Management of Green infrastructure elements

Training Module 2

Deliverable D.T4.2.2 Module for training on practical GIs management

Agricultural Institute of Slovenia

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Content

The LUIGI project

The Interreg Alpine space project LUIGI (Linking Urban and Inner-Alpine Green Infrastructure - Multifunctional Ecosystem Services for more liveable territories) brings together 14 partner institutions and 26 observers from Austria, France, Germany, Italy, Slovenia, and Switzerland with the aim of strengthening the link between mountain ecosystems and urban centres at the foot of the Alps through sound economic and social exchanges.

By recognising the pressures on Alpine ecosystems and the services they deliver to wider areas beyond mountain regions, the project aims to strengthen the link between mountain ecosystems and urban centres at the foot of the Alps. The project's objective is to recognise and valorise the joint benefits of a GI network between mountain/rural and urban areas, as well as their potential for sustainable economic development based on natural resources and ecosystem services, ensuring a higher quality of life and better urban environments for people living in urban centres.

Work Package 4 of the LUIGI project focuses on education and training for sustainable management of green infrastructure elements in LUIGI model regions, leveraging knowledge from the Alpine region and beyond.

Aims and objectives of this module

The aim of this module is to provide information on practical management measures for the establishment and maintenance of different green infrastructure (GI) elements. The module also includes detailed management instructions for maintaining tree-based GI elements. It aims to encourage participants to execute the necessary measures in their local tree-based GI independently. In the appendix, an example presentation for managing orchard meadows is provided, but it can be applied to other tree-based GI elements as well.

Who is this module for?

This module can be adopted and executed by:

- agricultural associations and administrations,
- regional development organisation and
- local, regional and nature park administrative bodies.

A local expert who is familiar with local environmental conditions and specific GI-elements should conduct the module's practical training or demonstration activity.

Suggested target knowledge end-users

Target groups are:

- landowners (from private gardeners to commercial producers) where GI-elements are located,
- professional gardening and landscape managing enterprises executing maintenance measures on public and private properties and
- representatives of local and regional administrative bodies in charge of landscape planning and management.

Suggested educational method

The first activity is an indoor lecture in which the lecturer provides general information of different measures which can be executed in local GI elements.

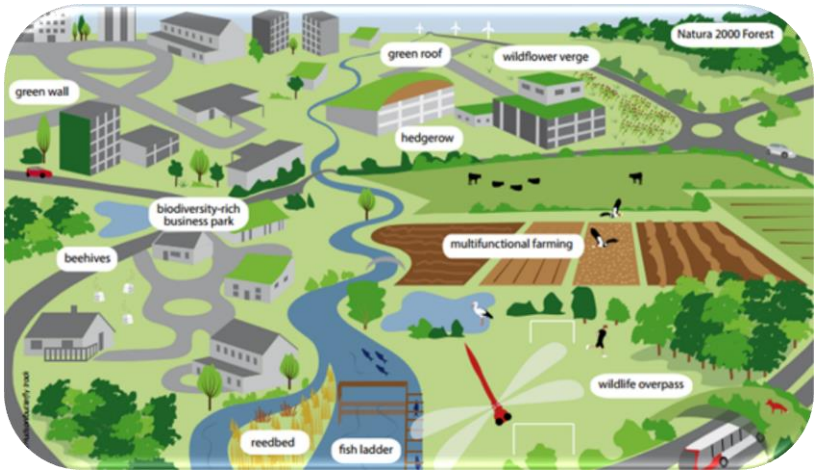
The second activity is a practical training session that presents specific measures to be executed in the tree-based GI elements. This activity should be adapted to local GI elements and conditions and it should be carried out by a skilled local expert.

What is green infrastructure (GI)?

Since there is no widely recognized definition of Green infrastructure GI in the scientific community, we decided to adopt the EU definition and approach within the LUIGI project. According to the European commission, a Green infrastructure is a strategically planned network of natural and semi-natural areas with other environmental features that are designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, recreational space, and climate mitigation and adaptation (COM/2013/0249). It incorporates green spaces (or blue space in the case of aquatic ecosystems) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in both rural and urban settings. It also supports a green economy, creates job opportunities and enables landscapes to recover from biodiversity losses.

Green Infrastructure can provide both socio-economic and conservation benefits at different scales – from local or regional (e.g. wildlife overpasses, migratory corridors, floodplains) to continental (e.g. Pan-European Ecological Network). It is made up of a variety of natural and artificial elements at different scales, from protected core areas to sustainable use buffer zones and green urban and peri-urban spaces (CEEweb).

GI can help us reduce our dependence on 'grey' infrastructure, which is often more expensive to build and maintain for the same function. Grey infrastructure, such as water and wastewater treatment plants, pipelines, and reservoirs, is human-engineered infrastructure that can be detrimental to the environment and biodiversity.



