



INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

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Content of lectures

1. Agroforestry
2. Fast growing tree species – forest plantations
3. Silviculture of pioneer tree species

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Agroforestry

- Introduction,
- Dividing, conception,
- Historical context – human land use
- Examples in Czech, Europe, World



Agroforestry - Introduction

- Kind of social forestry
- urban forestry, community f., farm
- Social forestry?
Jakarta 1978 – unsocial forestry
- Many form of definitions....



„System of land use where woody species are grown intentionally in the same land and in combination with agricultural crops and/or livestock; ecologic and economic interactions between the different components“.

Agroforestry - dividing

Benefits:

- Agrosilviculture – crops + trees
- Silvopastoral – pasture + trees
- Agrosilvopastoral – crops + pasture + trees
- Forest farm – trees + plants



Lands:

- Silviculture woody trees sp. on agriculture land (combination with pasture)
- Growing plants or crops (breeding animals) in forest



Why yes Agroforestry

- monocultures competitions in the same time and space for the same source;
- possibility of improving efficiency of the total system by exploiting the zone and time differences between the competing species in capture water, nutrients and light;
- reduce the risk of monoculture – benefits diversification
- space for research

1. Ecological reasons: biodiversity, erosion, CO₂
2. Economic r.: comb. 1 ha wheat + poplar the same yield like separately - 0,9 ha wheat and 0,4 ha poplar
3. Aesthetic reasons.: landscape management
4. Social reasons: working and living in the village

Historical context of agroforestry in examples of Central Europe and World

- What is older forestry or agroforestry?
- Human and landscape.
- Beginning of agriculture
- Beginning of forestry
- Connection of agriculture and forestry



Human landscape and natural resources

- Early human history (older Stone Age)
- modern man 500 thousands years ago Africa
- 400thous. years in Europe use wood (dwelling, fuel, tools), hunter and gatherer
- 100 – 8thous. years ago glacial
- in Europe oscillations warm: 40, 25thous. cool: 60, 20thous.
- warm: steppe - needle trees, birch, oaks, beech; man permanent
- cool: tundra – willow; man like nomad
- small impact on landscape – hunting large mammal
- controlled using of fire



Not agriculture, not forestry, not agroforestry – human like a part of nature (using wood)

From hunting to agriculture

- **Mesolithic:** 10 – 6 thous. BC (middle Stone Age)
- natural cond. – preboreal and boreal; increase in heat and humidity – the spread of forest 1. Birch, Pine 2. Oaks, Spruce

parkland

- Man permanent settlement: hunter and gatherer (hazelnuts), small impact - burning for hunting, wood for shelter fire, tool

Man changing environment - germ of agroforestry....



Early agriculture

- **Neolithic 6 – 5.5 thous. BC** (younger Stone Age)
 - increase in heat and humidity (climatic optimum) – the spread of forest (the most closed forest) lime, oaks, elm
 - starts of deforestation in settlement area (fertile lowlands) – burning agriculture (wheat, peas, grazing animals)

Palett of landscape (cultural land) – settlement, bur. land, abandoned, b. land, pasture forest, coppice forest - 5 – 10 km², climax forest.

Typical agroforestry land use

Picture Z. Burian



Developed agriculture

- **Eneolithic 4,3. thous. BC (late Stone age)**
 - the spread of forest: beech+fir,
 - increase of populations, **cattle for ploughing !!!**
 - permanent settlement, continuing of deforestation – secondary open gaps, palett of landscape
- **Bronze age 2 000 – 1000 BC**
 - Drought – subboreal, spread of forest: beech+fir - hornbeam
 - Deforestation – bronze tools and production, settlement of higher altitudes – **changes in humen society**, trade
- **Iron ages 750 – 0 BC**
 - wet, cold,
 - oscillation in settlement: succession process, deforestation (metal proc., increase of **meadow – scythe**)
 - continues the process of settlement and changes in human society (hillforth – ruling class)
 - continuing process of cultural land –
 - typical agro-pasture-forestry land use (appearance)

