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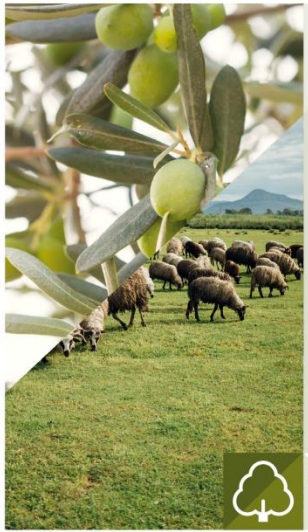

Module 2 for LL2, Agroforestry for Grazed Woodlands
Course 3 – Advantages of agroforestry for grazed woodlands

Chapter 3 - Effect of Agroforestry on the Biodiversity of Grazed Woodlands

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Biological diversity or biodiversity, the result of 3.5 billion years of evolution, plays a vital role in sustaining human life and the health of our planet.

Used as a natural resource management strategy, agroforestry sustains biodiversity by in situ conservation of tree species, reduction of pressure on the forest, and maintenance of a suitable habitat for plants and animals.

Introduction

Grazing and browsing by large herbivores are natural features of woodland ecosystems. Grazing management should be considered from the outset by managers of semi-natural and native woods.

Agroforestry is all about breaking down the wall between agricultural lands and woodlands and blending them together. It's a way of thinking creatively across a landscape.

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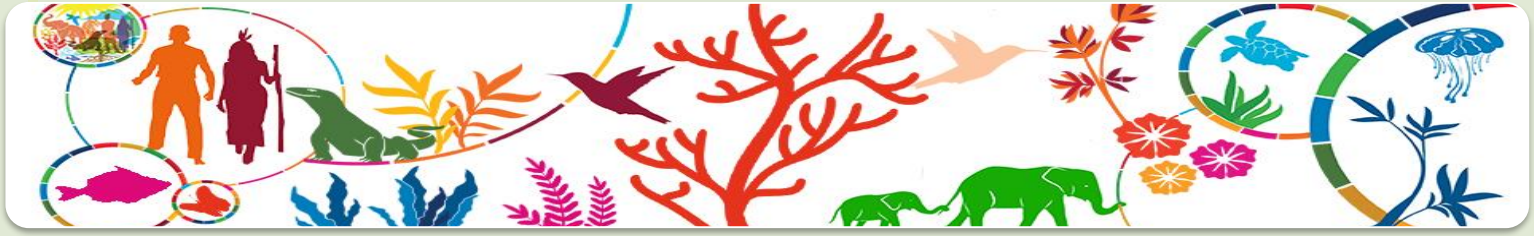
I. Biodiversity



The term means *biological diversity* and refers to all the variety of life. Whether that's plants, animals, fungi or micro-organisms. As well as to the eco-systems they form and the habitats in which they live.

Biological diversity comprises three levels: Species diversity: the variety of different species; Genetic diversity: the variety of genes contained in plants, animals, fungi and micro-organisms; and ecosystem diversity: all the different habitats that exist.[1]

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I.1. Benefits of biodiversity for the ecosystem

- Regulates elements such as climate, water quality, disease, and pollination
- Provides resources such as food, clean water, industrial raw materials, and genetic resources
- Offers cultural advantages, including recreational, aesthetic, and spiritual benefits

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I.2. Threats to biodiversity

- Climate change
- Habitat degradation and loss
- Pollution
- Invasive species
- Overexploitation with traditional agricultural systems
- Other potential threats

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I.3. The EU's biodiversity strategy for 2030

Protecting the natural world we have will not be enough to bring nature back into our lives. To reverse biodiversity loss, the world needs more ambitious natural restoration. With a new European Union (EU) Nature Restoration Plan, Europe will lead the way.

The European Commission proposed a dedicated **EU Forest Strategy** in 2021 in line with our wider biodiversity and climate neutrality goals. It includes a roadmap for **planting at least 3 billion additional trees in the EU by 2030**, with full respect for ecological principles. The uptake of agroforestry support measures under rural development should be increased, as it has great potential to provide multiple benefits for biodiversity, people and the climate.[2]

Based on this strategy, it is obvious that land use practices such as agroforestry, as part of a multifunctional landscape, will continue to play a major role in conserving and even enhancing biodiversity.