Picture 1: A schematic presentation of Green infrastructure elements in the landscape (European Commission, 2013)

The concept of ecosystem services (ESS) is often used to describe the importance of GI. These are the environmental, social, and economic benefits which humans receive from ecosystems (MEA, 2005). Humans depend on these services, but the valuation of these life-supporting services is a challenging task. However, only healthy and functioning ecosystems can sustainably provide these services. There are multiple ways to classify, measure and assess ecosystem services, as described in the LUIGI report WP1.1.1A by Giombini and Egarter Vigl (2020).

Activity 1: LECTURE on management of GI-elements

This activity presents basic prerequisites and measures for the creation and preservation of GI landscape elements and their ESS functions. The module presents the importance of a participatory management approach, as well as the basic characteristics of GI elements and their ecosystem functions. Management measures for grasslands and wetlands are presented in this activity, while the second activity delves further into tree management.

The topics presented serve as the basis for a 60-minute lecture for stakeholders who work with and on local GI elements. Bolded titles can be used for single presentation-slide creation.

1 GI governance approaches

Green infrastructure landscape elements require the dedication of substantial areas that could otherwise be used for other purposes. This is so called land use competition. However, simple placement of a GI element in the landscape does not guarantee that ecosystem services will be provided. To provide a maximum amount of ESS, GI elements must be integrated with other landscape elements, properly managed, integrated in the economic value chains and accepted by society.

Participatory management

In order to achieve sustainable GI management, a proper relationship with the local community needs to be established. Management plans that are created inclusively have a much better chance of long-term success. A strong correlation between communication, education and public awareness and participatory management is evident (Chatterjee et al. 2008).

Benefits of participatory management

Benefits of a participatory approach to GI-management planning include:

- established trust among stakeholders,
- pointing out possible key issues,
- building awareness among the most important stakeholder groups for achieving management objectives,
- broader support of projects,
- capacity building for continuous involvement.

Management plans must also be properly communicated. In addition to GI ecological value in terms of ecosystem services, an understandable Socio-cultural and Economic valuation must be presented. The necessary measures for the establishment and continued management of the GI element must be clearly defined and requirements for reaching the management plan's objectives clearly stated.

More information on possible GI-promotional activities is contained in the educational module 4.2.4 **Use of Green infrastructure products and society engagement** (Hladnik et al., 2021).

1.1 Present policy measures

The development, maintenance and sustainability of GI landscape elements are influenced by regulations and policies at the EU, country and regional levels.

These policies regulate the following:

- increase of humid areas and forests to counteract climate change (microclimate and summer drought),
- move to more environmentally sustainable forms of crop cultivation: organic, low-impact, biodynamic, permaculture (water quality), water meadows and flooded rice fields (microclimate and summer drought, circular economy), and soil preservation techniques in terms of structure and natural fertility,
- improvement of the performance of support and regulatory ESSs in order to increase the park's effectiveness in relation to external territories by intensifying the application of agro-environmental measures,
- environmental landscape design in territories affected by upgrades or new infrastructural forecasts, starting with alternatives that can express a variety of ecological and landscape functions (protection of environmental risks and landscape),
- expanding river belts and floodplains, providing them with adequate plant equipment to improve riparian and floodplain ecosystems (microclimate, landscape, sustainable water management),
- reconnecting the surface water network and rebuilding of the network of hedges/rows/wooded patches connected to the network (microclimate, landscape, sustainable water management),
- increase riparian vegetation along the minor water network, after reshaping the riverbed to minimize bank maintenance: the benefits include both emissions reduction and ESS integrity (reduction of environmental risk, microclimate and landscape),
- implement the ecological network by expanding the presence of patches and wooded areas and hedges/rows to reconstruct the agricultural landscape, which has been fragmented by infrastructure and settlement developments, and increase shaded area without interfering with agricultural activity (microclimate, ventilation, landscape, soil conservation),
- widespread implementation of SUDS - sustainable urban drainage systems in settlements (improving water quality),
- preventing new settlements placements and introduction of strategically organized green and blue urban and extra-urban infrastructures (microclimate, landscape, sustainable water management) into urban planning tools,
- building urban green and blue infrastructure that is designed and managed to provide a wide range of ESSs for climate change adaptation (urban floods and heat islands), improved urban water management and climate comfort and increase urban nature spaces,
- reconstruction of river morphologies and floodplain ecosystems through suitable NBS – nature-based solutions - (protection from environmental risk, ventilation, landscape, conservation of the interaction of soils and water).

1.2 Development opportunities

The first frontends of maintenance and utilization of GI-elements are landowners and those executing measures in the GI-elements. They can assure ecosystem service provision.

There are numerous opportunities for the landowners that arise from the presence of GI elements in the following areas:

- economic improvement of GI-products valorisation,
- the use of fruit and other products as raw material for processing,
- improvements through management modifications to achieve minimal GI care needs,
- use of modern equipment and services for GI-product processing,
- greater professional support for GI-related development,
- cooperation at all levels:
    - agricultural and nature conservation professions,
    - value chains for products,
    - tourism and related services,
    - education systems and
    - promotion and awareness raising.

For further business and value chain opportunities please refer to the LUIGI educational module 4.2.3. **Business models related to Green Infrastructure** (Rekič et al., 2021).

