra*. *Ribes spp.* grows well in partial shade and do not have any particular demand on soil pH. They give edible fruit and need a minimum of maintenance. Further up the field a plantation of *Juglans regia, Corya illinoinensis, Morus nigra* with *Corylus avellana* is proposed*. C. avellana* grows wild at the river bank already, but a higher yielding variety is suggested to be introduced. *J. regia* gives edible nuts with a high nutritional and market value. Its wood is of a high quality and will eventually provide an income for the owners or serve for carpentry in the village. It needs to be supplied with an additional chalk source as it prefers soils with a slightly high pH. The flowers are frost sensitive as the tree come into bloom early, but the microclimate produced by the river will probably protect it. *C. avellana* is a bush that gives edible nuts and its slender trunks serve to make trellies and also for making baskets. It tolerates partial shade and prefers sandy loam (Wiedermann). As *J.regia* grows bigger it will not only shade the *C. avellana,* but probably also affect it with its production of allelopathic compounds. *M. nigra* is not sensitive to these substances (Mollison, 1988). By time it will therefore probably turn into a zone dominated by a few big *J. regia, M. nigra* and *C. illinoiensis*. As the leaves develop in spring time they will shadow the herbs considerably, which makes combinations with early crops such as *Allium ursinum, Cardamine hirsuta* and *Claytonia perfoliata* a good choice. They are all adapted to a slightly humid and partly shadowed woodland floor. A hedge of the evergreen bush *Mahonia aquifolium* or/and *Elaeagnus commutata* is suggested to be planted along the northern wall until the trees are large enough to resist the winter winds. They both grow well in semi shadow and moderate winds. They produce edible fruits and are popular nesting place for insect eating birds (Fern, 2000). *E. commutata* has an extra function in the system as it has symbiosis with nitrogen fixating bacteria.

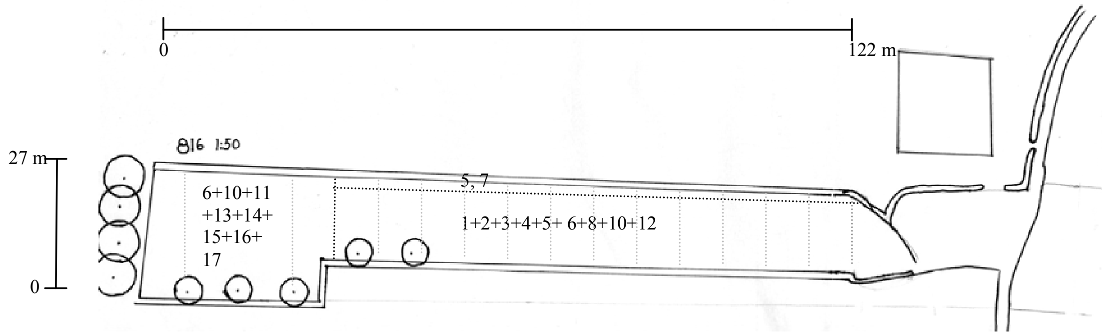

Figure 11. Showing the composition and design of plantation in field 6.

Table 16. Plants to be introduced to field 6.

Nr	Latin	English	Spanish	Gallego	Swedish
1	*Allium ursinum*	Ramsons	Ajo de oso		Ramslök
2	*Cardamine hirsuta*	Hairy bittercress	Mastuerzo amargo	Agriao menor	Bergbräsma
3	*Carya illinoinensis*	Hickory	Pecán, pacana		Pekannöt
4	*Claytonia perfoliata*	Winter purslane	Lechuga del minero		Vinterportlak
5	*Corylus avellana*	Hazel	Avellano	Abeleira	Hassel
6	*Cydonia oblonga*	Quince	Membrillero	Marmeleiro	Kvitten
7	*Elaeagnus commutata*	Silverberry			Silverbuske
8	*Juglans regia*	Common walnut	Nogal	Nogueira	Valnöt
9	*Mahonia aquifolium*	Oregon grape			Mahonia
10	*Melissa officinalis*	Lemonbalm	Toronjil	Melisa, Herba abelleira	Citronmeliss
11	*Mentha spp.*	Mint	Menta	Menta	Mynta
12	*Morus nigra*	Black mulberry	Morera negra	Moreira negra	Svart mullbär
13	*Ribes uva-crispa*	Gooseberry bush	Grosellero espinoso, uva espina	Sorbeira	Krusbär
14	*Ribes nigrum*	Black currant, casssis	Grosellero negro	Groselleira negra	Svarta vinbär
15	*Ribes rubrum*	Red currant	Grosellero rojo	Groselleira vermella	Röda vinbär
16	*Salix spp.*	Willow	Sauces	Salgueiro	Viden
17	*Sambucus nigra*	Black elderberry	Saúco	Sabugueiro	Fläder

Field 7 (896)-zone 5

Several parts of the forest are suggested to be preserved in the present state in order to encourage native flora and fauna to flourish.

