
ARTIFICIAL FOREST
REGENERATION AT SANDY
AND DRY HABITATS

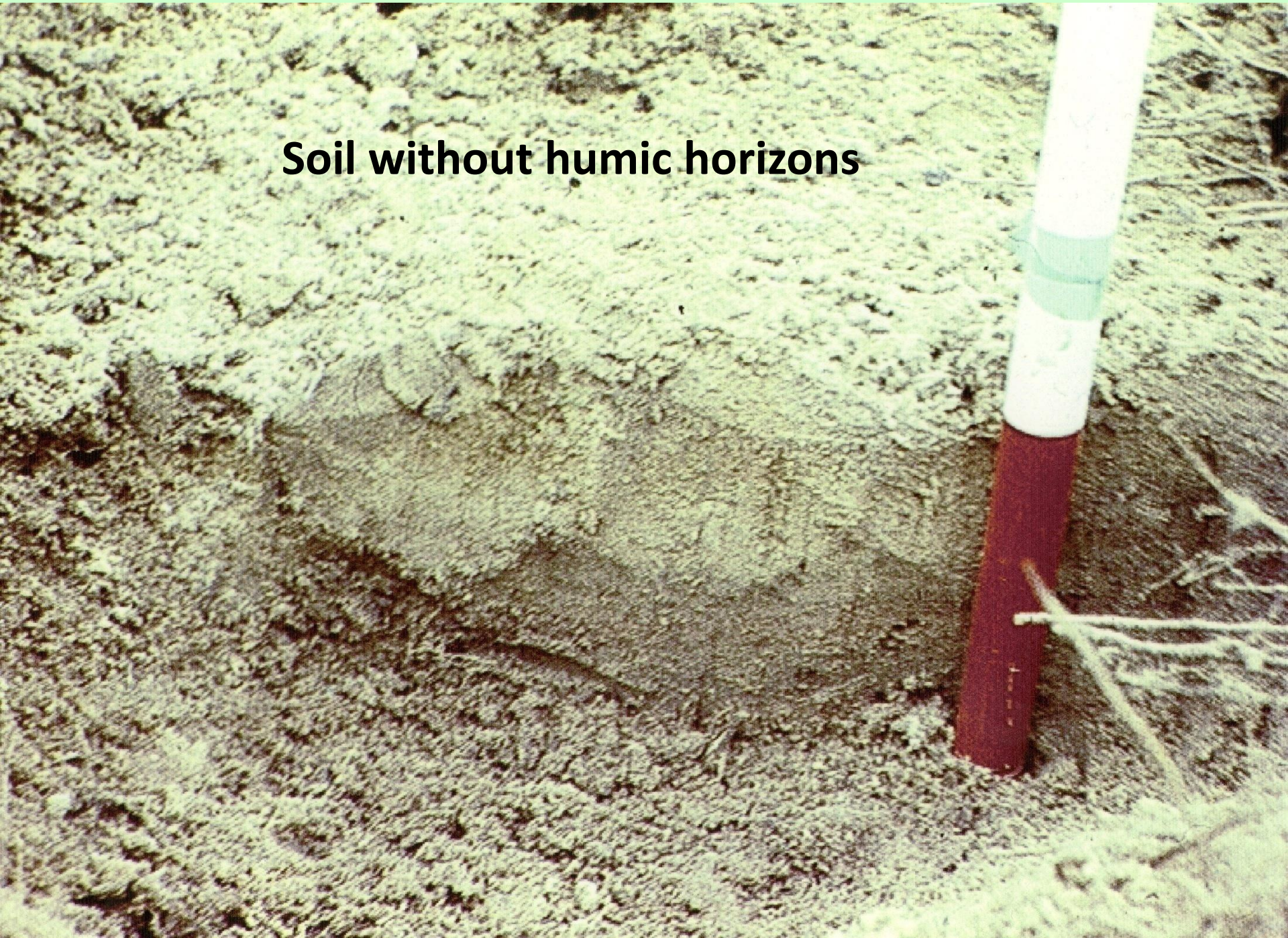
THE ECOTOPE ANALYSIS

- Mostly plane
- Small amount of precipitation, high temperature (up to +10°C on average)
- Soil characteristics
  - Sandy soil
  - High water and air permeability
  - Low water capacity
  - Capillary water - mostly unavailable
  - Low nutrient content
  - Lack of organic mass in the soil but accommodation of raw humus!
  - Surface temperature up to +60°C!

- **Movement of sand => mechanical damage of plants, plants buried in sand**
- **Persistent weed, especially *Calamagrostis* (grass)**
- **Often damaged by cockchafer (*Melolontha* sp.)**
- **Favorable characteristics – deep and cultivated land**
- **Physiological damage of the plants**
  - **Permanent wilting - transpiration is higher than reception**
  - **Overheating of tissues - denaturation of the protoplasm (proteins)**

