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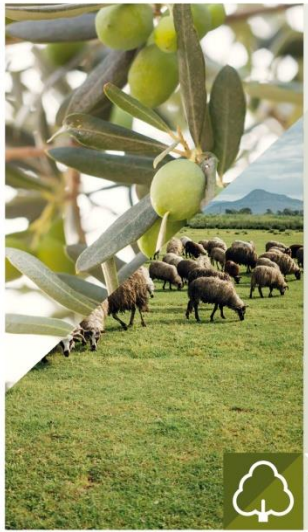

Module 1 – Agroforestry for Oliviculture
Course 3 – Agroforestry as a tool to manage olive pests and diseases

Chapter 1 – The Effect of Agroforestry on Biodiversity

By Zinette Moussa, Agricultural Engineer
Lebanese Agricultural Research Institute (LARI)

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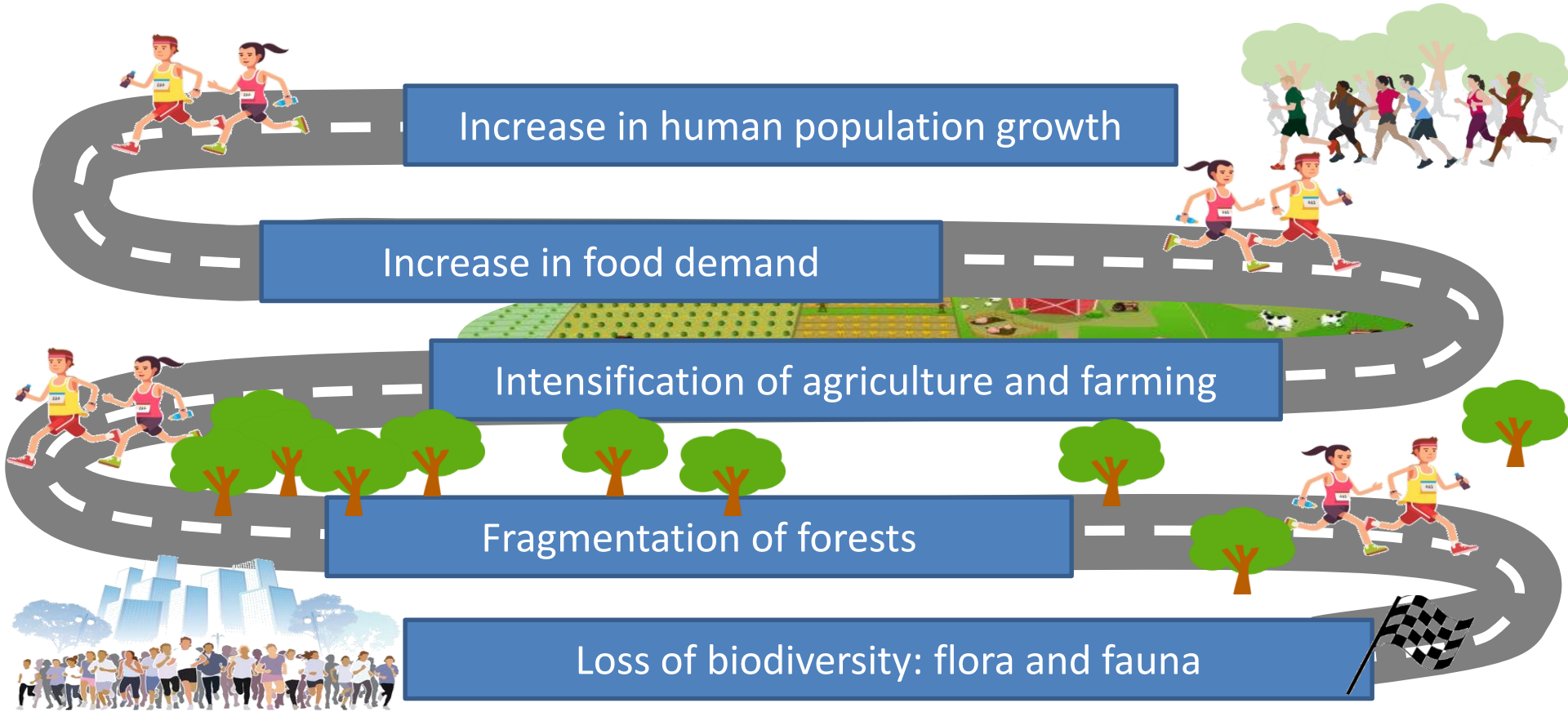
How Does Agriculture Affect Biodiversity and Ecosystem Services?

The increase in human population growth and in the demand for food has led to the intensification of agriculture, causing

- Fragmentation of forests
- Loss of biodiversity
- Increasing pest survival and increasing use of pesticides
- Reduction of suitable habitats, which disrupts the ecosystem services (processes of natural systems that benefit humans) important to agriculture, such as pollination and biological control of pests (pest control using their natural enemies)

How Does Agriculture Affect Biodiversity and Ecosystem Services?



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How Does Agriculture Affect Biodiversity and Ecosystem Services?

Since the 1960s and the 'Green Revolution':

Global Population went UP

Farming Yields went UP

This was due to the introduction of:

- **New Seed Types** (e.g. higher-yielding varieties of rice and wheat)
- **Farm Mechanisation** (e.g. tractors and combine harvesters)
- **Chemical Fertilisers** (i.e. synthetic compounds added to soil to provide plant nutrients)
- **Pesticides** (i.e. substances used to kill pests or weeds)

HEALTH & ENVIRONMENT CONCERNS

- Some of the chemicals used in pesticides are toxic for humans and animals
- Pesticides can reach destinations other than their target. They can contaminate (ground) water, air and soil
- Pesticides cause a loss of species that are needed to pollinate plants, like honey bees

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SOURCES: European Commission, Food and Agriculture Organization, United Nations, World Health Organization, June 2017.