4. Discussion

It is important that the persons that are to implement and live in the design keep on improving it as new problems will occur, such as plagues and climate change. Culinary preferences and market situation may also produce a need for different crops. Considering the estimated surface needed to support 14 adults there are good possibilities to reach a high level of auto sufficiency in Chozas. It should be noted that the calculations of Jeavons and Ahnström were made in locations where the climate limits the cultivation period to 6 months, whereas the climate in Chozas allows harvest all year around for a wide range of plants. If the land in Chozas would turn out to be too small for the tree garden there are possibilities to use the extensive common land in the mountain and then share the harvest with the rest of the settlers in the surrounding. There is also a possibility to rent or buy unused land from neighbours. Thorough planning with long term perspective is needed before establishing a woody perennial plantation as considerable energy is required to remove them.

Planting beds are proposed to be designed having a perpendicular orientation to the slopes. This is feasible as long as no heavy machinery is to be used, as they tend to slide downwards. The crop combinations suggested are proposed taking into account a low mechanization on the farm. Polyculture and other permaculture techniques can be used on larger fields and commercial land, but it is probable that fewer and different species than those proposed in this project are more adequate in order to facilitate management.

By encouraging biodiversity some of the harvest will be lost to herbivores, as happens in nature unaffected by human activity. If permaculture or organic farming is the base for the agricultural activity there need to be an initial acceptance of this fact. The farming practice is not isolated from the surrounding ecosystem and should rather be seen as a part of it. By copying natural biodiversity systems to serve the needs of humans a more stabile ecosystem with less specialized plagues can be achieved. The use of companion planting and allelopathy to decrease pest and weed problem are interesting, but more research needs to be done in these area in order to establish reliable production systems that function in the different climates.

Some detailed soil depth measurements were made initially, but as the fields generally seems to have more than one meter depth there did not seem to be a need for further measurements. All the fields have been cultivated in the past, including the area with forest and can therefore be assumed to have a soil layer that is sufficiently deep to grow vegetables in. There were plans to make soil samples contracting an agriculture laboratory, but the staff claimed that the conclusions you can make of the soil status by observing the growing plants are more reliable than lab results. The practice of using indicator values for different plants to make a conclusion of the micro habitat is not commonly used outside Germany and Austria, possibly because the information is hard to find in English. Even though the climate and soil composition is different from north east Spain, values achieved can serve as an indication of land properties. An obstacle has been that some local plants do not occurred in the Austrian plant list. It is advisable to make the botanical inventory at more then one station of the year to achieve more reliable date on microclimate.

One difficulty in making the field measurements has been the rainy winters of Galicia. Another problem has been the lack of housing as the village is just initiating the reconstruction of the houses.

There are several factors affecting the slow development towards a sustainable approach in the agricultural field. Farmers are often considered as being conservative, which can partly be explained by their large economical investments in machinery and established selling channels for a small variety of crops. The financial situation of the farmer is another explanation to a slow development in the western world. It has been economically viable to supply; lacking nutrients produced synthetically, apply pesticides when monocrops attract specialist insects and additional irrigation of water to get an increase in harvest. Research has been focused on producing varieties that give high yield with the need of high external input. The use of pesticides has slowed down the development of alternative strategies to protect the crops.

Permaculture will require a change in lifestyle and approach to the environment, compared to the prevailing viewpoint of seeing increased production, economical strength and consumption as the solution to problems of the world. Permaculture is a multidisciplinary lifestyle approach that has been developed to use the resources of the earth and its dwellers in a sustainable way, were the local resources sets the limit. Hopefully there will be an increasing interest in permaculture as the global climate change and bring new complications to civilisation and the surroundings. World production has reached a point of efficiency that the destruction of natural resources not only threatens the right to clean water and air, fertile soil, habitats etc. It has become a luxury in parts of the world. Everyone will suffer if we fail to see that the personal responsibility and effort of all humans are necessary to make a difference in the negative development. It is necessary to bring together multidisciplinary groups and collaborate in order to create modern lifestyles that are sustainable.