Grown weed before the regeneration

Soil without humic horizons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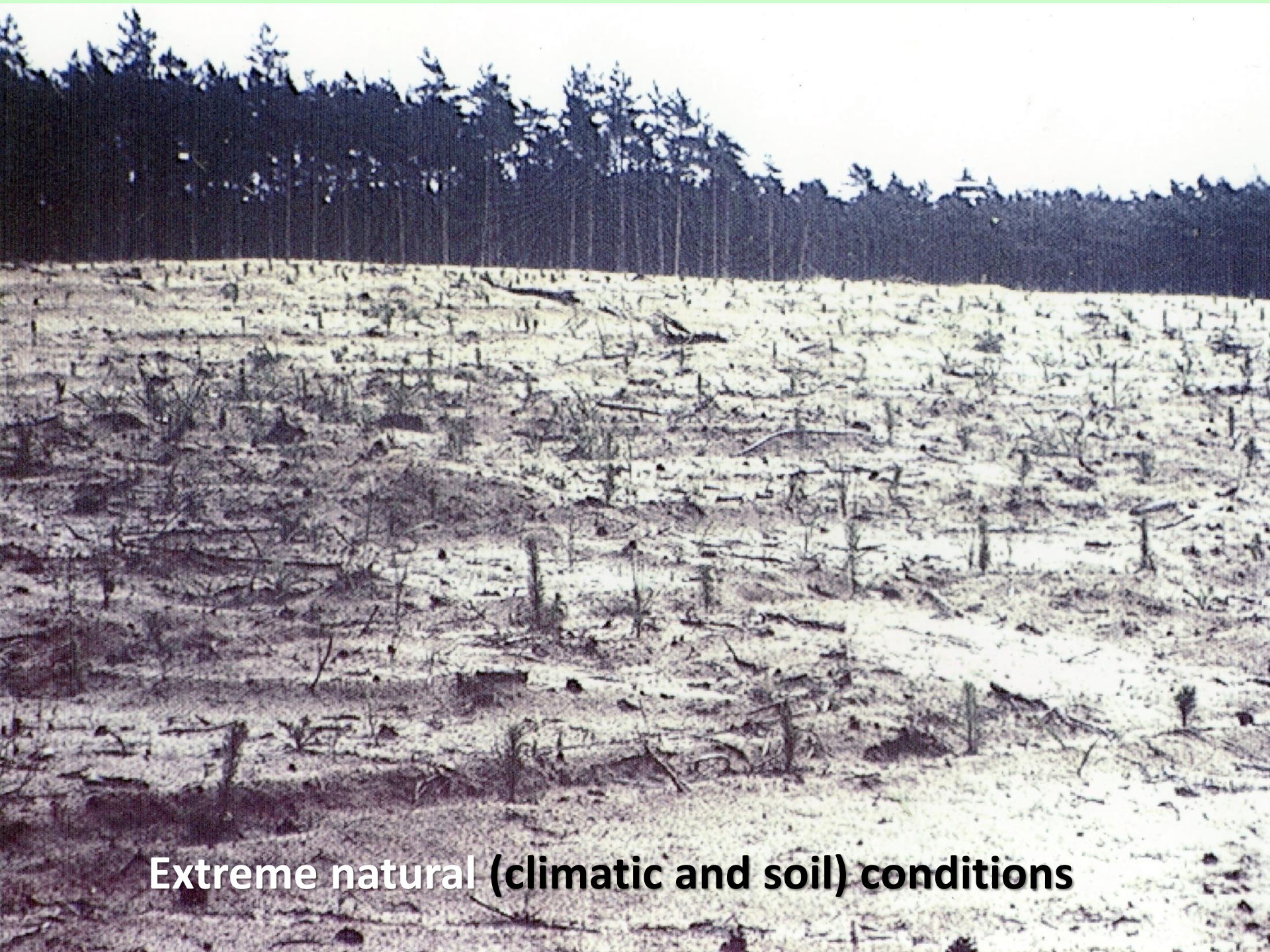

Extreme natural (climatic and soil) conditions

MAIN CONCLUSIONS FROM THE ECOTOPE ANALYSIS

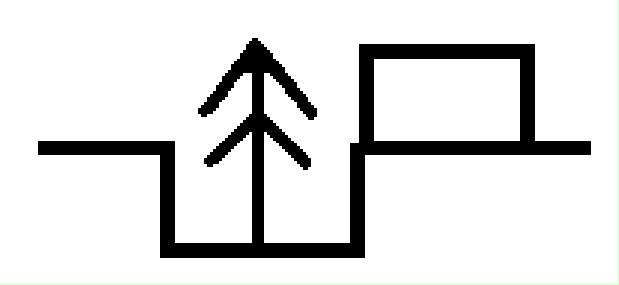
critical factor - lack of organic matter, high temperatures

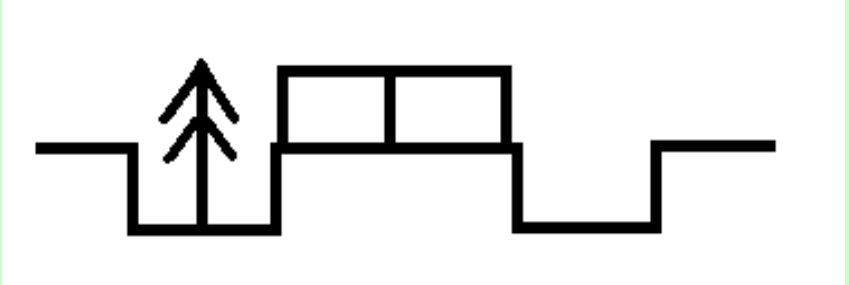
- Treatment of the site – mechanic
  - Provide for a higher proportion of the organic matter in the rhizosphere
  - Eliminate the weed and the cockchafer
- Tree species
  - Suitable for poor and dry habitats
- As young planting stock as possible
  - Able to adapt in general
  - Able to grow at places with high surface temperatures
- The regeneration should be realized on larger areas (above 2 ha)
  - Light-demanding plants