II. Agroforestry: "Landscapes that work for biodiversity"

- When managed using biodiversity-based techniques such as agroforestry, silvopastoralism, diversified farming, and ecosystem-based forest management can help maintain biodiversity and provide **habitat connectivity** by facilitating the movement of animals, seeds and pollen.
- Without these tree-based systems, forest fragments stay isolated from each other or from larger forest protected areas. The agroforestry systems make significant contributions to the connectivity for forest biodiversity in the fragmented landscapes when considered as corridors between forest patches, or as buffer zones around protected forest areas [19].
- These socioeconomic systems can facilitate **functional connectivity,** which is the movement of organisms across the landscape and among habitat patches. Such movement promotes population persistence by allowing for gene flow, recolonization, and adaptation to climate change and other global changes.

II. Agroforestry: "Landscapes that work for biodiversity"

- Agroforestry has conservation implications, it maintains tree species diversity in agricultural landscape outside natural habitats such as forest or protected areas.
- This conservation tool is important where natural forests have declined and remaining fragments are degraded.[4]
- Conservation of trees in agroforestry system can **complement protected areas** and provide greater resilience in the face of climate change.

II. Agroforestry: “Landscapes that work for biodiversity”

- We cannot rely on protected areas alone to preserve species. As protected areas become increasingly isolated because of habitat loss and degradation, much research has revealed that they will lose species over time.
- Working lands can provide food, breeding sites, and shelter for a myriad of species while maintaining abiotic conditions, including temperature, light, wind, water, fire, and other disturbances, within required ranges.[3]

III. Agroforesty for biodiversity conservation and food supply

- Conservation
- Sustainable Use
- Food Supply

III.1. Agroforesty contributes to conservation and to the sustainable use of biodiversity

To understand how agroforestry systems contribute to conservation and sustainable use, we need to understand the definitions of these words.

Conservation	Careful preservation and protection of something, especially planned management of a natural resource to prevent neglect, over-exploitation or even destruction and to achieve a sustainable exploitation[18].
Sustainable use	"'Sustainable use' means the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations."[1]

III.1.1. How does agroforesty conserve the biodiversity of grazed woodlands?

In general, agroforestry plays five major roles in conserving biodiversity:[4]

- Provides habitat for species that can tolerate a certain level of disturbance
- Helps preserve the germplasm of sensitive species
- Helps reduce the rates of conversion of natural habitats by providing a more productive, sustainable alternative to traditional agricultural systems that may involve clearing natural habitats
- Provides connectivity by creating corridors between habitat remnants, which may support the integrity of these remnants and the conservation of area-sensitive floral and faunal species
- Helps conserve biological diversity by providing other ecosystem services such as erosion control and water recharge, thereby preventing the degradation and loss of surrounding habitat

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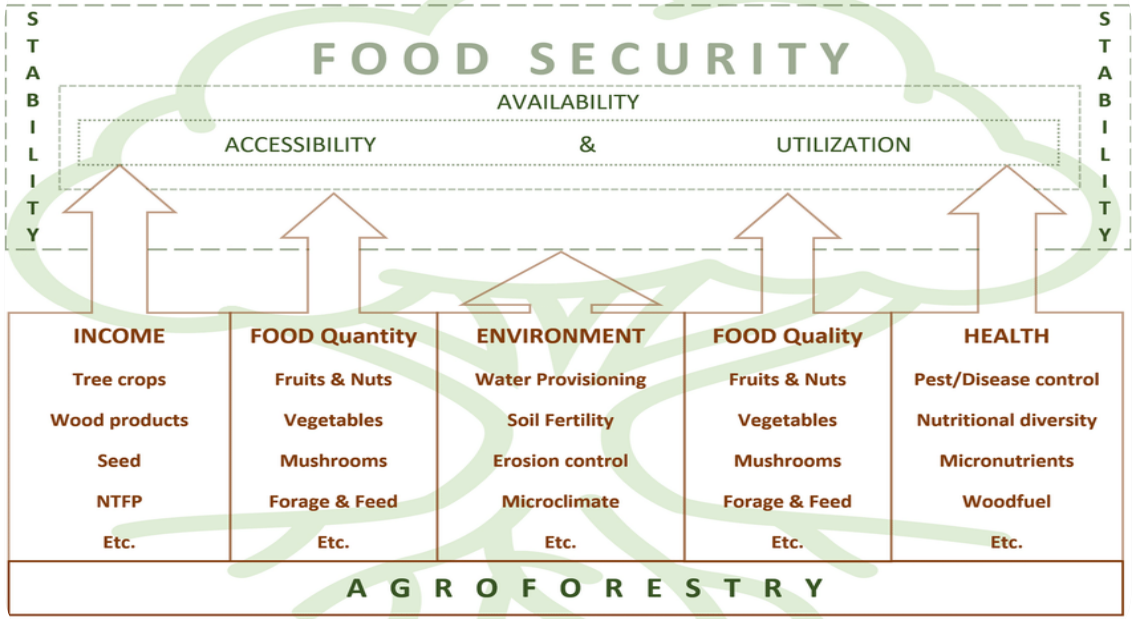
III.2. Agroforesty influences food and nutrition security in three ways:[6]