World examples –

The rise and fall of humen civilization



Early agriculture

Mesopotamia – 5500 BC

- river Euphrates and Tigris (Iraq, Syria, Turkey, Iran)
- fertile soil – development of cities states
- Floodplain- irrigation
- Increase population – deforestation – produce of food
- Soil erosion and degradation – fall of civilisation

Bronze age

Mycenae - 1 450 BC

- deforestation only in plains (Early Neolith), oaks, pine, fir, poplar, alder
- produce, export of bronze and ceramics – dominated in trade
- wood for shipbuilding, bronze and ceramic produce
- increase population
- cleaning forest for agriculture land
- deforestation, erosion, depleted sources - 1250 BC

Attica – 600 BC

- well forested
- agriculture only on rich-better soil,
- 500: development, trade, increase population – food – deforestation (fuel-shipbuilding-houses-agriculture land, silver mining),
- erosion of soil, depleted of wood

Roma Empire

- 600 BC – extensively forested (fir, spruce, pine, beech, oak, lime);
- 300 BC- expansion and development Roma (city, populations, bath, smelting of metals, shipbuilding's - remote forest; new agriculture land);
- Agriculture progress – composting, legume rotation, ploughing, terraced;
- Now land management – colonies;
- **Forest management – first methods (thinning, plantation establishment) under pressure of wood use;**
- Declining of Roma Empire;
- war – environmental degradation, deforestation, erosion, reduce agriculture yields.

Land use in Czech after AD

0 – 500: **decrease of population** – impact on forest, pasturage

500 – 1000: gradual increase of population like early agriculturalist – palette lands beginning of feudal

1000-1400: development of human society – cities colonization – deforestation: fuel, agriculture lands, buildings, changes in lands use

1400 – 1450: **decrease of civilization**
forest regeneration



1450 – 1600: now development of human society – deforestation: agric., mining, glass industry, fuel – cities, mountains, first silviculture practice

1650 – 1600: **decrease of civilization,**
forest regeneration



1650 – 1850: continuing development (deforestation) process, lack of wood – silviculture practice,

1850 – end of deforestation, restriction on grazing, litter gathering, changing in human society - industry revolution

Summary – history of agroforestry

- One of the oldest land use management (after hunting and gathering)
 - *mother of forest and agriculture management*
- Decrease of agroforestry system with human community developed (industry revolutions, increase of populations – land utilizations, human work specialization – with regard to economy effectiveness)
- With regard to social and ecological aspect (economy in long term) increase of possibility agroforestry systems like sustainable landscape management

Examples of agroforestry

1. World agroforestry –

Tropical

Taungya,
Alley cropping,
Homegardens

Temperate

North America
China
New Zealand



2. Agroforestry in Europe

Mediterranean
Temperate

3. In Czech: *history - future*

Tropical agroforestry

- **Taungya**
 - Southeast Asia (Thailand, India, China) - use in region with shortage of agriculture lands.
 - Combination of wood from plantation and crops,
 - Crops (rice, maize) is cultivated between rows of teak (*Tectona grandis*) in early phase of plantations establishment,
 - Crops cultivation help weed suppress,
 - Plantation are owned by government - disadvantage, not so attractive for farmers – **small social success**.
 - Peasant have only income from crop,
 - Beneficial for owners rather than farmers.