- **Traditional ways of planting <u>agricultural crops in inter-rows</u> of tree species, but the regenerated areas should not be grassed or raked (the forest litter removed)**
- **After whole-area mechanical treatment, the protection against pine weevil is not necessary**
- **Can be connected with the natural and artificial regeneration of pine tree**
- **There may be heavily wet spots (tangles; in this case *Alnus* should be used)**

TREATMENT OF THE HABITAT – FURROWING

- **Single-side and double-side furrows (made also with disc cutters)**





- **Planting on the furrow bottom – “sunk”**
- **The treatment of soil only deals with the negative influence of weeds and deeply located water (the slice gets mineralized quickly)**

- **Advantage – stumps are not removed - better economics**
- **More suitable – stripe cutting (use disc cutters in rows)**

  - does not disturb the ecosystem

  - provides the organic matter


Treatment of the habitat by furrowing on the sand


Treatment of the habitat by furrowing

Creating furrows


Treatment of the habitat by furrowing on the sand

Narrow width cutter AHWI

TREATMENT OF THE HABITAT – FULL-AREA (BROADCAST) PLOUGHING

- **Most suitable method (ploughing-in humic horizons)**

1. Stump removal

- **Grubbing, plucking, firing, drilling, milling**
- **The humus must not be removed or re-layered**

2. Stump disposal

- **Creation of piles (to reduce the wind speed, occupy the land, to create a cover for pests; decomposition for decades)**
- **Sale**
- **Burning the piles (the least suitable method)**
- **Burying the piles (they are integrated in the soil; disadvantage = the soil drops down wherever covered)**

3. Root combing (cultivator, manual collecting)

4. In the autumn: deep ploughing
   - Min. depth: 45 cm
   - Organic or mineral fertilizers can be applied

5. In the spring next year
   - The terrain is levelled (a log, dragged); followed by planting

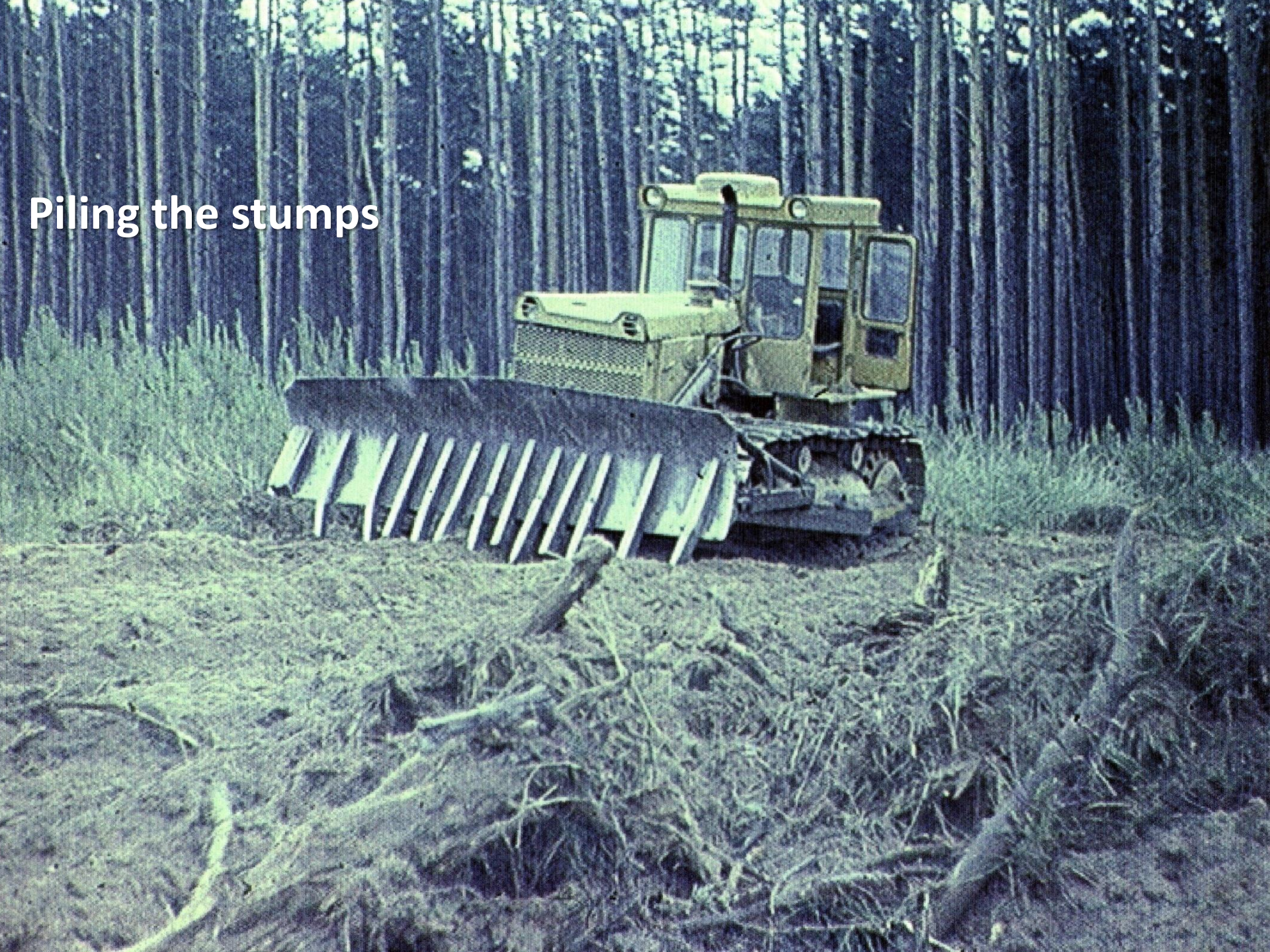
Planting, year 2
   - If the weed is present – 1-year-long fallow (not used, the weed is processed into the soil)
   - Lack of the organic matter – 1-year-long green fertilization