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How Does Agriculture Affect Biodiversity and Ecosystem Services?

Chemicals are not ECOLOGICALLY SUSTAINABLE!

While pesticides and fertilizers help farmers grow food intensively, they can have short-term toxic effects on many wildlife species, including mammals, earthworms, natural enemies of pests, and pollinators. In addition, they have long-term effects because they cause changes to habitats and the food chain.

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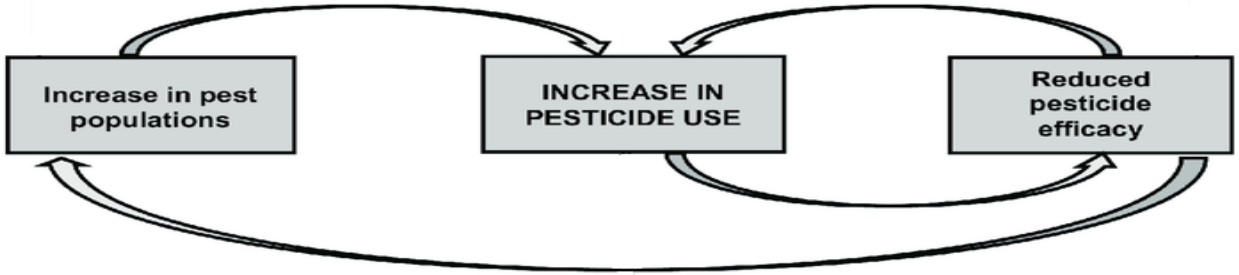
Continuing Loss of Flora and Fauna Biodiversity

Reduction of Suitable Habitats for Soil Organisms, Beneficial Insects and Pollinators

Dysfunction of Ecosystem Services for Agriculture: Biological Pest Control and Pollination



The USA spent 11 billion USD on 480 million pounds of pesticides in 2008.

How Does Agriculture Affect Biodiversity and Ecosystem Services?

According to the FAO, world consumption of the three main fertilizer nutrients, nitrogen (N), phosphate (P_2O_5), and potash (K_2O), was estimated to reach 186.67 million tonnes (N, P_2O_5 and K_2O) in 2016. With an average annual growth of 1.9 percent in the following years, it was expected to reach 201.66 million tonnes by the end of 2020. Over the next five years, the global capacity for fertilizer production is expected to increase.

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How Does Agriculture Affect Biodiversity and Ecosystem Services?

World demand for fertilizer nutrient use, 2015 – 2020 (thousand tonnes)

Year	2015	2016	2017	2018	2019	2020
Nitrogen (N)	110 027	111 575	113 607	115 376	117 116	118 763
Phosphate (P_2O_5)	41 151	41 945	43 195	44 120	45 013	45 858
Potash (K_2O)	32 838	33 149	34 048	34 894	35 978	37 042
Total (N+ P_2O_5+K_2O)	**184 017**	**186 668**	**190 850**	**194 390**	**198 107**	**201 663**

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How Does Agriculture Affect Biodiversity and Ecosystem Services?

The use of a lot of chemical fertilizers reduces small-scale plant species richness among taxa which are more associated with natural habitats. This could be due to the enhanced growth of cultivated crops stimulated by fertilizers, which in turn could favour their ability to monopolize other resources such as light and water, outcompeting weeds and other wild plants.

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Continuing Loss of Flora and Fauna Biodiversity

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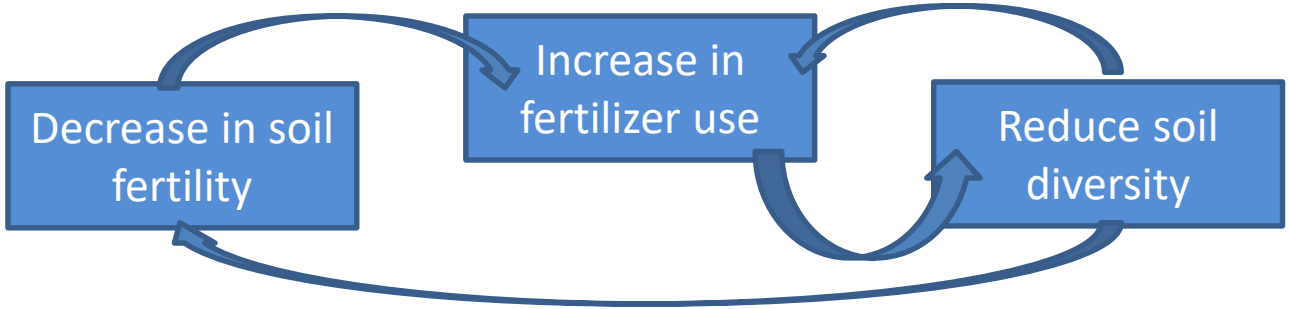
Dysfunction of Ecosystem Services for Agriculture: Biological Pest Control and Pollination