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III.2. Agroforesty influences food and nutrition security in three ways[6]

1. Availability

- Agroforestry significantly increases food availability by **supporting crop production.**
- **A diverse variety of locally available trees** has great potential to fill nutrition gaps and contribute to nutrient adequacy in poor rural communities. Trees offer an underexploited opportunity to improve nutrition: direct consumption of tree foods.
- Leguminous fodder plants or shrubs increase crop or livestock product yields due to the increase in soil nitrogen after the planting of legumes or certain other intercropped plants.

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III.2. Agroforesty influences food and nutrition security in three ways[6]

2. Access

- Agroforestry contributes to increased access to food.
- Agroforestry helps give households enough resources to obtain food in sufficient quantity, quality and diversity for a nutritious diet.

III.2. Agroforesty influences food and nutrition security in three ways[6]

3. Utilization

Agroforestry helps compensate for seasonality in at least two ways:

1. Planting a **diversity** of trees with different harvest times can address month-on-month fruit availability and micronutrient gaps in local households' diets. This can also create greater resilience in food systems by spreading the risk of crop failure over time.

2. The deep and extensive root systems of trees make them more drought tolerant than annual crops, meaning they can provide food for humans and livestock in dry periods when other sources are not available.

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IV.1. The influence of agroforestry on floristic diversity: positive impact

- Agroforestry systems enhance native floristic diversity. They harbor a much higher species richness and diversity than monoculture cropping systems.
- Agroforestry can serve as an important ecological tool for conserving tree species diversity.
- Some species in these systems could be of special interest for conservation, if they are among the Red List of Threatened Species according to The International Union for Conservation of Nature IUCN.
- Suitable native species selection is a challenge in farm forestry or restoration forestry projects.
- Indigenous knowledge is invaluable in selecting native species, as the local population is likely to be aware of the varying functions of trees in their landscape.[7]

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IV.1. The influence of agroforestry on floristic diversity: positive impact

- Indigenous mixed species plantations harbor a diverse mix of understory plant species.
- Several years after the establishment of such plantations in one agroforestry system, species richness increased by 24%, and the number of families represented increased by 48%.
- These species enhanced habitats on degraded sites and thereby helped to recover biodiversity.[7]

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IV.1. The influence of agroforestry on floristic diversity: positive impact

- Two main aspects influence the role of agroforests in biodiversity conservation. First, the species and structural composition of plants in agroforests and second, the degree of management intensity and human disturbance in these systems.

- Agroforestry systems that contain a species and structural composition similar to native forests can be part of a broader regional biodiversity conservation strategy, and potentially serve as buffer zones or ecological corridors.[8]

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IV.1. The influence of agroforestry on floristic diversity: positive impact

- "Buffer zones are defined as areas peripheral to a protected resource designated with the intention of benefiting the local community, while simultaneously providing an extra layer of protection to a conservation area" (Lynagh and Urich 2002, Oldfield 1988).
- An ecological corridor, is a functional zone of passage of species between several natural zones in environments that have been disturbed.

IV.2. The influence of agroforestry on floristic diversity: negative impact on flora

- Deliberate species selection is evident in agroforestry in order to meet the demand for wood, food, fuel, and fodder in many parts of the world.