Full-area cutting: not recommended; if wood is processed (crushed brushwood), nitrogen needs to be added

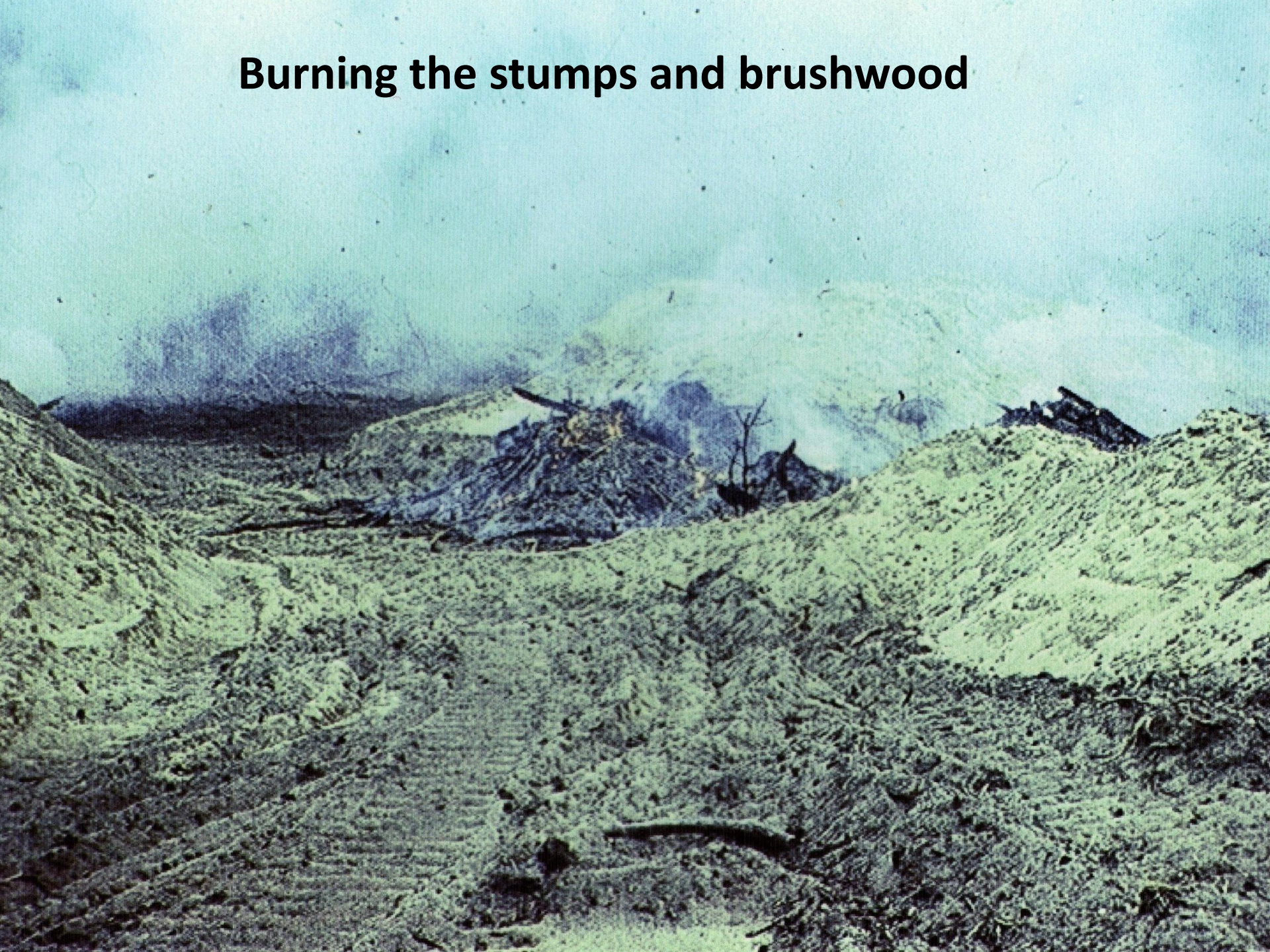
Tearing cod off or dozer treatment - inacceptable.

The weed must not be eliminated by controlled fire.


The area for afforestation with grubbed stumps


Piling the stumps

Burning the stumps and brushwood




Furrowing

THE TYPES OF THE SPECIES TO BE USED

- **As young planting stock as possible – preferably the one year old**
- **Sowing is risky**
- **Completing with natural regeneration is suitable (after mechanical treatment)**
- **Main species: pine tree, the portion of amelioration species at least 30% (*Tilia cordata, Quercus robur, Quercus rubra, Betula, Carpinus betulus, Robinia pseudoacacia, Acer negundo, Fraxinus excelsior;* wet habitats: *Fagus sylvatica*)**
- **Coniferous: also suitable are: *Pinus nigra, Larix decidua***
- **For the driest habitats: *Tilia tomentosa***
- **Naturally regenerated spruce has the sheltering and modifying (tending) functions, aggressive regeneration should not be allowed (WALLENSTEIN MIXTURE)**

PLANTING

- After full-area treatment, after the soil becomes flattened (4 months) – mechanized operations are possible
- After treatment by furrowing (in belt) – manually (or with use of machinery)
- Bare-rooted planting stock is used
- Negatives of containerized planting stock:
  - The ball of soil covering the root system gets dry quickly (peat)
  - Different chemical properties of the ball of soil on the roots and of the soil => deformation of the root system
  - Do not use containers that allow root penetration – do not decompose => deformation of the root system