1.3 General management approach

It is helpful to divide large or complex sites into units or zones based on ecological or functional criteria when preparing management plans. Management strategies for zones like the main, buffering and border zones are to be defined (Chatterjee et al. 2008). Finally, a management plan is translated into concrete actions for preparing and managing a defined zone.

2 Characteristics of GI elements

History of GI elements present in alpine landscapes

All green infrastructure elements have evolved over time or have been influenced by local historical developments. Some GI elements are simply natural ecosystems adapting to human needs, while others were intentionally designed and introduced to landscapes as human awareness of needs have evolved. However, GI elements form the traditional landscape image.

GI elements are part of the landscape image

Typical cultural landscape images from different alpine regions (Photos provided in the LUIGI photo collection).

Trees characteristics in human-made GI elements like parks and meadow orchards:

- they were planted and nurtured by someone,
- trees are mostly aged and dying due to poor care,
- they have not been pruned in a long time,
- they have a lot of hangings, degenerated and dry branches,
- they are a part of our heritage that we must preserve for future generations.

2.1 Local culture and GI elements

Tillage, cultivation and nurturing are used by people who work and create in harmony with nature and local traditional GI elements. Many economic, scientific, creative and ethical fields of society development have evolved as a result of this. Working, walking and being in tree-based GI elements such as urban parks, orchard meadows and tree rows can serve as occupational therapy for overcoming stress in today's stressful world.

Trees and shrubs are a respected part of nature in the alpine space. If trees were to be cleared extensively in hilly regions, people would be reminded of the importance of trees by land- and snow-slides. Storms, winds, and heavy rains are also mitigated by trees. Fruit-bearing trees and shrubs, on the other hand, also provided additional food-source in times of hunger.

Local names

Many areas, settlements and places in the alpine space have names derived from trees and shrubs, especially fruit-bearing ones.

For example: Around 100 settlements in Slovenia are named after fruit species:

- Oskoršnica in Bela Krajina - Service/sorb tree,
- češnja (23x) – Češnjica – cherry ,
- oreh (17x) – Orehek - walnut,
- hruška (11x) – Hrušica - pear,
- jablana (9x) –Jablanica - apple,
- sliva (9x) – Slivnica - plum,
- leska (9x) – Leskovec - hazelnut,
- dren (8x) – Drenovec - cornelian cherry,
- kostanj (5x) – Kostanjevica – chestnut.

3 Ecosystem services (ESS) of GI

"Ecosystem services are the benefits people obtain from ecosystems." (MEA, 2005). They are life-sustaining and the basis for our society's existence, yet it is hard to put a direct value on most of them.

The following are some of the concrete benefits of tree-based GI elements:

ESS - Provisioning services

- Food (fruits, mushrooms and herbs)
- Raw materials and energy (wood and fibre)
- Clean water (natural water filtration can occur in a semi-natural environment)
- Medicinal and ornamental resources
- Habitat provision and biodiversity, pollination
- Genetic resources (variety of plant and animal species)

ESS - Regulating services

- Carbon sequestration (global climate mitigation)
- Local climate regulation (cooling, stopping winds)
- Pest and disease control
- Predation/prey animal balance (prevention of overpopulation of pest species)
- Purification of water and air
- Waste decomposition and detoxification
- Flood protection (better infiltration and slower runoff of rain)
- nutrient cycling (a GI-element's natural cycles occur independently or in connection to other landscape elements)
- soil formation (if GIs are properly managed soils are improving trough time)

ESS - Cultural services

- Spiritual and historical importance
- Recreational and therapeutical (good and healthy place to be and move around)
- Science and education (we can learn from and in GI landscape elements)

Refer to the LUIGI WP.T1.1.1 report; **Green Infrastructure for the Alpine Space: from theory to practice** (Giombini et al., 2020) and references therein for further details on ecosystem services different GI-elements provide.

3.1 Biodiversity

People are becoming increasingly aware of the coexistence of plants and animals in GI landscape elements.

The great biodiversity of the plant world attracts a lot of insects.

The importance of birds in GI elements

Small living animals

We depend on the hard work of pollinators and the weather

Photos: Janez Gačnik, Ivan Esenko and the LUIGI photo collection

Fruit-bearing trees and shrubs

Although all tree and shrub species are important for ESS provision of GI landscape elements, we focused on fruit-bearing trees and shrubs. Fruits are the most tangible ESS any GI element can provide and society comprehends. GI elements with fruit-bearing plants provide the most participatory (Hladnik et all. 2020) and value chain (Rekič et all 2020) opportunities.

Indigenous fruit-bearing tree species

They are present in the surroundings of human-made GI elements and influence biodiversity and pollination.