- This can lead to **invasion by non-native species** that change habitat composition and structure around the world. **This is the second most significant threat to biodiversity, after habitat loss.**[7]

IV.3. Maintaining plant species richness by grazing in woodlands

- Numerous studies have reported positive effects of grazing and mowing on plant species richness in Europe.
- Many plant species are threatened due to the cessation of grazing and mowing. This also suggests that grazing and mowing are important for maintaining plant species richness.[10]
- Controlled grazing can not only enhance biodiversity but also be used as a management tool to encourage tree **regeneration**. Some species of high conservation importance, such as the pearl-bordered fritillary and the marsh fritillary (butterfly), require controlled grazing in their habitats for survival.
- Biodiversity can be enhanced by maintaining open habitats, **reducing over dominant or invasive plant species**, and maintaining woodland plant communities.

Grazing animals can affect an ecosystem through defoliation, treading and leaving excreta[17]

Defoliation

- Defoliation is defined as a widespread loss of leaves. There are many things that can cause this, such as grazing animals.

- Effect of Grazing depends on how it is managed.

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Grazing animals can affect an ecosystem through defoliation, treading and leaving excreta[17]

To manage grazing and browsing and protect the range resources, managers should:

- Observe signs that the range is being overused, presence or absence of seedlings.
- Rest species periodically, but not at the same time every year.
- Timing of grazing: The most critical grazing period is usually from flowering to seed production.
- Leave enough residual forage ungrazed to keep plants healthy and to capture rainfall.

Grazing animals can affect an ecosystem through defoliation, treading and leaving excreta[17]

- To manage grazing and browsing and protect the range resources, managers should:
- Note when the more palatable key species start to show overuse. Grazing and browsing animals are selective: They graze or browse the most palatable forage species first and often. If the more palatable species are overused and disappear, the plant species that survive will be those that can best resist grazing.

Grazing animals can affect an ecosystem through defoliation, treading and leaving excreta[17]

Treading

Creates gaps in the sward, thus allowing seeds to sprout, which in effect speeds up the growth of grasses, and eventually prevents soil erosion.

Grazing animals can affect an ecosystem through defoliation, treading and leaving excreta[17]

Animal manure

- The excreta produced by herbivores during grazing act as a natural fertilizer and influence seed distribution.
- The dispersal of faeces results in species and structural diversity of flora.

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❖ Biodiversity in silvopastoralism across Europe[11]

- A cycle of grazing in the forest may encourage optimum botanical diversity and regeneration.
- A crucial factor affecting the dynamic and health of the system is the stocking rate (animal units per unit of land area).
- Horses are valued for their ability to control encroaching tall grass vegetation in the Netherlands and in France, helping to prevent forest fires.
- In the Alps, 15% of the mountain forests are grazed in the summer. Grazed forests have a more heterogeneous structure and less density than ungrazed forests.

❖ Biodiversity in silvopastoralism across Europe[11]

- With no intervention trees are intensive and old with little light reaching the floor.
- Species cannot easily regenerate under these conditions and decline in abundance.
- Browsing animals contribute to open conditions, where more seedlings grow faster and the structure of the habitat will not be only large trees.
- Grazing reduces vigorous, unwanted species such as bramble and bracken.
- "Their vigorous growth habit can make a troublesome weed in some woodland, as they can prevent newly germinating tree seedlings from establishing, rapidly invade new areas, kill existing regeneration",(Harmer, 2004).

V. The effect of agroforestry on the biodiversity of grazed woodlands: fauna richness

- Agroforestry takes advantage of physical and biological **interactions** among crops, animals, and trees. A synergy is created when **different aspects of the environment complement each other**. Trees provide wildlife habitat, and the wildlife in turn keeps pests under control.

- Large trees provide room for birds, bats, and other species to find food and establish nests where they otherwise wouldn't be able to.

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V. The effect of agroforestry on the biodiversity of grazed woodlands: fauna richness

Agroforestry can increase pollinator diversity, which is essential for food production and maintenance of wild plants' population levels. The pollinator service is invaluable, because

- ~90% of flowering plants are pollinated by insects
- over 75% of the world's most important crops depend on animal pollination
- 35% of food production depends on animal pollination[3]

Photo credit: Dr. Peter Moubarak

V. The effect of agroforestry on the biodiversity of grazed woodlands: fauna richness

Biodiversity is enhanced by corridors for the movement of species that grazed woodlands provide.

Agroforestry systems have more invertebrate species and numbers compared to open grasslands,

as well as more arthropod groups and birds.