The USA consumed approximately 20.74 million tons of fertilizer in 2015

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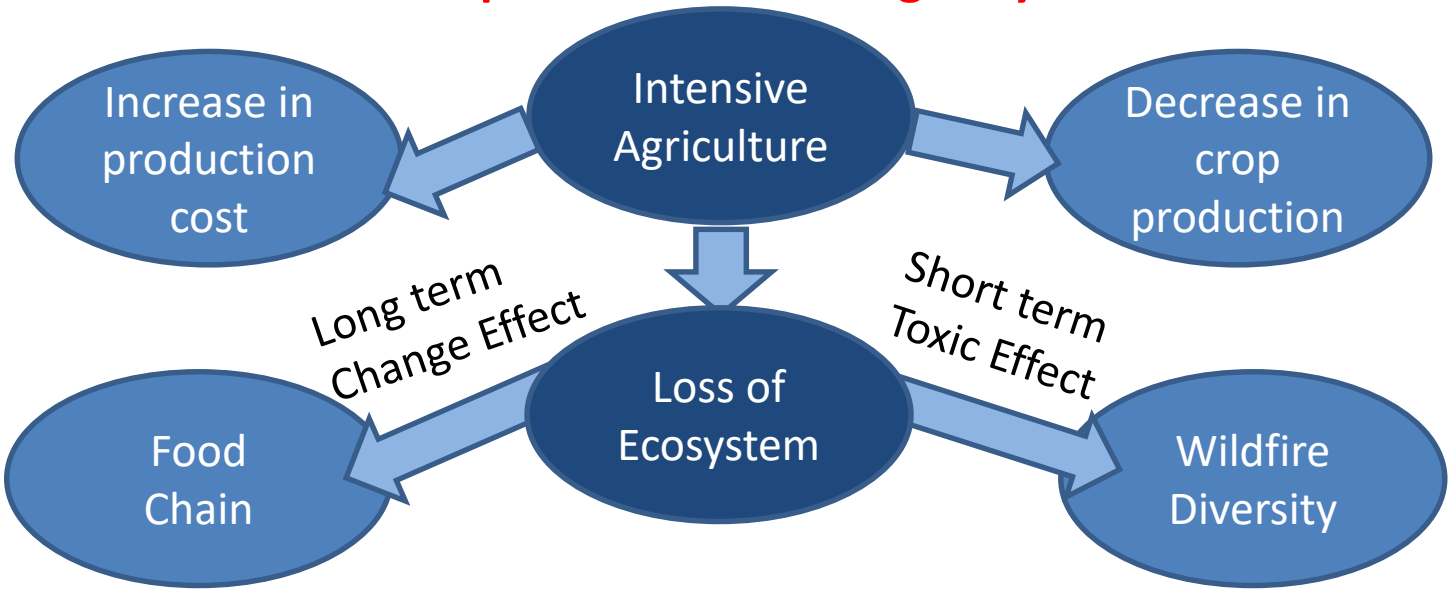
Chemical Inputs are NOT Ecologically Sustainable!



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In terms of ECOSYSTEM SERVICES

The richness of wild plant species declines with increasing use of herbicides, insecticides and fungicides.

The richness of natural predators decreases as more insecticide is applied, and the predation rate significantly declines.

The richness of bird species declines as the frequency of pesticide application increases.

The richness of pollinators declines as the amount of insecticides applied increases, and the wild plant richness declines.

In terms of ECOSYSTEM SERVICES

There are many insects in forests and agricultural areas that do not threaten crop production, but are beneficial to farmers in different ways. They provide valuable ecological services as pollinators, productive insects, scavengers, weed killers, soil builders and natural enemies of pests.

The intensification of agriculture and the use of broad spectrum pesticides have negatively affected these ecosystem services.

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In terms of ECOSYSTEM SERVICES:

1) Intensive agriculture decreases the potential for <u>BIOLOGICAL CONTROL</u>

Synthetic inputs (pesticides, herbicides and fertilizer) affect the extent of pest control indirectly by reducing the richness of wild plant species or by reducing the diversity of predators in the field

Indirectly enhancing PEST SURVIVAL !

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In terms of ECOSYSTEM SERVICES:

2) Intensive agriculture decreases the potential for CROSS POLLINATION

Synthetic inputs (pesticides, herbicides and fertilizer) affect the extent of pollination indirectly by reducing the richness of wild plant species or by reducing the diversity of pollinators in the field

Indirectly affecting CROP PRODUCTION !

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In terms of ECOSYSTEM SERVICES:

3) Intensive agriculture decreases the potential of <u>BEES</u>

Synthetic inputs (pesticides, herbicides and fertilizer) affect the extent of honey production indirectly by reducing the richness of wild plant species or by reducing the number of bees in the field

Indirectly affecting INCOME SOURCES !