- Sweet chestnut - Castanea sativa
- Midland hawthorn - Crataegus laevigata
- Common hawthorn - Crataegus monogyna
- Common walnut - Juglans regia
- European crab apple - Malus sylvestris
- Wild cherry - Prunus avium
- Mahaleb cherry - Prunus mahaleb
- Bird cherry - Prunus padus
- European wild pear - Pyrus pyraster
- Whitebeam - Sorbus aria
- Rowan/mountain-ash - Sorbus aucuparia
- Service/sorb tree - Sorbus domestic

Shrubs and herbaceous fruit plants

- Black Elm - Sambucus nigra
- Blackthorn - Prunus spinosa
- Cornelian cherry dogwood - Cornus mas
- Common hazel - Corylus avellana
- Rosehip - Rosa sp.
- Common juniper - Juniperus communis
- Common barberry - Berberis vulgaris
- Wild blackberry - Rubus fruticosus
- Forest raspberry - Rubus idaeus
- Blueberry - Vaccinium myrtillus
- Cranberry - Vaccinium vitis idae
- Wild strawberry - Fragaria vesca

Cultivated tree fruit species in GI-elements

In human-made tree-based GI elements like parks and meadow orchards, the most important fruit-tree species are:

- apple
- pear
- cherries
- plum
- walnut

Other commonly grown fruit species

- Blackberry - Rubus ursinus
- Honeyberry - Lonicera caerulea
- Blueberry - Vaccinium
- Raspberry - Rubus idaeus
- Ribes and Gooseberry – Ribes
- Strawberry - Fragaria

There are several cultivars of these species that are traditionally grown in GI-elements. They serve as a large genetic pool for the preservation and development of commercially grown cultivars.

4 Management of grassland

Tree-based GI-elements mostly have grassland underneath them, but clear grassland can cover substantial areas of GI elements on its own. However, mixed landscapes dominated by grasslands have the highest level of plant and animal biodiversity per unit of surface area (Plantureux et al., 2005).

Due to the favoured conditions for woody plants and/or the absence of a sufficient amount of grass-feeding wild animals, grassland is seldomly found naturally in the alpine space area. To guarantee long-term stable ESS provision, grassland areas need proper planning and management strategies

Grassland management measures

ESS, and especially grassland biodiversity, may be influenced by several management factors such as:

- ploughing and other soil disturbances,
- seeding and reseeding,
- grazing and cutting of grassland,
- the use of organic and mineral fertilizers,
- drainage and watering and
- the use of pesticides and anthelmintics.

Ploughing and reseeding

Although ploughing and other soils-interfering management practices are not common in the establishment and management of GI grassland, they have a big influence on the plant and animal population composition. However, it is often easier to restore naturally-biodiverse vegetation from intensive arable land when mechanical soil-disturbance measures are applied in comparison to successive transition (Walker et al., 2004).

Grazing and cutting management

Grazing generally enhances biodiversity by providing soil structural heterogeneity (Plantureux et al. 2005). It is now well established that large ruminants are able to enhance plant diversity at low stocking rates while decreasing it at higher stocking rates due to overgrazing (Olff & Ritchie, 1998).

Grassland management influences the presence and abundance of different plant and animal species (Guilio et al 2001). Intensively managed meadows are dominated by more common and less specialised species, while extensively managed meadows are species-rich habitats supporting some rare and specialised species.

Some insect species become more abundant as the number of grassland cuts increases, while others become severely reduced or disappear altogether. Only a few plant species can persist in an intensive grassland management system, and their ecological value is poor (Muller 2002).

Grassland with high natural value and species diversity is threatened by intensification on one hand and abandonment on the other. Therefore, several policies and initiatives encourage the use of grassland-management alternatives that strike a balance between high-quality forage production and biodiversity maintenance in hay fields.

Alternative grassland management:

- late or only one grassland cut per growing season to allow grassland plants to germinate and animals' offspring to be cared for. Concrete timing of the grass cutting window depends on the local flora and fauna and it must be carefully considered by experts.
- late grazing at high stocking rates for a short period around the time of the one-per-season grass cut. This measure is easier to implement than mechanical cuttings, especially if the soil is wet or marshy or located on steep slopes. Moreover, short-term grazing increase sward heterogeneity, which increases plant and animal diversity.
- an early season cut (e.g. in May for lowlands) and a late season cut (e.g. in late September) that allows for plant flowering in the middle of summer and seed maturation in August and September.

Mixed management (grazing + cutting) has also been demonstrated to be preferable to grazing or cutting alone.

Animals used for pasturing:

- Cattle
- Horses
- Sheep
- Goats
- Pigs
- Poultry

Liming and fertilizing

The supply of nutrients for plants is increased when a substantial number of fertilizers are added to any environment. Fewer fast-growing plant species can compete for light in such conditions, resulting in the gradual elimination of less competitive plant species (Plantureux et al 2015). However, in nutrient-poor soils, only a few species are able to compete for these nutrients, resulting in low biodiversity and a reduction in ecosystem services in general so proper nutrient supply is to be determined for maximising biodiversity and ESS provision.

High fertilizer inputs cause changes in the chemical, biological and, indirectly, physical status of the soil. Plant biodiversity is believed to be reduced by nitrogen as it favours a few more competitive species. Potassium fertilisation, however, has a significantly lower biological effect (Plantureux et al. 2005).