Photo credit: Dr. Peter Moubarak

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V.1. Insect diversity[12]

- Combining pastures with trees creates a diversity of microclimates that increases **insect diversity**.
- Because of their great diversity and sensitivity to disturbance, insects have been commonly used as bio-indicators in both silvopastoral and monocultural systems.
- Abundance, richness and diversity of insects were assessed in a study, which found Hemiptera the most abundant order, followed by Hymenoptera, Diptera and Coleoptera.

V.1. Insect diversity[12]

- Hemiptera: Aphids, assassin bugs, leaf hoppers
- Hymenoptera: Bees, wasps, ants
- Diptera: All flies, including syrphids
- Coleoptera: All beetles including lady beetles, leaf beetles, soldier beetles

V.1. Insect diversity[12]

- Study results show changes in the abundance and species richness of several insect orders, as well as changes in **community composition**, even though no differences were observed in overall insect abundance, richness or diversity.
- Compositional changes are from generalist to specialist insect species—that is, agroforestry resulted in more specialist insects.
- High numbers of natural enemies and beneficial insects.

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V.1. Insect diversity[12]

- Silvopastoral system provided microhabitats, greater protection from predators, and increased availability and diversity of food resources and nesting substrates.
- Insects have diverse functional roles in agroecosystems as phytophagous (that feed on green plant), predators (animals that eat other animals), detritivores (that feeds on dead and decomposing organic matter.), and pollinators.

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V.1. Insect diversity[12]

The sustainability of pastures depends on organisms that play important roles in maintaining ecological systems, including insects. Since agroforestry helps increase the number of beneficial organisms, measures should be taken to encourage the implementation of silvopastures on a larger scale.

V.2. Dung beetles[13]

A scientific study compared treeless improved pastures (IP) with those that had been converted into silvopastoral systems (SPS) in a cattle ranching landscape in the Colombian Andes.

The study evaluated the recovery of some of the ecological services in which dung beetle insects play a role, in natural and anthropogenic (human-influenced) ecosystems.

Dung beetles are used as indicators of land-use change and pasture health.

V.2. Dung beetles[13]

Dung beetles are critical to a wide variety of ecological processes :

- Incorporation of organic matter into the soil
- Mixing of the different soil layers
- Control of parasites that harm domestic animals and human health. Because of their strong dependence on vertebrate excrement, particularly that of mammals, for feeding and reproduction, beetles dries manure rapidly, leading to parasite death
- Secondary dispersal of seeds

V.2. Dung beetles[13]

- This study suggests that over a relatively short period of time (5 years), the conversion of treeless improved pastures (IP) into silvopastoral systems (SPS) favours the recovery of dung beetle activity.

- Increase in dung removal and, consequently, greater soil and seed removal were apparent in the SPS, whereas the abundance of dung flies and particularly their larvae was lower compared with the treeless IP.

V.2. Dung beetles[13]

Another outcome of greater dung removal in silvopastoral systems is the increase in the number of seeds buried by the beetles. The spatial relocation of seeds often favours germination and seedling emergence by reducing predation and reducing mortality caused by pathogens. This also could favour the recovery of areas too deteriorated for grazing.

V.3. Birds[14]

- Agroforestry systems have conservation value because they support more biodiversity than unshaded agroecosystems.
- Shady areas provide a high quality habitat for migrating birds.
- The use of forests by birds in agroforestry systems is influenced by structural habitat features, including shade cover, canopy height, and tree density.
- Managing for floristic diversity will increase the variety of food resources (e.g., insects, seeds, nectar, and fruit) available to wildlife using shady plantations. The energy available in fruits has been shown to influence the species richness of bird communities.
- Agroforestry plantations can be managed so they offer structural and floristic characteristics that promote conservation and reduce the likelihood of deforestation by providing a habitat for numerous species and creating a hospitable landscape.

V.4. Iberian lynx[15]

Just 20 years ago, Spain's Iberian lynx was at risk of extinction. Now its numbers have jumped tenfold, with 1,100 Iberian lynx living in the wild. The cat's fortune has changed due to a combination of EU legislation and LIFE projects involving conservation enhancement and land management.

- Developing ecological corridors that help wildlife like the lynx move around and breed in newly connected habitats
- Creating natural feeding conditions for the Iberian lynx by sowing 60 hectares of pastures
- Improving their natural refuge by planting 3,200 trees and bushes (creating an agroforestry system)

This success story shows how important EU laws are for enhancing Europe's biodiversity. The International Union for Conservation of Nature (IUCN) has lowered the Iberian lynx's threat category from "critically endangered" to "endangered."