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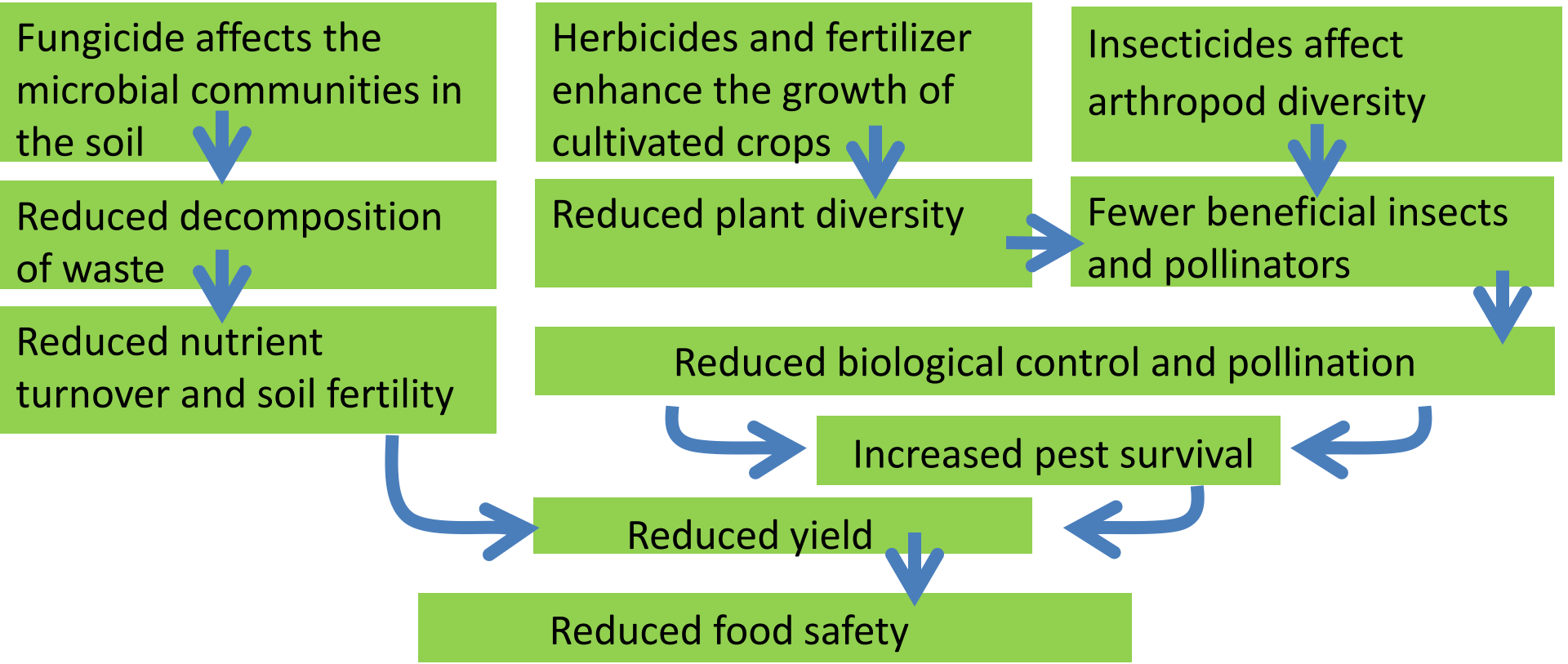
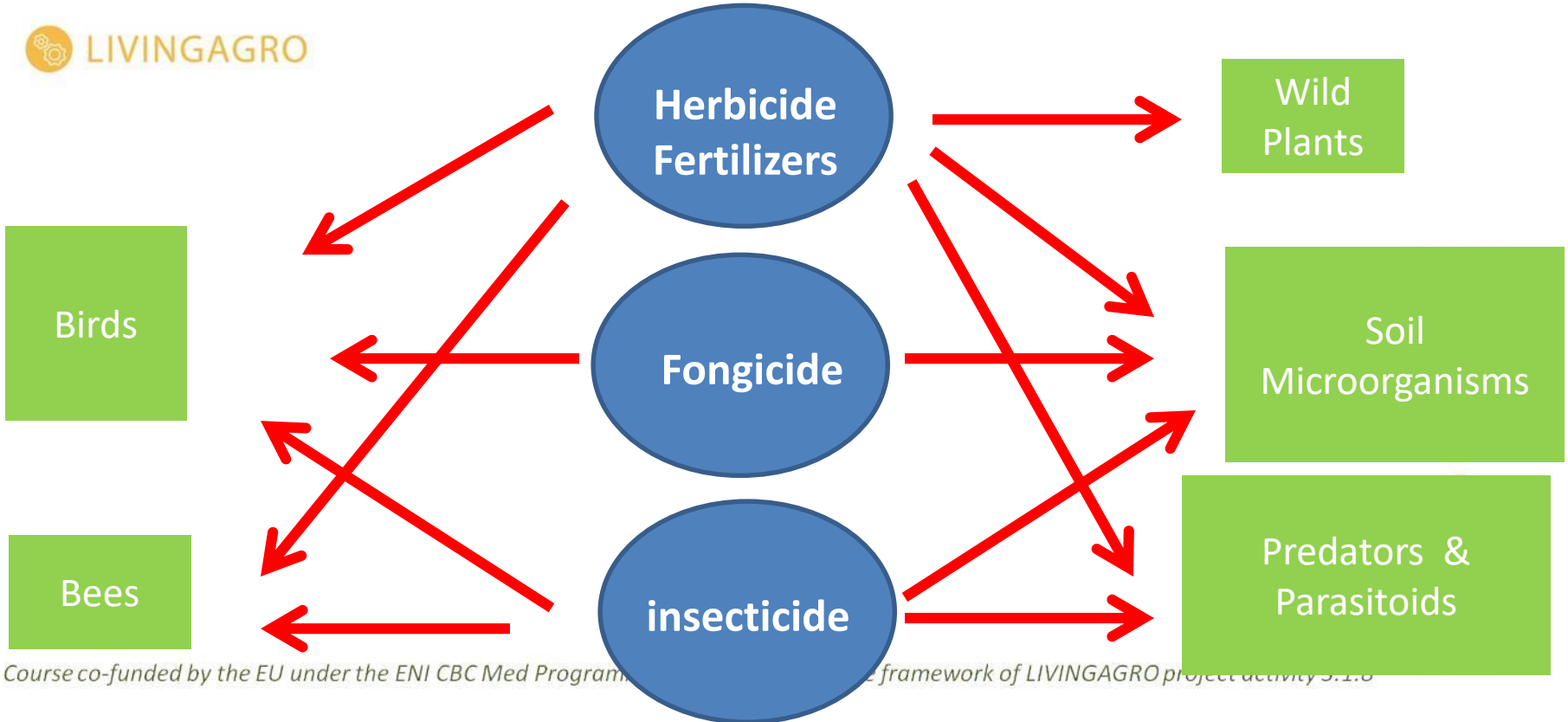
Chemical Inputs are NOT Ecologically Sustainable!

Different stages in the same food chain are affected by the intensification of agriculture



Chemical Inputs are NOT Ecologically Sustainable!

It is a multitrophic system where different stages in the same food chain are affected by the agriculture intensification



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Chemical Inputs are NOT Ecologically Sustainable!

During World War II, the most toxic pesticides used were DDT, arsenic and hydrogen cyanide. Discovered after decades of use in agriculture, their toxicity and capacity to accumulate in soils and in the food chain have played a key role in the degradation of natural resources, habitats and biodiversity and the reduction in the nutritional value of foods that we experience today.

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The Effect of Agroforestry on the Conservation of Biodiversity

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A return to traditional land use has become ESSENTIAL!

Agroforestry systems (AFS) are traditional land use systems.

AFS are multifunctional, combining trees or shrubs, agricultural crops and/or silvo-pastoral activities, and conservation of natural resources.