The method of determining the best nutrition threshold levels for a given grassland GI area is a complex process and depends on the soil, climate and fertilizer type used. For newly established GI elements and agriculturally used grasslands, a soil analysis and fertilization plan are recommended.

Manure application affects grassland biodiversity by introducing nutrients, as well as by providing temporal mechanical soil coverage that favours litter-resistant species. Additionally, seeds from a few species with poor ecological value, such as broad-leaved dock (Rumex obtusifolius L.) and Umbelliferae are imported my manure and can slowly prevail in ecosystem (Plantureux et al. 2005).

Water regime regulation

Draining wet grasslands is ordinarily connected to the grassland use and all of the above-mentioned measures. When the soil water regime is changed, the plant coverage composition gradually changes (Plantureux et al. 2005).

Drainage of wet soils benefits earthworms, but it reduces soil penetrability for probing birds, and intensive grass growth in the spring reduces access to the soil surface for birds and other animals (Ausden et al., 2001).

Pesticides and anthelmintics

Most of the pesticides used in permanent grasslands are herbicides controlling forbs and broad-leaved weeds. Insecticides may be used to control soil-dwelling larvae, which are a grassland pest, but they may also serve as a food source for a range of farmland birds (McCracken et al., 1995).

The application of anthelmintic to control internal parasites of grazing animals is the most widespread use of chemicals in semi-natural environments. Residues are excreted in the dung of treated animals, and these residues may have a wider insecticidal effect on the ecosystem. This has an indirect influence on feeding resources for meadow dwelling birds and animals.

5 Management of wetlands

Wetlands are home to some of the most biologically diverse biotopes on earth due to the unique land and water characteristics found in marshy areas. However, wetland management serves several functions beyond feeding and sheltering wildlife biodiversity because wetlands:

- serve as floodwater storage and filters,
- helps prevent erosion during storms,
- provides natural resources and
- generates economic benefits through tourism and recreation.

Wetlands are delicate ecosystems that are susceptible to even subtle disturbances. Nutrient oversaturation can occur when stormwater runoff containing fertilizers, livestock waste, grass clippings and other pollutants enters a wetland ecosystem. This may lead to excessive algae blooms and fuel the growth of invasive plants (e.g.: Purple Loosestrife, Phragmites, Japanese knotweed, Flowering rush, Giant reed).

Invasive species mitigation

When invasive plant species take root in a wetland, they can quickly grow out of control, displacing native plants and animals. Invasive species are fast growing and, unlike native species, lack natural predators that could ensure the species' balance within the habitat.

The complete removal of an invasive species from a wetland habitat is possible, but it can take many years. From an environmental and financial standpoint, prevention is a much easier approach. As

part of an Integrated Management Plan, routine inspections and wetland surveys can help identify invasive species before they have a chance to thrive.

Control methods for invasive species:

- physical methods (e.g.: hand-pulling or cutting),
- mechanical methods: mechanical harvesting and cutting, surface and bottom tillage, weed rolling
- chemical methods: applying weed control chemicals (this is subject to the relevant legal, health and safety considerations)
- biological methods such as introducing herbivores, parasites and predators (extreme caution is needed to avoid causing additional problems with introduction of a new species)

Prevention of nutrient contamination

Practising strategies that prevent nutrient loading and sedimentation are important in the management and protection of wetlands. The establishment of stormwater management facilities in settlements and surrounding farmland is the first step in these efforts. Professional inspections of storm- and waste-water management facilities for cracks and corrosion should be performed once a year. It's important to consider the possible sources of blockades, such as leaves, twigs, grass and other organic materials.

Reducing fertilizer use in gardening and farming, which is a common source of excess nutrients, is beneficial. The introduction of swales and vegetative buffers zones can help keep fertilizers and eroded soil in the intended areas instead of polluting the stormwater runoff to wetlands.

Activity 2: Establishment and cate for tree-based GI elements

In this activity, participants are empowered with applicable knowledge on the management of tree-based GI elements in their local area. Measures from the establishment of new plantations to the care for elderly trees in historical GI elements are presented.

Appendix 1 contains an example of the presentation to be used in this activity. It focuses on Slovenian orchard meadows. For your region, a similar presentation should be prepared, focusing on local GI elements and their challenges.

Trees play an important role in many of GI elements. They grow and develop naturally, but they need to be properly managed in order to facilitate their ESS function. This is especially true for fruit-bearing trees in parks and orchard meadows.

1 Establishment of new tree-based GI elements

Young trees in newly established GI elements, as well as new trees in existing GI-elements, require planning, planting and care.

1.1 Selection and preparation of the area

New tree plantings must be approached with good preparation and adequate knowledge. Firstly, we must gather information on:

- macro- and micro-climate conditions,
- orientation and surface shape of the selected area,
- pedological traits, including soil analysis,
- landowner preferences and expectations.

We must avoid land depressions and other terrain irregularities that could aggravate mechanical work. Special care must be taken in the preparation of land to prevent erosion and waterlogging.

Further steps

Once the area is selected, we:

- decide on tree species and cultivar (for fruit species)
- order seedlings for planting,
- prepare a planting plan,
- make a fertilization plan,
- make an establishment and management time plan,
- order the needed materials for planting and
- prepare mechanisation and working equipment.