Positives: Less damage caused by cockchafer

- **The planting must be made carefully to avoid root system deformations**
- **Manual planting: organic matter should be added onto the roots**
- **Planting – below-level and sunk (the plants are close to the ground water)**
- **The roots should be protected with anti-desiccant**
- **After the planting: starting fertilizers are recommended (slowly releasing)**
- **Hydro-absorbents: can be applied**

PINE TREE INCREMENT (1+0, HS 13) AFTER HUMIC HORIZONS WERE REMOVED
Year 1 after the planting

Technology	Increment (%)
1. Removal of humic horizons	100
2. ad 1 + 0.1 l of organic matter added	185
3. ad 1 + 0.3 l of organic matter added	171

THE INFLUENCE OF HYDROGEL APPLICATION ON THE MORTALITY (%) OF SPRUCE 2+2 IF THE DRY SPELL PERIODS VARY

		Dry spell	
		3 weeks	6 weeks
Spruce Stress 0 min	Without hydro-absorbent	10	52
	With hydro-absorbent	8	14
Spruce Stress 30 min	Without hydro-absorbent	55	91
	With hydro-absorbent	23	31

Stress = exposure to drying before planting


Planting the pine tree after furrowing

Planting the pine tree into the furrow


The pile of roots protects the area to reforested against wind

Planting the pine tree

TAKING CARE FOR YOUNG PLANTATION

- Compared to other habitats
  - Lower evaporation
  - Consistent elimination of the weed pressure (the pine is the most vulnerable tree species)
  - Releasing of poured-over plants (sand)
- After the full-area treatment – soil loosening
  - Min. 2 years, min. twice per year
  - Mechanized in between the rows
  - In the row: manually – including the releasing of the poured-over plants
- Loosening is also beneficial after stripe and furrow treatment


The surface area after loosening in between the rows


Loosening the rows with tree species, releasing the tree species from the sand

REFORESTATION OF HEAVILY WEEDED LOCALITIES

REFORESTATION OF WEEDED LOCALITIES

- **Occurrence in any altitudinal zone**
- **The cause of the weed spreading – inappropriate management approaches and procedures**
- **Why weed is harmful:**
  - competition in terms of nutrients and water
  - fight for light, leading to limited or reduced growth of the plants
  - creeping weeds may throttle the plants 
  - allelopathic relationships in the root system zone (adverse effects of root exudates, if the depth of the plant and weed rooting is the same)
  - if in the winter season the weed is taller than the plants, supported by the snow cover the weed will overlie the plants (which results in mechanical damage of broadleaves, at conifers nearly every time parasitic fungus will appear – *Herpotrichia nigra*)

REFORESTATION OF WEEDED LOCALITIES

- **herbs cause less problems than grass (main problems are related with *Carex* and *Calamagrostis)* and less trophic habitats**
- ***unwanted plants, however, may fulfil sheltering and tending (modifying) functions***

Afforestation concept:

1) **To eliminate the negative effects of the weeds**
2) **So that the planting stock grows over the weeds as soon as possible**

- **the standard reforestation techniques – the planting into holes and the mechanic protection against weeds do not lead to success**

  - ***necessary***
    - **loosening approx. 3 times**
    - **cutting around approx. 6 times**

1) CHEMICAL WEED ELIMINATION

- application in stripes (not full-area)

- very strong, preferably containerized planting stock

- in stripes, elimination (cutting) of the weed several times

- total herbicides without residua

2) *MECHANICAL WEED ELIMINATION BY PLOUGHING*

- **preferably full-area (the effects last for 3 years); furrowing does not show any significant effects (max. 1 year)**
- **soil up to 40% of clay → otherwise the soil will get flattened again soon**
- **in the summer: ploughing to 20 cm, "vertical slice"**
    - **the roots get drier**
    - **it is recommended to provide lime (Ca) on the surface**
- **in the autumn: deep ploughing**
- **in the spring: levelling and afforestation, level planting**
- **full-area cutting (cutters) is not recommended, removal of sod from larger areas is not possible**

- **if the weed is persistent – *fallowing* or *planting agricultural crops in between tree species***
- **preferably strong plants; *drought* - short plants, well developed root system**
- **the species that would not develop properly in open spaces such as *Abies alba, Fagus sylvatica, Pseudotsuga menziesii* - should not be used - instead, underplanting is recommended**
- **15-30% amelioration species – *Tilia, Carpinus betulus, Betula, Quercus rubra, Alnus, Populus tremula, Sorbus aucuparia***
- **it is necessary to loosen the soil and remove weeds in years 1 and 2**
- **regular spacing (in rows)**

3) GRASS LAYING

- Mown weed is put into layers (min 30cm) at the site; after 4 months the layer is spread, the tree species are planted, the layer is put back

4) USING LARGE SIZED PLANTS AND SAPLINGS

5) ELEVATED PLANTING

6) PREPARED STANDS BEFORE CAN BE USED

- *Betula, Alnus, Populus tremula* – followed by reconstruction/underplanting

- shrubs, blueberries, heather, genoa should be plucked with roots

Also possible

- grass laying

- bio cloth

- fallowing

- pancake-like planting

- temporary planting of agricultural crops in-between rows

- plants: chemical protection; in-between rows: mechanical protection

- *planting stock* – **well developed, containerized**
- *composition* – **depending on the forest type**