AFS are beneficial for both agriculture and the forest ecosystem, because soil, water, energy and natural resources are used in a more sustainable way than in monocropping practices.

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Agroforestry systems play four major roles in conserving biodiversity:

- They provide a habitat for species that can tolerate a certain level of disturbance, such as birds and mammals.
- They help preserve sensitive species, such as pollinators and the natural enemies of pests.
- They create corridors between habitats, thus supporting the conservation of endangered animal and plant species.
- They provide other ecosystem services, including soil nutrient cycling, erosion control, pest control and pollination.

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Agroforestry systems are a sustainable solution.

Agroforestry provides:

- Habitat complexity
- Refuges from cultivation
- Sheltered microclimate
- Food sources e.g. nectar

→ **Higher biodiversity**

→ **Beneficial wildlife**

- Predators of pests
- Pollinators

→ **Possible economic benefits**

- Higher crop yield/quality
- Reduced pesticide inputs
- Insurance against future risk e.g. pesticide bans, pesticide resistance, honey bee declines

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1) Soil organism diversity

The soil includes an incredibly diverse community of organisms:

1 gram of soil can contain billions of bacteria and fungi, and a vast variety of nematodes, mites, earthworms, and arthropods.

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1) Soil organism diversity

Soil organisms are grouped by their ecological function into

1) **decomposers and nutrient transformers**
2) **ecosystem engineers**
3) **bio-controllers**

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1) Soil organism diversity

These organisms interact, and their interactions influence soil fertility as much as or more than the organism's individual activities.

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1) Soil organism diversity

The major role of soil fauna is to contribute to the **decomposition** and **mineralization of organic matter (OM)**, ensuring the **circulation of nutrients** (nitrogen, phosphorus, potassium, etc.) and their availability for plant development on the soil surface. Without these decomposers, plants would have no nutrients to help produce the energy they need. **Soil structuring** is another fundamental action of soil organisms.

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1) Soil organism diversity

1.1 - Decomposers and nutrient transformers: bacteria and fungi

- These are microorganisms in the soil.
- They get their energy by breaking down dead materials.
- Their primary function is to decompose organic matter such as the remains of dead organisms, and release nutrients into the soil. **They are decomposers and recyclers.**

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1) Soil organism diversity

1.1 - Decomposers and nutrient transformers: bacteria and fungi

- **Bacteria** are active in the early stages, while **fungi** tend to dominate the later stages.
- They play a crucial role in the balance of ecosystems, since they break down organic matter that would otherwise not be recycled within the habitat.

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1) Soil organism diversity

1.1 - Decomposers and nutrient transformers: bacteria and fungi

- They influence the chemical and physical properties of the soil and increase soil fertility and long-term sustainability.
- The high input of organic matter into the soil in agroforestry systems contributes to the diversity and abundance of microorganisms in the soil.

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1) Soil organism diversity

1.1 - Decomposers and nutrient transformers: bacteria and fungi

These organisms are the essential component of the **FOOD WEB** that are responsible for breaking down organic matter into basic components such as carbon, oxygen, nitrogen, and phosphorus, and making these nutrients available for use by other living organisms in the ecosystem, such as plants.

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1) Soil organism diversity

1.2 - Ecosystem engineers: earthworms, ants, termites, millipedes …

- These are the **SOIL ENGINEERS** or **ECOSYSTEM ENGINEERS.**
- Earthworms, ants and termites are the main ecosystem engineers.
- They play key roles in creating habitats for other organisms by excavating the soil and producing a wide variety of organo-mineral structures, such as excretions, nests, mounds, macro-pores, galleries and chambers.

1) Soil organism diversity

1.2 - Ecosystem engineers: earthworms, ants, millipedes …

- They have a significant impact on soil structure and fertility.
- They improve soil aeration, water holding capacity, infiltration capacity and drainage by increasing porosity and releasing nutrient elements.
- They play a major role in the decomposition of waste, in processing soil organic matter and driving soil structure formation, which directly and indirectly affects the flow of energy and nutrients in the ecosystem.

1) Soil organism diversity

1.2 - Ecosystem engineers: earthworms, ants, millipedes …

- Earthworms eat dead plants and animals, fungi, and bacteria. Their digestive system transforms that organic matter into mineral-rich waste called **CASTS** that significantly enrich the soil with nutrients that are easily used by plants.
- Earthworms play an important role in soil fertility maintenance by mixing organic matter into the soil so it can decay, thus helping to produce humus, which contributes indirectly to plant growth.

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1) Soil organism diversity

1.2 - Ecosystem engineers: earthworms, ants, millipedes …

A study in Denmark found that earthworm density was 148 /m^2 within agroforestry systems, but only 63 /m^2 in a conventional barley production system.

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1) Soil organism diversity

1.2 - Ecosystem engineers: earthworms, ants, millipedes …

Ants are also important ecosystem engineers:

- Ants turn and aerate the soil through a network of galleries and chambers, reducing bulk density, increasing soil porosity, drainage and soil aeration, and allowing water and oxygen to reach plant roots.
- Ants eat a wide variety of organic matter and provide food for many different organisms. They incorporate nutrients by food storage, fungus cultivation, and accumulation of feces and corpses.

1) Soil organism diversity

1.2 - Ecosystem engineers: earthworms, ants, millipedes …

Ants are also important ecosystem engineers:

- Ants can provide habitats for other organisms in the soil. Many arthropods and microorganisms such as fungi and bacteria live in ant mounds, queen chambers, storage areas or nests.

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1) Soil organism diversity

1.2 - Ecosystem engineers: earthworms, ants, millipedes …

Forests have the greatest ant species diversity:

4 km^2 of forests contain 98 species in the Brazilian Amazon, 66 in southern Brazil, 41 in Australia, and 12 in Tasmania.

A survey of 250 km^2 of a Malaysian rainforest yielded 460 species, while 272 species (71 genera) were recorded in 1.6 km^2 of forest in Brazil.