Handling with tree seedlings

To avoid causing damage to the seedlings, they should be properly protected during transport and handling. Tree seedlings should be planted as soon as possible after delivery. If direct planting is not possible, they can be stored for up to 48 hours. Seedlings should be kept hydrated and shielded from extreme cold or heat.

1.2 Planting plan

The height (and width) of trees, as well as their planting distance, are determined by the selected species growing habits. Additionally, the soil quality, terrain slope and future technical measures in the tree stand all influence the final planting distance.

The planting distances for the following fruit-bearing trees are:

- Apple (rootstock seedling): 7 - 9 m
- Pear (rootstock seedling): 6 - 8 m
- Cherry (rootstock seedling): 5 – 7 m
- Apricot: 4 – 5 m
- Sour cherry: 4 – 5 m
- Plum: 4 – 5 m
- Mulberry: 7 – 9 m
- Walnut: 8 – 9 m
- Chestnut: 8 – 9 m

Fruit tree cultivars can be planted on weaker growing rootstocks, resulting in a smaller final canopy size, and planting distances should be reduced accordingly.

If possible, the new plantation's rows should be oriented north to south. Alternatively, a planting plan can be formed according to the slope, size and form of the area. A planting plan must be created prior to ordering materials and seedlings so that exact number of seedlings can be estimated.

Marking locations of trees

To perform distance measurements and marking of tree locations, at least two persons are required, as well as the following equipment:

- measuring tapes and ropes,
- rods or poles,
- distance measuring bar,
- labels and other materials.

Rods are used to mark the planting sites and serve as tree support after the trees have been planted.

Preparation of planting pits

If the terrain allows, the planting pits can be dug mechanically in the autumn, when the weather is dry and at least a few weeks prior to planting. The planting pit should be 1 m wide and 50 to 60 cm deep. Before planting, mineral fertilizers can be added if the soil analysis results and tree species requirements are not balanced.

If the pits are dug manually, the topsoil (0 – 20 cm) should be stored separately and the subsoil and topsoil should be mixed until the pit is filled up. If the land has been deep-ploughed and the soil is homogeneous, we will need a smaller pit - about the size of a root system of planted trees.

Material per planting pit:

- support pole - about 2,5 m high rod,
- mineral fertilizer if required,
- manure or other organic fertilizer: 20 – 30 kg,
- wired mesh against European water vole.

1.3 Planting

Planting should be performed in the autumn, before the first frost. For good stability, the support rod should be buried 50 – 70 cm deep in the soil. The support rod is placed on the south side of the seedling or on the upper side of the slope. A wired mesh should be placed at the bottom of the pit and the inside should be filled with good topsoil. The seedling with shortened roots should be put in the mesh at a distance of 5 – 10 cm from the support rod. Once the soil settles, the grafting point should be 10 to 15 cm above the ground. We gently shake the seedling and press the soil with feeds to ensure that the roots come into contact with the soil. The rest of the soil should be added to the sides of the pit. We add manure or other organic fertilizer to the sides of the pit and on top of the soil. Manure should not be placed in the bottom of the pit or in direct contact with the seedling roots. The soil should be shaped like a funnel around the seedling, so that water seeps to the soil around the tree. The seedlings should be tied to the support rod after they have been planted.

When planting trees on a slope, it is better to put them on a small terrace, or plateau, so that water does not run down the sides of the seedling and wash away the nutrients. To make a water barrier, some of the soil from the pit should be placed on the pit's downward-directed side.

Irrigation

After planting, we must water the plants and monitor the rainfall. If a drought occurs, seedlings must be irrigated extensively. The water quantity depends on the soil type and ranges from 30 to 50 L per m^2. Irrigation is best performed in the morning and done carefully to prevent nutrient leaching. Irrigation is especially important when trees are planted in the spring prior to the growing season.

When seedlings are well rooted and the soil has settled, the newly planted area can be levelled.

Seedling protection

Tree seedlings must be protected from the start. Domestic grazing animals, as well as rabbits, deer and other wildlife can cause significant damage. Therefore, a high fence around the individual trees or entire plantation must be built. The height of the fence depends on the species and population of present animals that could cause damage to trees.

1.4 Young tree training

Trees must be cared for after they are planted in order to form a proper canopy. The number of secondary shoots and the quality of the seedling determine the first steps after planting.

The height of a tree trunk depends on the tree species and planned future activities in the plantation. Basic tree frame branches of young trees should be grown as soon as possible. Branches are best grown in a 45° open corner from the trunk. Thus, they are stable under the weight of fruit or snow or in heavy wind and don't cause trunk-branch cracks as they grow thicker.

Every year, 2-3 evenly spaced shoots are chosen to serve as frame branches. If the shoots are too weak, we shorten them to "a plugs" in order for them to grow strong from the remaining buds. If the shoots are too strong or growing too vertically, we remove them completely. We consider lighting conditions when choosing shoots for frame branches so that branches do not overlap and shadow one another. By the time a tree reaches full size, it should have 5-7 spirally arranged and well-lighted frame branches. The lower frame branches are stronger, while the upper ones are kept weaker to form a pyramidal canopy structure that assures good lighting.