• **Alley cropping – hedgerows intercropping**

- Kenya,
- Wood: perennial hedge legumes –fix atmospheric nitrogen, arrest soil erosion, provide litter mulch, pruning - fodder, fuel, food (*Leucaena leucocephala*, *Calliandra calothyrsus*) – frequent pruning,
- Crops: maize in rows between hedge,
- Mixed success – balance negative and positive effect,
- No on acid soil and in low rainy area,
- **Homegardens**
 - Indonesia,
 - Planted trees around homes to provide range of produces (shade, fruit, spices, vegetables, fuel, fodder, honey, medicines, timber,
 - Multi-species – uneven age forest management, single-tree selection system,

Temperate world agroforestry

- Agroforestry-typical for tropical developing country,
- In temperate – the same reason + biodiversity, nature conservation, environmental reasons - emotion
- Returning trees in rural landscape
- Wood produce: Height volume trees crops – *walnut, sorbus...*

Alley cropping with Black Walnut

- North America,
- BW (*Juglans nigra*) excellent tree for agroforestry (quick grow, attractive timber, edible nuts, easy manage),
- Light conditions for crop under *Juglans*
- Crop in rows 75 trees pro ha, RP 60 years
- Maize, soybean, grass, winter wheat



Crops interplanted with *Paulownia*

- China – native fast growing tree
- *P. fortunei, elongata,*
- Wide variety of use wood, provide fodder, nectar – honey.
- Good leaf arrangement
- Deep rooted tree
- Crops – winter wheat, soybean, garlic, cotton,
- Crops in rows or along roads, rivers, canals



Paulownia agroforestry models

1. **Timber oriented**
 - Paulownia - wheat –maize (P-Chinese herbaceous, P – garlic, ...)
 - Crops changes- light conditions 1-4 years, 4+ years....
 - P. density: 4x4 – 5x8 m, 625 – 200 trees pro ha.
 - Rotation period 8 – 10 years; DBH 30 - 32 cm, 60 – 120 m³ pro ha
2. **Crop fields with scattered P.**
 - Ecological reasons, wind speed, humidity
 - In rows 30 – 50 m, 30-60 trees per ha
 - wheat –maize – P, sweet potato-tobacco- wheat-P



- Ecologic benefit**
- Reduce wind speed in May: 20 - 50 % ----- increase in wheat yield 5-13%,
 - Reduce evapotranspiration: 23 -34 %
 - Reduction of light intensity: depends on distances of row 54-91 % research...
- Economic**
- Timber produce yield: Paulownia timber - 56.4% of the total net profits of timber-oriented intercropping systems, in crop fields with scattered Paulownia trees 22.2-33.3% of the total net profits came from timber production.
 - the Paulownia-lettuce-wheat comes first, then the Paulownia-Chinese herbaceous peony followed by Paulownia-garlic: their annual net profits are 190%, 178% and 118%, respectively, higher than that of any crop field with scattered trees
 - When intercropped with Paulownia, wheat yields were the same as in an open field when the trees were planted 5 m apart with 10 m between rows. When the distance was increased to 20-40 m between rows, wheat yields increased 7-10%.

Farm forestry in New Zealand

- Farmland ½ of lands
- Deforestation 150 year from forest to pasture (sheep + cows)
- Effort to return forest (trees)



- soil protection
- landscape
- climatic change
- production wood

- *Pinus*
- *Black Walnut*
- *Eucalyptus*,
- *Poplars*,
- *Douglas-fir*



- previously

- now



- Results from using browse blocks to manage internal parasite burdens in weaned lambs



	Pasture	Browse Block	Fat
		Decreased	Gain
Stemweight gain grams per day			
Shearshed	118	123	187
Unshearshed	111	107	154
Wool live weight			
Shearshed	1.11	1.02	1.13
Unshearshed	1.85	1.68	1.48
Live weight at slaughter			
Unshearshed groups			
Overage	1,300	2,609	8,188
Removalist	2,886	2,680	714
Technologist	4,942	1,414	898