There is a well established academy in England that among other objectives, serve as facilitators for the development of permaculture in Europe. An English magazine is produced each month and can be ordered from all parts of Europe, which serves as a source of inspiration and knowledge. There are two teachers in Spain at the moment, but several persons are in the process of achieving the teaching diploma. There is an Internet forum called “Red Iberica de Permacultura” were all interested Spanish speakers can take part in the discussions and get updated on courses and other activities. Internet is greatly facilitating the communication between the interested persons. There are now centres of permaculture in many places of the world and the amount of dedicators are increasing. A short list with interesting address can be found in appendix.

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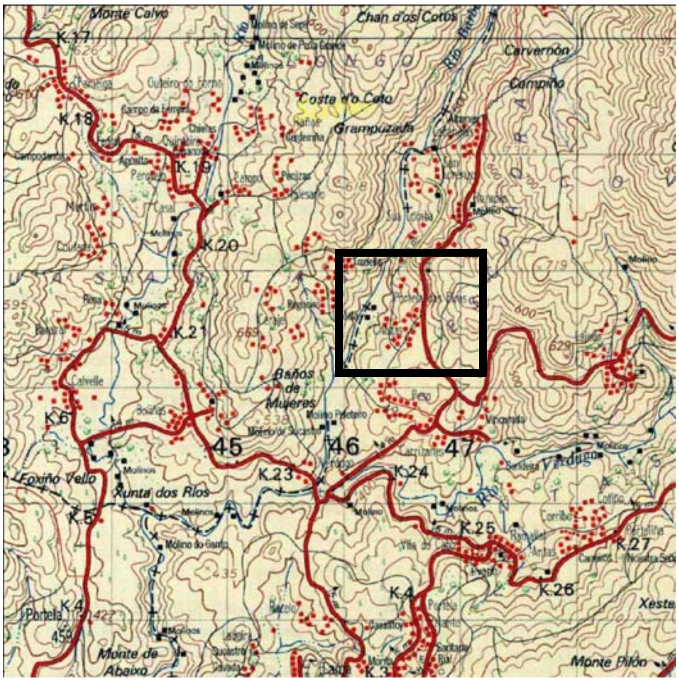
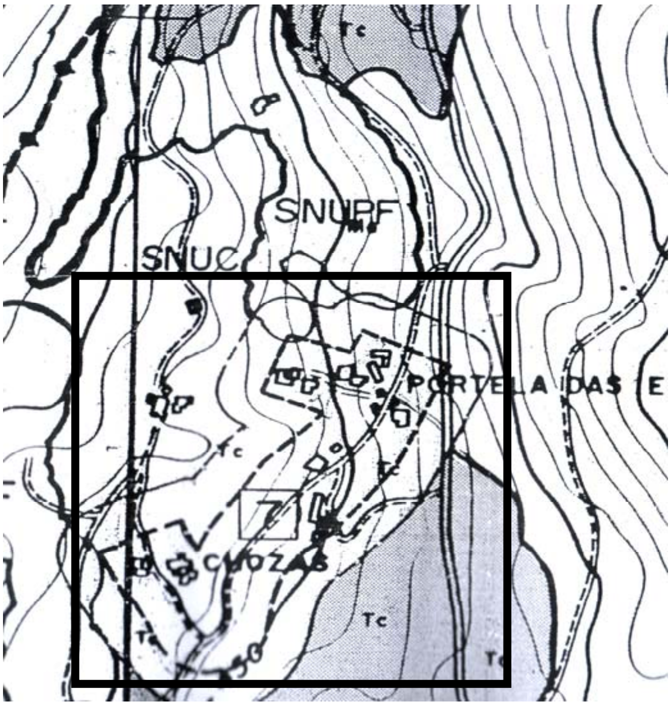
Appendix

Map 1. Galicia is marked on the map of Spain.



Map 2. The topographic map shows the variation in height of the mountainous area surrounding the village.



Map 3. Detail of a topographic map showing that the village Chozas and the surrounding cultivation areas are situated at 450 m over sea level.

Map 4. The map shows the multitude of small fields in the village. The coloured fields with a number beside, belongs to the project.

Table 17. List of indicator plants, bushes and trees observed and named in Latin, English, Spanish, Gallego and Swedish.