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VI. Farmer's management that does not support biodiversity of agroforestry system [16]

- Agroforestry system is a **human intervention**
- Some farmers choose to exclude particular trees and plants that would attract monkeys, birds or insects for fear of damage to their crops.
- Plants which do not produce anything deemed valuable or useful for people, are excluded.

VI. Farmer's management that does not support biodiversity of agroforestry system [16]

- Farmers hunt animals that thrive in agroforestry systems because Wild meat requires little to no management and can be an alternative to domesticated livestock, providing nutritious food and additional income for them.

So some farmer's management will not support biodiversity. However, properly managed agroforestry can benefit both biodiversity and farmers.

VII. Soil biodiversity[4]

- Soils are multifunctional: they are important for primary productivity, carbon sequestration, nutrient storage and regulation, water storage and cycling, and as a habitat that enables biodiversity.
- A higher diversity of soil microorganisms has been observed in agroforestry systems than in conventional agricultural systems.
- Agroforestry systems tend to have a higher abundance of earthworms, beetles, centipedes, millipedes, termites, ants, collembola, mites, and non-parasitic nematodes than monocultures; the only group that had a higher abundance in monoculture was parasitic nematodes.

VII. Soil biodiversity[4]

- These organisms(except parasitic nematodes) fulfill various functions, like allowing the soil to absorb processed organic matter such as leaves, wood, trunks and branches and with this nourishing crops; they also maintain an ecological balance capable of preventing the invasion of pests and provide greater fertility without using chemicals.

VII. Soil biodiversity[4]

Most studies have found that agroforestry (AF) has a positive effect on soil fauna abundance and/or diversity in temperate climates.

- Differences in soil biota diversity and abundance can be attributed partly to the increased plant diversity in AF systems compared to monocultures in conventional systems, since plant diversity is linked to microbial diversity in soil.
- For example, higher soil invertebrate diversity is found near the trees compared to the alleys, due to a great diversity of leaf litter resulting in substantial organic matter accumulation.

VII. Soil biodiversity[4]

- Among the soil microorganisms, **the fungi** are exceptional for their heterotrophic activity for organic matter decomposition and their potential as biological control agents of nematodes and arthropods. They are also associated with most plant species in symbiotic (mycorrhiza) or parasitic (diseases) relationships.
- A comparison of three land use practices (forest, agroforestry and monoculture systems) showed that the structure of the soil mycobiota in forestry and agroforestry were more than 50% similar. This similarity of the structure and composition of soil mycobiota was mainly due to the rich plant diversity in agroforestry.
- In general, forest soil presented the highest ecological indices of diversity, species richness, equitability, dominance, similarity and density, followed by agroforestry (Costa et al).

VII. Microbial soil biodiversity[4]

- The combination of trees, crops and grazing in woodlands enhances the growth of arbuscular mycorrhizal fungi, which enhances litter decomposition, making **more nutrients available to plants**.

- Evaluation of the arbuscular mycorrhizal fungal community measured by spores in agroforestry systems in comparison with natural forests shows that with the exception of one species exclusive to the forest, the agroforestry systems all shared the same arbuscular mycorrhizal fungi species as the forest (Arias et al).

Conclusion

- **Better landscape planning and management** that seek to avoid the ecological and social consequences of biodiversity loss may offer better preservation and enhancement of biodiversity.

- **Biodiversity is essential for the processes that support all life on Earth, including humans**. Without a wide range of animals, plants and microorganisms, we cannot have healthy ecosystems.

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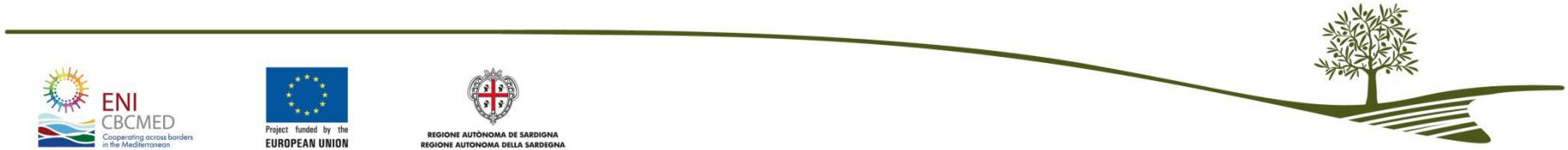

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