Care of young plantation

- **Weed elimination – line planting, also mechanized line planting**
    - **cutting around at least 3 times**
    - **mulching**

- Often: elimination of the weeds and use of tall plants

- Frequent interventions will change the herbal vegetation into grass

- Cutting around to form a “high stubble field” (at the level of the tree species) will stimulate the growth and inhibit forming doubles (double stems)

THE INFLUENCE OF CUTTING AROUND ON „THE HIGH STUBBLE FIELD“

		Height above ground (cm)	% of double stems
Quercus	High stubble field	160	18
	Full-area cutting	95	37
Abies alba	High stubble field	148	2
	Full-area cutting	78	13

THE CHANGE IN THE WEED COMPOSITION AFTER VARIOUS WAYS OF ITS ELIMINATION (*Urtica* habitat)

Treatment method	1 year after intervention		3 years after intervention	
	% of grass and *Galium*	% of herbs	% of grass and *Galium*	% of herbs
Low stubble field	75	25	95	5
High stubble field	5	95	36	65
Herbicidal stick	5	95	65	35


Weeded locality


eded locality

Weeded locality


Weeded locality


eeded locality


eeded locality with full-area mowing


Weeded locality
(*Urtica dioica*)


Weeded locality
(*Galium aparine*)


eeded locality


eded locality

Weeded locality after full-area treatment of soil by ploughing

Weeded locality after full-area treatment of soil

Weeded locality after full-area treatment of soil


Weeded locality after full-area treatment of soil and marking rows for planting tree species

Soil loosening (elimination of weeds) in the in-between row

Planting after loosening of the soil in the in-between row

Afforested weeded locality during the care for the young plantation

Veeded locality after full-area treatment of soil by ploughing
nd sowing

Prepared stand on a weeded locality

REFORESTATION IN HABITATS EXPOSED TO FROST

REFORESTATION IN HABITATS EXPOSED TO FROST

Frost is caused

- **by inflow of cold air**
- **heat radiation out of the soil**
- **occurrence of water**

terrain depression, inversion valley, also planes

- **Both early and late frost cause damage (even in June)**
- **Frost may occur at any altitudinal zone, worst damage happens in lower altitudes**

- symptoms of damage
  - the shoot is losing the turgor (the pressure of the water inside the tissues) - it is bending down and the color is changing into brownish - the leaves falling off
  - leaves – getting brown and falling off
  - the plant will regenerate but damage happening every year is not acceptable – often multiple trunks will develop
- damage up to the height of 1.5-2.5m (or even higher at terrain furrows – this should be mapped before planting)
- afforestation concept:
  1. do not let the frost occur
  2. reduce the effects of the frost by means of vegetation
  3. accelerate the growth so that the planting stock is moved out of the frost zone as quickly as possible

1) Do not let the frost occur

- **drain the site**
- **open the stands → let the air circulate**
- **build obstacles – direct the movement of the air/frost**

2) Reduce the effects of the frost by means of vegetation

- **plant a prepared stand (able to withstand the frost attacks) (stand density at least 0.8, preferred spacing 1x1 m)**
- **under this protective stand, after 6-12 years target species should be planted (full numbers, depending on the locality - planting across the entire site)**
- **prepared stands - *Pinus, Betula, Alnus incana, Sorbus* (but small crowns)**

- **Not species sensitive to frost and light demanding (*Fraxinus, Fagus, Pseudotsuga menziesii, Quercus*)**
- **the prepared stand can be removed only after <u>the target species reach above the frost level</u>**
- **instead of prepared stand: the plants may be overlaid by weeds (intentional/calculated sowing – uncultivated rye)**

3) Provide for faster growth to get away from the zone with effects of frost

- **elevated planting**
- **or large sized plants and saplings are used**
- **not species sensitive to frost should not be used very much**

- *Planting stock*
  - **as developed as possible, preferably containerized**
  - **late budding!**
  - **pine resisting to frost, the most resistant species – *Picea mariana***
- *Care of young plantation*
  - **maintaining a drainage network, hills**
  - **support to vitality – fertilization, borax (B), weed elimination (but we can also keep the weed)**
  - **after planting: the plants can be "treated for winter survival" (covered with sod or brushwood); if the root system would freeze out, it should be backfilled**
  - **some methods of protection against game can be useful (brushwood around the plant etc.)**

REGENERATION OF SPRUCE 2+2 IN THE FROSTY ZONE (1m above ground)

Regeneration method	Time of growing (years)	Mortality (%)
No selection of species Level planting	8	60
Late budding species Level planting	4	5
No selection of species Elevated planting	3	21

Localities exposed to effects of frost (in the nursery: liquid fertilizers in the last year of the cultivation, planting at the locality exposed to frost, the freezing height approx. 80 cm)

Cultivation method	Nursery				5 years after planting			
	Spruce 2+2		Fir 2+3		Spruce 2+2		Fir 2+3	
	Mortality (%)	Height (in % of control)	Mortality (%)	Height (in % of control)	Mortality (%)	Height (in % of control)	Mortality (%)	Height (in % of control)
Fertilization K-1x	**14**	**105**	**8**	**94**	**73**	**100**	**87**	**100**
Fertilization P-1x	**9**	**95**	**11**	**102**	**66**	**105**	**86**	**103**
Fertilization P+K-1x	**11**	**97**	**14**	**100**	**67**	**106**	**83**	**97**
Fertilization P+K-2x	**14**	**104**	**12**	**106**	**38**	**100**	**45**	**101**
Fertilization Bo-1x	**14**	**101**	**12**	**94**	**10**	**408**	**22**	**365**
Fertilization Bo-2x	**12**	**97**	**13**	**98**	**9**	**396**	**11**	**382**
Control variant	**12**	**100**	**14**	**100**	**65**	**100**	**84**	**100**