Latin	**English**	**Spanish**	**Gallego**	**Swedish**
Anthemis arvensis	Dog fennel, corn chamomile	Manzanilla borde	Macela brava	Åkerkulla
Arrhenatherum elatius	Tall oat grass	Porrillas	Nocella	Knylhavre
Brachypodium pinnatum	Tor grass, false brome			Backskafting
Carum verticillatum	Whorled caraway	Cominero borde		Kummin
Centaurea nigra	Rough star-thistle	Centáurea	Centáurea	Svartklint
Cirsium palustre	Marsh thistle	Cardo	Cardo	Kärrtistel
Conyza canadensis	Horseweed, Marestail	Zamarraga		Kanadabinka
Crepis capillaris	Smooth hawk’s beard			Grönfibbla
Cytisus scoparius	Broom	Escoba	Xesta	Harris, harginst
Cynodon dactylon	Hyrbid Bermudagrass	Grama común	Pata de galiña	Hundtandsgräs
Dactylis glomerata	Cocks’s foot	Dáctilo, pata de pollo	Datilo	Hundäxing
Erica spp.	Heather	Brezos	Queirugas, carrascas, uces	Ljung
Eucalyptus globulus	Blue gum eucaliptus, white eucalyptus	Eucalipto blanco, eucalipto azul	Eucalipto branco	Feberträd
Filipendula vulgaris	Meadowsweet	Filipéndula	Herba da ferida, Herba do ferro	Brudbröd
Frangularia alnus	Alder buckthorn	Arraclán	Sanguiño	Brakved
Holcus lanatus	Yorkshire fog, common velvet grass	Heno blanco, holco	Herba triga	Luddtåtel
Hypericum undulatum	St. Johns wort	Hierba de San Juan	Herba de San Xoán	Johannesört
Hypochoeris radicata	Cat´s ear	Hierba del halcón	Paciporcas	Rotfibbla
Iris pseudacorus	Yellow flag	Lirio amarillo	Espadaina	Svärdslilja
Juncus effusus	Soft rush	Junco	Xunco	Veketag
Laurus nobilis	Sweet bay	Laurel	Loureiro	Lager
Leontodon taraxacoides	Hawkbits	Diente de las peñas		Fibbla
Lotus corniculatus	Bird´s-foot trefoil	Trébol de cuernitos	Loto	Kärringtand

Lythrum salicaria	Purple loosetrife	Salicaria, arroyuela	Herba salgueira, salgueiriño	Fackelblomster
Mentha suaveolens	Apple mint, pineapple mint	Hierba sapera, mentastro	Mentrastre, Hortelá	Rundmynta
Pinus spp.	Pine	Pino	Pino	Tall
Plantago lanceolata	Narrower plantain	Llantén menor	Chantaxe	Svartkämpe
Plantago major	Greater plantain	Llantén mayor	Chantaxe	Groblad
Potentilla erecta	Tormentil	Tormentilla	Solda	Blodrot
Prunella vulgaris	Common self heal	Bruneta vulgar, Consuelda menor, Hierbas de las heridas	Herba da ferida, Herba do ferro	Brunört
Pteridium aquilinum	Fern	Helecho	Fento comun	Örnbräken
Quercus spp.	Oak	Roble	Carballo	Ek
Ranunculus repens	Creeping buttercup	Botón de oro	Herba belida	Revsmörblomma
Rubus fruticosus	Bramble, Black berry	Zarzamora	Silva	Björnbär
Rumex acetosa	Common sorrel	Acedera	Acedas	Ängssyra
Rumex acetosella	Sheep sorrel	Lengua de vaca, acederilla	Acedas	Bergssyra
Salix spp.	Willow	Sauce	Salgueiro	Vide
Senecio aquaticus	Marsh ragwort	Hierba de Santiago		Vattenstånds
Sambucus nigra	Elderberry	Saúco	Sauce	Fläder
Spergularia spp.	Sandspurry	Esperguraría		Narv
Stellaria media	Chickweed	Pamplina	Muruxas, herba paxareira	Våtarv
Teucrium scorodonia	Word sage, garlic sage	Camedrio de los bosques, escorodonia	Teúdo, seixebra	Lundgamander
Tilia cordata	Lime	Tilo	Tileiro	Lind
Ulex europeus	Common gorse	Tojo	Toxo arnal	Ärttörne
Ulex parviflorus	Gorse	Aulaga morisca	Toxo	Ärttörne

Adresses of interest

Australia
The permaculture research Institute:
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Network for Iberian permaculturists:
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