Example of tree training over time

2 Basics of tree pruning

Most GI elements include trees, which need special attention. Through pruning, we influence the growth of the tree, regulate its fertility over time, ensure uniform size and health, reduce the risk of diseases and pests, rejuvenate the tree and prevent decay and of course, form the canopy.

Goals of pruning

- to form tree canopies according to our needs,
- maintain a canopy,
- assure good lighting of all frame branches,
- to keep trees vital and healthy,
- stimulating or inhibiting tree growth with different time and intensity of pruning,
- care for tree health,
- rejuvenation of trees,
- to perform regular fruiting and good quality fruits on fruit-baring trees.

Time of Pruning

Trees can be pruned throughout the growing season. Pruning at different times of the year has different effects on tree physiology:

Time	Pruning goal
Spring pruning	tree lighting improvements, thinning of branches
Pruning at the time of flowering	thinning of flowers
June pruning	thinning of fruitlets, cutting of treetops
August Pruning	improve branch lighting, growth potential suppressing
Pruning after harvesting	weakening of growth

Different pruning times are important from the standpoint of work organisation. This way, we will be able to prune more trees, achieve a better effect, and cause less stress to trees.

The time and intensity of pruning are always adjusted to the growth potential and growth exuberance of the tree. We prune more intensively in years when the trees have larger flower sets. In years when the trees do not have a flower set, we prune minimally to avoid encouraging vegetative growth. Thus, in the spring, weaker trees are pruned more intensively, while exuberant trees are pruned in the autumn.

Pruning at different tree life stages

Pruning intensity is adapted according to the physiology of the tree in different stage of its life.

- in its youth, the aim of pruning is to shape the tree and achieve rapid attainment of target canopy volume and entry into fertility,
- during the adult or fertility period, the aim is to maintain tree health as long as possible,
- in eldered trees, the aim is to revive trees to keep them in good shape and production.

Tree production periods	Pruning intensity
juvenile (1-7 years), strong growth, low fertility,	minimal pruning
initial fertility (7-12 years), moderate growth and fertility	moderate to intense pruning
ageing of trees (30- 50 years), minimal growth, moderate - alternating fertility.	more intense cutting

2.1 Understanding the laws of growth

It is important to understand how newly planted trees grow and respond to applied treatments. The concepts of tree growth are presented below. However, talent, rich experiences and good observation skills are needed for proper tree growth steering.

Rules determining the growth of branches on a tree

1. Rule - A branch growing vertically or at a steep angle has more growing lush than one with an open-angle. A horizontal or downward-curved shoot start bearing faster and more intensive.

2. Rule - Two equally thick branches growing at the same height and angle have equal strength.

3. Rule - The branch at a higher position grows faster and stronger.

4. Rule - The greater the diameter of the branch, the stronger it grows.

5. Rule - The branch with more secondary shoots grows stronger.

6. Rule - The branch closest to the tree's trunk grows stronger.

7. Rule - The branch that has a smaller angle to the trunk grows stronger.

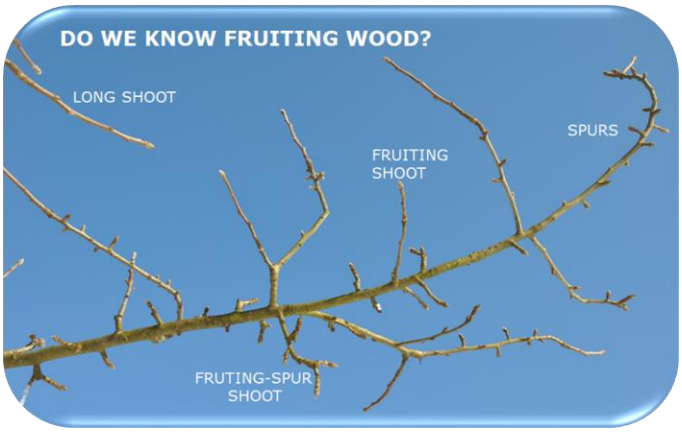
8. Rule – The more we cut a tree, the more it grows. This is especially true for winter and spring pruning.

9. Rule – Vegetative growth is limited by fruits (fertility). Fruit-bearing and vegetative growth are in direct opposition to one another and compete for resources.

10. Rule – The shoot is more likely to set more flowers if it is not shortened. The more the shoot is cut short, the more it is promoted in vegetative growth.

Different wood types

Recognising different wood types is the basis for proper pruning and cutting of trees.



- long shoot,
- spurs,
- fruiting,
- shoot,
- fruiting-spur and
- shoot.

Other tree wood types:

- water sprouts and suckers - these are useless shoots that are densifying the canopy and need to be removed,
- old and diseased wood and
- old fruit cakes and bourse shoot.