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1) Soil organism diversity

1.2 - Ecosystem engineers: earthworms, ants, millipedes …

- Given their potential contribution to soil fertility management, it is essential to consider these soil engineers in agroecosystem management decisions in order to make land use more sustainable.
- Proper soil organism management may sustain crop yields and reduce the need for fertilizer.
- An understanding of the biology and ecology of soil engineers can help us devise management strategies that may impact the living organisms in the soil, as well as crop performance.

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1) Soil organism diversity

1.3 - Bio-controllers: Collembola, non-parasitic nematodes, centipedes, millipedes…

- These are predators that feed on other soil organisms and contribute to the regulation of the communities in the ecosystem.
- They form the link between the primary decomposers and the larger animals in the food web in the soil that begins with dead organic matter.
- They regulate the activity of the soil's microbial community, thus affecting the flow of nutrients.

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1) Soil organism diversity

1.3 - Bio-controllers: Collembola, non-parasitic nematodes, centipedes, millipedes…

- **Centipedes and millipedes** are teammates that work together to turn unwanted pests and waste into rich, fertile soil. Each plays a separate and equally crucial role in the natural soil-building process.

1) Soil organism diversity

1.3 - Bio-controllers: Collembola, non-parasitic nematodes, centipedes, millipedes…

- In the soil food web, **millipedes** are recyclers, eating all kinds of debris, and pooping out the minerals from leaf litter, grass clippings, food scraps, finished crops and dead animals.
- They also benefit other soil microorganisms that work intimately together to turn debris into nutrient-rich soil.

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1) Soil organism diversity

1.3 - Bio-controllers: Collembola, non-parasitic nematodes, centipedes, millipedes…

- **Collembola** are important bio-controllers. Their main role is to regulate the microorganisms responsible for the decomposition of organic matter and the recycling of nutrients that will be used by plants.
- Most species feed on microorganisms (fungi, bacteria), most often fungal filaments. Others consume dead plants. A very small proportion are predators of nematodes.

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1) Soil organism diversity

1.3 - Bio-controllers: Collembola, non-parasitic nematodes, centipedes, millipedes…

Collembola are the main representatives of microarthropods in the soil. There are 10,000 to 100,000 in a square metre of soil.

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1) Soil organism diversity

Soil organisms improve habitat diversity, which in turn increases species diversity in the ecosystem.

It is important to preserve soil biodiversity in order to maintain the integrity of the processes that sustain ecosystem services, such as decomposing, primary productivity (making food from inorganic sources, as through photosynthesis), and nutrient cycling (the cyclical movement of nutrients from the environment to living organisms, and back to the environment again).

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1) Soil organism diversity

Biodiversity is also important for maintaining soil resilience, that is, the soil's capacity to recuperate after a natural or human-induced disturbance.

Plant diversity in agroforestry systems increases the abundance and diversity of soil organisms, which keeps the soil healthy and fertile.

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In agroforestry, trees influence above and below-ground resources such as light, water and nutrients, with the following results:

- Preserving water and soil moisture by reducing air and soil temperature
- Increasing soil microbial activity due to the large amount of leaf litter, which results in significant organic matter accumulation
- Preserving soil nutrients by increasing microbial activity

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In agroforestry, planting cover crops between the alleys can enhance the ecosystem:

- Increasing the diversity of microbes and arthropods
- Increasing the diversity and heterogeneity of animals and wild plants
- Preserving soil nutrients by increasing microbial activity

Photo credit: Dr. Peter Moubarak

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In agroforestry, planting cover crops between the alleys can enhance the ecosystem.

The right combination of trees and crops is required to prevent any competition. In the case of olive agroforestry, olive trees are able to survive in dry environments and do not require the large amount of water that is needed for the plants in the alley.

Photo credit: Dr. Peter Moubarak

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2- Beneficial insect diversity

Beneficial insects or natural enemies are insects that attack and feed on other insects or organisms. Through this type of feeding, natural enemies contribute to a type of pest regulation referred to as biological control.

In agricultural lands, natural enemies have the potential to prevent crop pests from reaching economically damaging levels without environment impact result from pesticide use

Photo by Z. Moussa

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2- Beneficial insect diversity

There are two types of Beneficial insects:

1- Predators are generally characterized as free-living, mobile, and are able consume several preys throughout their life cycle.

2- Parasitoids are more host specialized. They lay eggs on or within their host and the immature parasitoid(s) feed on their host to complete their development

Photo by Z. Moussa

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2- Beneficial insect diversity

The larva or the immature stage of the beneficial insects such as hover flies, lacewings, lady beetle, and parasitic wasps is the essential stage in feeding on other organisms and contributing in reduction of pest population.

Photo by Z. Moussa

Larva of Lacewing (Chrysoperla)

Adult of these beneficial insect feed mostly on pollen and nectar. Providing adults with food and habitat with a variety of plants will encourage the production of natural enemies.

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2) Beneficial insect diversity

Agroforestry systems with high flora (plant) diversity can sustain higher fauna (animal) diversity compared to monocultural systems devoted to a single crop.

The varied vegetation in agroforestry systems furnishes sites for mating, breeding and resting, as well as supporting a high diversity of insects which provide a valuable food source for a variety of natural enemies and birds.

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2) Beneficial insect diversity

- In agroforestry, the irregular distribution of host plants makes it harder for pests to find the host plants.
- In agroforestry, using “trap-crop” species such as sunflower or repellent plants such as lemongrass or lavender can protect other crops from pest attacks.
- In agroforestry, hedges, boundary plantations, and windbreaks create a physical barrier for pests transported by wind.

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2) Beneficial insect diversity

- Understanding the habitat needs of beneficial insects and providing their appropriate habitats can improve integrated pest management programs.
- To increase and stabilize the presence of natural enemies, secondary plants should be cultivated to provide shelter and alternative prey.