Agroforestry in Europe

- wide diversity and long history
- **In Mediteran:**
 - sylvopastoralism – *Castanea*, *Quercus*
 - agrosylvopasture – *Dehesa* (Spain), *Montado* (Portugal), *Quercus* – 30 – 80 per ha, cereal – 5-10 year, pasture
- Breeding fruit trees
 - cereal between olives trees (midstream –Greece, Sicily, France)
 - tree grapevine crops (Italy)
 - grass orchards (oceanic area, mountain landscape)
- Forest trees on farmland
 - fuel-wood, protective – steep slope, wind (UK, France, Poland)
- Traditional E. agroforestry
 - farm produce to improve trees stands - in fertile soil (Hungary, Germany, Czech)

Dehensa



Future of Agroforestry in Europe

- Traditional agroforestry – problem with high costs of labour
- High volume (luxury) produce – local product high quality
cheese – grass orchards, ham – Dehensa
- Modern-scientific-mechanized base agrof.
high quality timber trees in crops or pasture
row 10 -14 m, 50 – 80 trees per ha
(*Prunus, Sorbus, Acer, Junglans*)

Three examples of agroforestry in Czech

1. Growth crops on forest soil
- *in the past*
2. Planting trees on agriculture lands
- *for landscape and like fuel*
3. Grazing on bush area
- *for nature protection*



Growth crops on forest soil

- In lowlands rich forest soil,
- In beginning and half of 20 century,
- Now decay (soc-economic situation),
- After clear-cut, stump removal, 2 – 3 years,
- Oaks, Black walnut, ash,
- corn, potatoes, beets,
- Weed suppress, better high grow of trees,



Research of influence agriculture on trees

- Floodplain forest on South Moravia,
- Ploughing – agriculture crops – field without preparation,
- Oaks tress,
- No impact on oaks growth,
- The same above-under-ground parts of trees,
- No impact on soil biologic activity and synusia of plants under-storey.

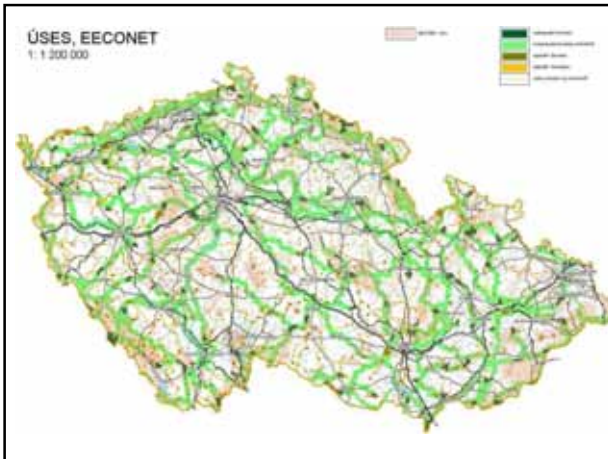
Planting trees on agriculture lands

- Non economic reason
- Landscape, aesthetic, natur and soil conservation,
- Ecological network –
- Economic aspect -...?



plantations





Fast growing tree species forest plantations

- **Defines:** *FAO: „forest stands established by planting or/and seeding in the process of afforestation or reforestation. They are either introduced or indigenous species – minimum area 0,5 ha, tree crown cover of at least 10 % of the land cover, and height of adult trees above 5 m“*
- **What they are and what not – boundary of plantations**
 - Even-age-monoculture stands regenerated by planting– stands with minimal human impact and natural regeneration*
 - Even-age-monoculture stands with exotic sp. well adopted and with natural regeneration*
 - Even-age- composition native and exotic sp. with natural regeneration*

How much is plantation

- **How much is plantation**
 - World total 187 086 000 ha – 4,8% of total forest*
 - Japan 44,4 %; India 50,7 %; USA 7,2%; Spain 13,2 %;*
 - Brazil 0,9% of total lands forest*
 - Asia 62 %,*
 - Europe 17 %,*
 - North + Central America 9 %,*
 - South America 6 %,*
 - Africa + Oceanic 6 %.*
- Increase 4 500 000 ha years*