The influence of the boron applied after planting (the mortality after 3 years)

Tree species	Without boron	With boron	Grass laying
Spruce	**41**	**12**	**19**
Beech	**62**	**17**	**31**
Fir	**53**	**14**	**25**
Pine	**7**	**8**	**12**

Localities exposed to effects of frost - prepared stands: birch, after 12 years

	Right planting of spruce	Underplanting of spruce	Right planting of beech	Underplanting of beech
Motality (%)	**34**	**25**	**52**	**65**
Height (cm)	**180**	**490**	**170**	**390**
Double stem (%)	**57**	**4**	**10**	**55**

Spruce damaged by frost

Heavy damage by late frost – *Picea abies*

Heavy damage by late frost – *Picea abies*

Heavy damage by late frost – *Picea abies*

Heavy damage by late frost – *Fagus sylvatica*

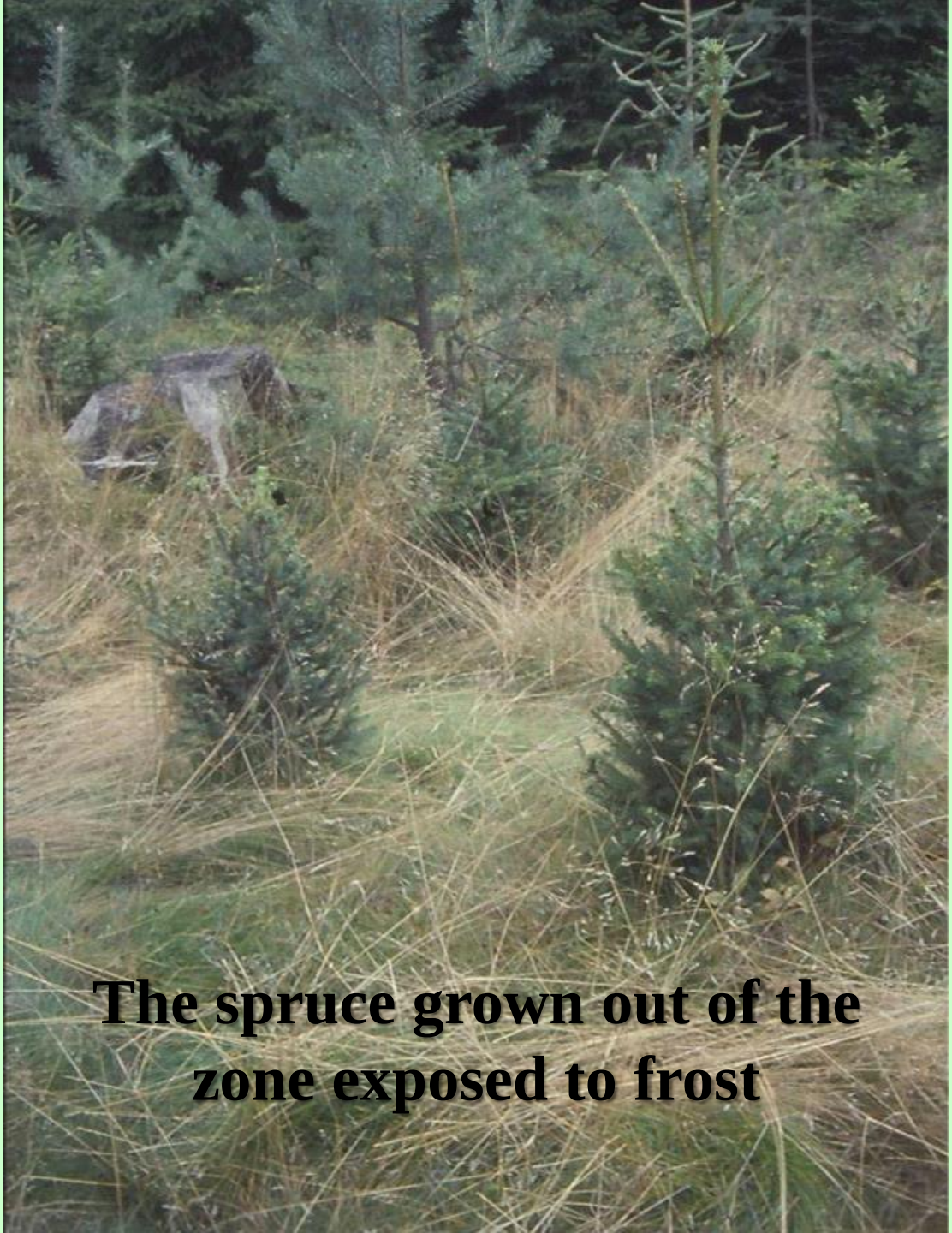
Heavy damage by late frost – Acer pseudoplatanus