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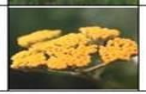
2) Beneficial insect diversity

To increase and stabilize the presence of natural enemies, secondary plants should be cultivated to provide shelter and alternative prey.

Plant Photo	Plant Name	Beneficial Insect	Plant Photo	Plant Name	Beneficial Insect
	**Faba bean** فول سوداني (*Vicia fabae*)	Geocoris Beetles		**Stinging nettle** قريص (*Urtica dioica*)	Parasitoid & predator for aphids
	**Fennel** شمرة (*Foeniculum vulgare*)	Chrysopa Beetle Parasitoid Syrphus		**Sunflower** دوار الشمس (*Helianthus* sp.)	Chrysopa Geocoris Beetles Parasitoid
	**Golden rod** عصا الذهب (*Solidago altissima*)	Orius Geocoris Chrysopa Parasitoid		**Sweet Alyssum** ألوسن بحري (*Lobularia maritime*)	Parasitoid Syrphus
	**Marigold** قطيفة (*Tagetes* sp.)	Chrysopa Parasitoid Syrphus		**Tansy** حشيشة الشفاء (*Tanacetum vulgare*)	Beetle Chrysopa Orius Parasitoid
	**Mint** نعنع بري (*Mentha microphylla*)	Parasitoid Syrphus		**Vetch** باقية (*Vicia spp.*)	Beetle
	**Mustard** خردل (*Brassica spp.*)	Parasitoid Syrphus		**White clover** نفل أبيض (*Trifolium repens*)	Parasitoid
	**Parsley** بقدونس (*Petroselium sativum*)	Chrysopa Parasitoid Syrphus		**Wild Carrot** جزر بري (*Daucus carota*)	Orius Geocoris Chrysopa Syrphus
	**Radish** فجلة (*Raphanus raphanistrum*)	Parasitoid		**Yarrow** الألفية أو الأليخا (*Achillea* sp.)	Syrphus Orius Geocoris Parasitoid

Plant Photo	Plant Name	Beneficial Insect	Plant Photo	Plant Name	Beneficial Insect
	**Alfalfa** الفصة (*Medicago sativa*)	Beetle Orius Geocoris Parasitoid		**Coriander** كزبرة (*Coriandrum sativum*)	Syrphus Beetle
	**Angelica** حشيشة الملاك (*Angelica* sp.)	Chrysopa Beetle Parasitoid		**Corn** الذرى (*Zea maïs*)	Geocoris Beetles
	**Anise** بانسون (*Pimpinella anisum*)	Parasitoid		**Cornflower** قنطريون أو العنبري (*Centaurea cyanus*)	Syrphus
	**Baby blue eyes** الناموفلية (*Nemophila inignis*)	Syrphus		**Cotton** القطن (*Gossypium sp.*)	Geocoris Beetles
	**Caraway** كراويّا (*Carum carvi*)	Parasitoid		**Daisy** مرغريتا صغرى بليس (*Bellis perennis*)	Orius
	**Celery** كرافس (*Apium graveolens*)	Parasitoid Syrphus Chrysopa		**Dandelio** هندباء البرية (*Taraxacum officinale*)	Chrysopa Beetle Parasitoid Syrphus
	**Camomille** بابونج (*Camomilla sp.*)	Syrphus Parasitoid		**Dill** بقدنة (*Anethum graveolens*)	Beetle Syrphus Chrysopa Orius
	**Clover** النفل (*Trifolium spp.*)	Parasitoid of wooly aphids		**Dog rose** ورد بري (*Rosa canina*)	Syrphus

Source: Z. Moussa, 2007. **Pests and their Beneficial Insects on Fruit trees and Olive in Lebanon** - SABIL. World Vision.

LIVINGAGRO

2) Beneficial insect diversity

To increase and stabilize the presence of natural enemies, secondary plants should be cultivated to provide shelter and alternative prey.

Ideally, these secondary plants should consist of a mixture of local species, avoiding the introduction of alien species and weeds:

- A mixture of plants with a long flowering period
- A mixture of plants that provide plenty of pollen and nectar

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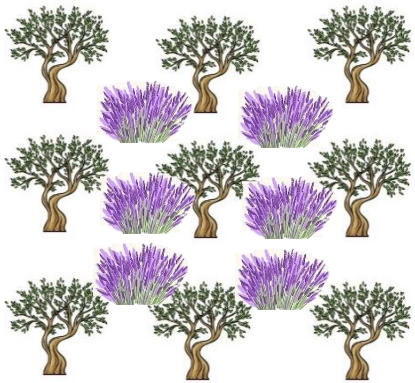
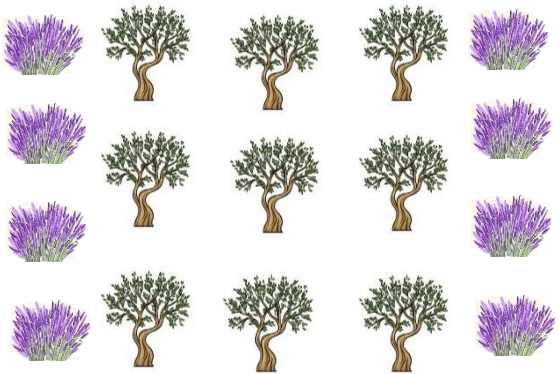
2- Beneficial insect diversity

There are different ways to introduce the secondary plants: they can be either planted near the agricultural crops or on the border of crop fields.





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Multiple criteria should be taken into consideration when selecting secondary plant species:

1- soil and climatic requirements
2- plant characteristics: growth habit, flowering period, nectar and pollen capacity, and flower structure
3- cost and availability of seeds
4- possible threats to the cultivated crops and native plants due to domination of the habitat or by sharing the same pests or diseases
5- presence of species that are important to conserve (such as those classified as rare, endangered or vulnerable)

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LIVINGAGRO

2) Beneficial insect diversity

***Calosoma*, "the caterpillar hunters," are ground predator beetles that feed mainly on forest caterpillars such as gypsy moths (*Lymantria dispar*).**

Photo by Z. Moussa

- Adults are predominantly found under rocks, logs, leaves, bark, decomposing wood and other debris on the ground.
- Forests are their natural habitat, but they can also be found feeding on insects on agricultural land close to forests.