2.2 Pruning

The purpose of the GI-element trees determines the particular aim of tree pruning. Prior to pruning, we define the target shape of the canopy of the selected tree species and how we want to influence tree growth.

Tree canopy evaluation

Prior to pruning we take a look at the tree and evaluate the following:

- Growth of shoots and branches. Are they upright or drooping, what is the growth characteristic of the plant species and cultivar?
- Growth potential or exuberance of the tree. What is the length of one-year shoots?
- Light penetration in the canopy. Are branches too thick and bushy?
- Overall tree volume.
- Present year flowering intensity and fruiting potential.
- Health status of the tree. Is there an excess of moss and lichen growth? Are pests and diseasespresent?

Wide-open tree canopy

Upright main branches

Strong branches

Back-cut downward growing branches

Photos: Jani Gačnik

What to prune?

The following parts are removed first while pruning:

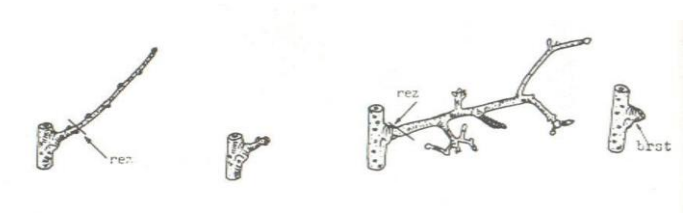
- dead branches and woody parts,
- broken and rubbing-damaged branches,
- crossed branches,
- vertical growing branches and shoots that are growing too upright.

Pruning techniques

Different techniques may be used depending on the pruning aims and tree development status:

- cutting out of branches for lighting and thinning of the canopy,
- cutting shoots at the base to remove water shoots,
- shortening of shoots,
- “drainage” of upright shoots on sideward growing buds and spurs to direct growth,
- cutting on a short or long “plug” or “ring” or
- cutting out hanging branches.

Cut on the plug *Cut on the ring*



2.3 Pruning equipment and work safety

We strive to make as many cuts from the ground as possible while pruning tall trees, avoiding climbing trees and ladders. For this purpose, telescopic saws and telescopic and extended-reach scissors are used. Working on branches higher than the operator’s head necessitates paying close attention to dropping pieces.

However, since tree-tops and thick branches are not always reachable, climbing is often necessary. Then additional precautions for protection and safety must be taken. Folding ladders are of great help, but they should be as stable as possible and properly placed prior to climbing. Safety belts and ropes should be used.

Protection gear:

- helmet and goggles,
- gloves for strengthened hand protection,
- working clothes and
- appropriate safety working shoes or boots.

It is recommended that at least two people work on the pruning job for the purposes of splitting work assignments, encouragement and safety reasons.

3 Rejuvenation pruning of older trees

Many GI landscape elements have trees that are neglected and do not exhibit sufficient vitality to perform the expected ESS. They had not been pruned for a long time and the canopy had become thickened with drooping branches and/or too many vertical shoots.

The aim of rejuvenating pruning is to achieve good light penetration into the frame branches, remove old and damaged branches and encourage the trees to grow more intensively.

The following parts are removed from older and aged trees:

- too dense branches in the upper and middle part of the canopy to permit light penetration to the lower parts of the canopy,
- drooping and degenerated branches to direct growth to more upright and vital shoots,
- dry, sick and diseased parts of a tree,
- parts with parasites are removed (e.g.: white mistletoe, ivy, Clematis) and
- branches grooving at a too small angle to the trunk or at the base of the frame branches.

It is important to adjust the pruning intensity to the growth potential and condition of the individual tree and its flower set in the current year.

Corrective pruning

Rejuvenating a tree is a significant intervention and it is not recommended to prune a tree too rigorously in a single year. After the first rejuvenating pruning, corrective pruning is usually done 2-3 years later. Its timing and intensity depend on the tree's response to the applied measures. Thick and upright growing shoots are removed during corrective pruning and canopy top corrections are made.

Rejuvenating pruning is necessary every several years to ensure the vitality of trees for a longer period of time.

3.1 Common pruning mistakes

The most common mistakes are:

- lack of pruning,
- excessive cutting (creating so called living sculptures),
- incorrect selection of branches and shoots to remove (causing canopy to become unstable and non-functional) and
- neglecting the removal of Common ivy, Mistletoe and Clematis.

Tree training mistakes

If trees are not pruned when they are young and developing, they will grow several leaders. Especially walnut trees have a naturally spreading canopy and will produce strong lateral branches and a weak central leader if they are not pruned.

Missed pruning in spring and June may result in over-fruiting especially in years with intensive flowering. Fruit-loaded branches may bend too far down or even break under the weight of fruits.

Someone cut the tree without regard, sense of responsibility, knowledge or feeling. Despite its doom, the tree continues to struggle and grow.

Appendix WP4_D.T4.2.2: Rejuvenation of orchards meadows

In the appendix a complete lesson prepared and executed by Janez Gačnik from the Zavod Jabolko is presented. The lecture covers all of the orchard meadows management relevant topics.

These slides can be used directly or as a source of idea for the preparation of lectures on local GI element management.

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