Plantations yes or no

- **Productions:**
 - Plantation: 10 – 40 m³/ha/years
 - „forest“: 2 m³/ha/years
 - Regional diversity Czech
 - Plantation: 10 – 35 m³/ha/years
 - „forest“: 5-10 m³/ha/years
- **Biodiversity:**
 - Lower with compare to nature forest, with compare to abandoned land?
- **Protection of nature forest:**
 - With respect to high production can plantations protect virgin (primary) forest..
- **Fuel sources:**
 - Compare wood to fossil sources – environmentally friendly
- **Sustainability:**
 - Nutrient depletion – good management
- **Economy:**
 - included all costs
- **Non productions plantations:**
 - Soil protection



It is better to have a lots of plantations and virgin forests or lot of sustainability forests and no so mach plantations and virgin forest?



Dividing of plantation

- Wood produce,
Fuel and power
Industry wood
- Soil protection,
- Aesthetic reasons,
- Improve water quality,
- To protect livestock and crops,



Species for plantations

- Monoculture
 - Pioneer tree species
 - Boreal zone
 - Native or exotics
- *Pinus* 20 %,
- *Eucalyptus* 10 %,
- *Hevea* 5 %,
- *Acacia* 4 %

Pinus plantations in Australia



Pinus radiata - natural occurrence

Rotation period

- Connected with productions and wood use
- Like biomass (energy) plantations
 - short coppice rotations
 - mini-rotation 2-3 years: Height 4-8 m, DBH 2-5 cm,
 - midi-rotation 4-6 years: Height 8-14 m, DBH 6-12 cm,
- Like industrial wood
 - planting establishment plantations
 - fast-growing plantations: 15-40 years
 - slow- growing species in cool climates: 100 years

Plantations in Czech

- **Allochthonous coniferous (spruce, pine) stands**
naturally: spruce 11 %, pine 3,5 %
current: spruce 52 %, pine 17%.
- **Ligniculture – industry use wood,**
populus, rotations 20 - 40 years
- **Energy plantations**
 - coppice stands on agriculture land, RP 3-6 years (populus, wilow)
 - fast growing tree species on forest lands, RP 15-30 years (birch, aspen)



Silviculture of pioneer tree species in natural close management

- Position of pioneer tree in natural forest large development cycles
- Typical in - boreal forest
- mountain forest
- Connected mainly with spruce
- Clear area – conditions for pioneer trees
- In temperate forest (gap)
pioneer – rare, after disturbance



Examples of position pioneer tree species in temperate (nature – virgin) forest

- Badinský virgin forest – Slovakia
- Protected from 1913, 30,75 ha
- Natural conditions: fir – beech zone (700 – 780 m, 5 °C, 850 mm)
- 1947 wind calamity- 5 ha clearing:
 - 5 years after young willow stand,
 - 10 years after: will. 89 %, 6 % beech, 3 % fir, 2 % birch, aspen, elder.
 - 20 years after: transitional forest – beech, fir, maple – begins to prevail
 - 30 years after: willow mortality under beech pressure



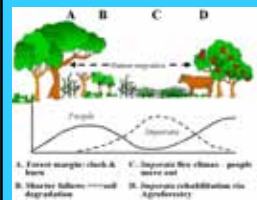
Using of pioneer to transformation allochthonous spruce stands

- Spruce-pine monoculture
- Declining of spruce stands
- Clearing – environment for pioneer
- Gap – climax tree sp.
- Transformation – un-even ages and species,
- Tress – Birch, Aspen



Birch (*Betula pendula* Roth.)

- Fertility (seed produce and spread)
- Soil conditions (mineral soil)
- Climatic condition
- Fast grow in young - 0,5 m first years
- Economic possibilities – thinning, fuel wood
- Transform - underplanting



Thank you for your attention

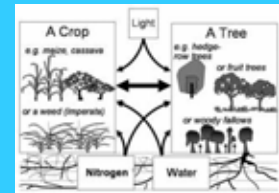


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