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LIVINGAGRO

2) Beneficial insect diversity

***Calosoma*, "the caterpillar hunters," are ground predator beetles that feed mainly on forest caterpillars such as gypsy moths (*Lymantria dispar*).**

Photo by Z. Moussa

They can also play a major role in the biological control of cutworms, which can infest vegetable crops.

An average larva can consume 50 caterpillars during its 2-3 week development stages, while one adult can eat several hundred caterpillars during its 2-4 year lifetime.

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2) Beneficial insect diversity

Important predators of insect herbivores, lady beetles play a major role in biological control.

Adults and larvae feed primarily on aphids but also on mites, small insects, and insect eggs.

Seven spotted lady beetle adults may consume several hundred aphids per day, and each larva eats 200 to 300 aphids as it grows.

Photo by Z. Moussa

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LIVINGAGRO

2) Beneficial insect diversity

Important predators of insect herbivores, lady beetles play a major role in biological control.

Adults overwinter in the forest, often in aggregations along hedgerows, beneath leaf litter, and under rocks and bark.

Photo by Z. Moussa

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LIVINGAGRO

2) Beneficial insect diversity

Important predators of insect herbivores, lady beetles play a major role in biological control.

In spring, they disperse in search of prey and suitable sites for laying eggs.

Eggs are usually deposited near prey such as aphids, often in small clusters in protected sites on the leaves and stems of wild plants.

Photo by Z. Moussa

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LIVINGAGRO

2) Beneficial insect diversity

Important predators of insect herbivores, lady beetles play a major role in biological control.

Adults consume pollen as an important part of their diet and fertility.

A source of nectar and pollen or an artificial substitute may attract adult beetles and reduce their dispersal.

Adult lady beetles need shelter to protect them from weather and to provide overwintering sites.

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3) Pollinator diversity

Photo by Z. Moussa

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3) Pollinator diversity

Insect pollinators are flower-visiting insects that forage on flowering plants to obtain plant-provided food (nectar and pollen).

During foraging, flower-visiting insects have the potential to transfer male gametes (reproductive cells) to female gametes, resulting in pollination.

Pollination is an essential step for seed and fruit production.

3) Pollinator diversity

85% of flowering plants depend on pollinators.

Honeybees account for about 50% of crop pollination.

Wild solitary bees, bumblebees and hover flies perform the other 50%.

Pollinators are in decline globally, and estimates suggest that up to 40% of invertebrate pollinators are at risk of extinction due to loss of biodiversity.

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3) Pollinator diversity

Trees and flowers in agroforestry systems (AFS) are sources of nectar that provide high nutritional value and sugar content for pollinators. AFS thus provide better pollination service than monocultures.

Improving the presence of pollinators in AFS enhances the production of cross pollinating crops and therefore increases the yield.

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3) Pollinator diversity

A study in Greece on the potential of intercrop ground cover with mixtures of plants to provide habitats for pollinators in an olive grove showed this:

The number of bumblebees is higher in a mixture of coriander (*Coriandrum sativum*), corn marigold (*Glebionis segetum*), chamomille (*Matricaria chamomilla*), borage (*Borago officinalis*), white mustard (*Sinapis alba*), pea (*Pisum sativum*), crimson clover (*Trifolium incarnatum*), Persian clover (*T. resupinatum*), vetch (*Vicia sativa*), and barley (*Hordeum vulgare*).

Patches sown with plant mixtures
attract higher numbers of pollinators compared
to the native vegetation due to the higher floral diversity and density, which provide a long flowering period.

By Nancy Seiler

Best plants to include: those with plenty of pollen and nectar and a long flowering period

LIVINGAGRO

4) Bird diversity

Birds play an important role in controlling forest pests by feeding on insects.

The intensification of agriculture increases the risk of bird extinction, especially for specialist endemics (those native to a specific area), since forest fragmentation reduces their habitat, and also because insecticides used to control pests end up reducing the insect population. This reduces birds' food supply, including the food supply for nestlings.

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4) Bird diversity

Birds play an important role in controlling forest pests by feeding on insects.

Agroforestry can support a high diversity of wild birds and small mammals by conserving their habitats and food sources.

Birds also prey on crop pests. Manipulating farmland habitats can influence the composition and abundance of bird communities; the right decisions can therefore increase birds' pest control services.

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4) Bird diversity

A study in California on the effectiveness of bird predation on the walnut pest *Cydia pomonella* with and without AFS demonstrated increasing larval predation from 11% to 46% with increasing proportions of natural habitat thanks to agroforestry. This increase coincided with a higher number of birds.

Adding nest boxes near woody field margins or other bird habitats also increases bird abundance.

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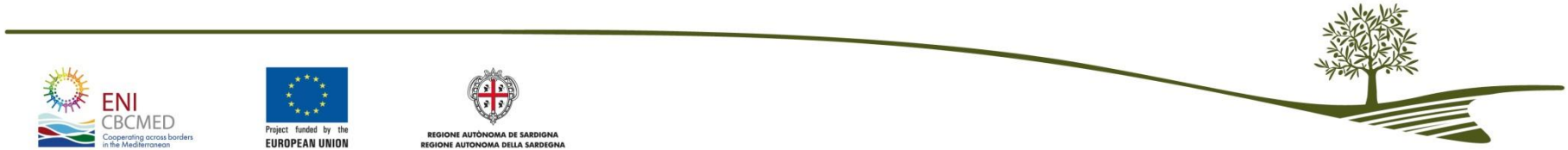

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