Regeneration after damage by frost

Terminal bud damaged by frost

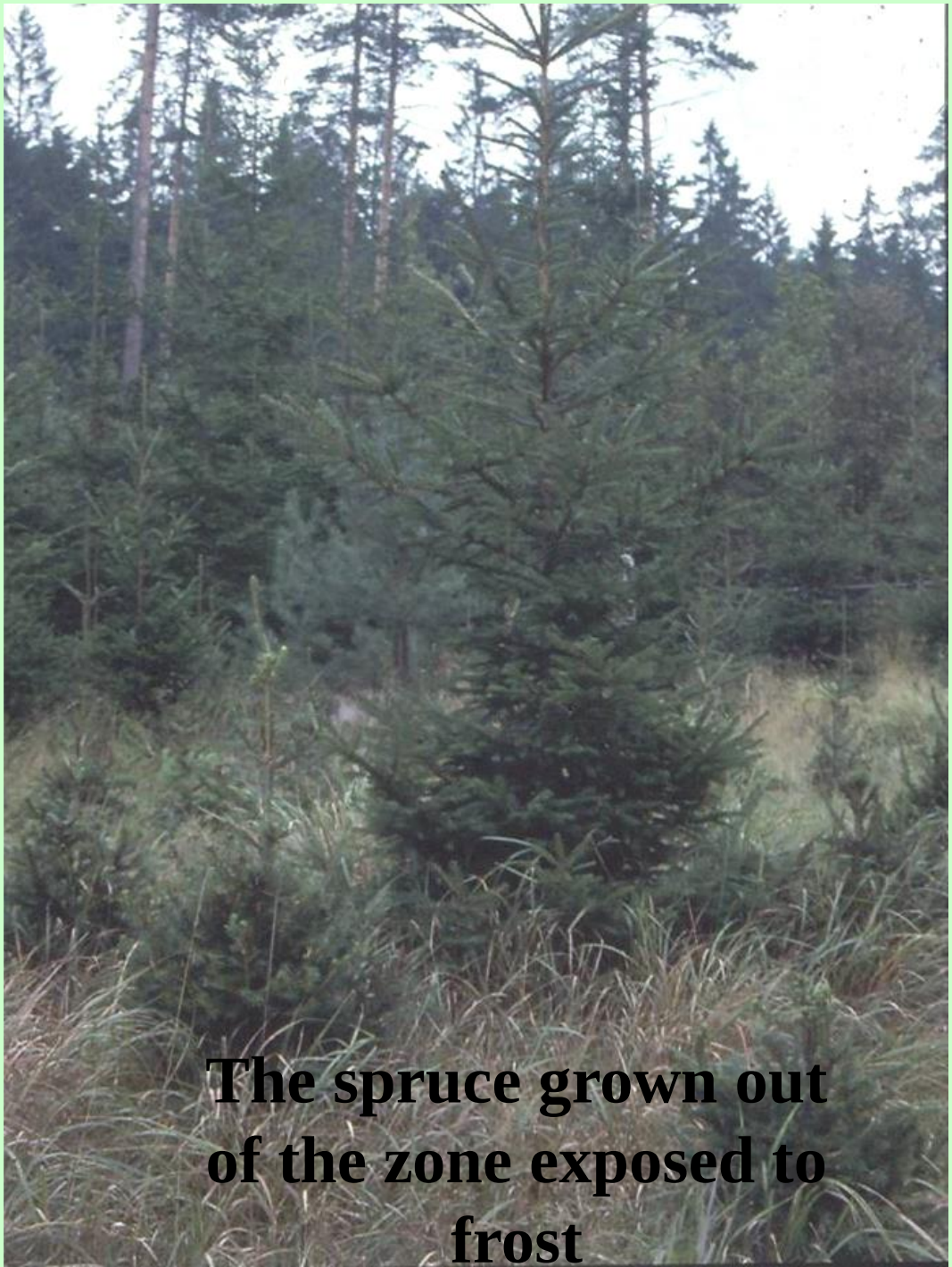
The spruce grown out of the zone exposed to frost

Terminal bud damaged by frost



The spruce grown out of the zone exposed to frost

The spruce grown out of the zone exposed to frost



The spruce grown out of the zone exposed to frost

REFORESTATION OF HIGH MOUNTAIN LOCALITIES

HIGH MOUNTAIN REFORESTATION

- the environment is specific due to climatic conditions
- occurrence at altitudinal zones 8 and 9 but 7 as well
- depands on vertical divisions and different exposure of the slopes (the north being the worst)

- **limiting factors:**
  - **short vegetation period**
  - **the soil gets deep frozen**
  - **the snow melts late**
  - **wind**
    - **decreases the temperature**
    - **has influence on the growth of the above-ground part of the plant**
  - **hoarfrost**
  - **rainstorm**
  - **persistent weeds**
  - **lack of snow cover →**

→ “frost needle blight”

For regeneration: the heat is necessary (and the light as well)!

TREATMENT OF THE HABITAT

- depending on the characteristics, shows also the features typical for wet, weeded, exposed to frost zones; erosion (air pollution) + high altitude
- you should keep in mind the occurrence of the main agent + high mountain position
- do not disturb the soil surface – avoid internal erosion

SUITABLE SPECIES

- ***Picea abies, Abies alba, Larix decidua, Pinus mugo, Pinus cembra, Acer pseudoplatanus, Sorbus, Fagus sylvatica, Pinus sylvestris*** **(highland ecotype)**
- **well-developed plants with rich root systems**
    - **using large-sized plants is not suitable – they fall down because of snow or wind**
- **CONTAINERIZED PLANTING STOCK**
- **cultivated in acclimatization nurseries!**
- **of suitable origin (this is more important than in other habitats)!**
- **for altitudinal zones 8 and 9, there is a different sorting of the planting stock**

THE INFLUENCE OF UNSUITABLE ORIGIN OF THE planting stock on the quality of the stand (altitudinal zone 7, spruce 2+2 originating from altitudinal zones 5 and 7, assessed 17 years after planting)

The origin of the planting stock (altitudinal zone)	Time for growing (the care is necessary) (years)	Mortality (in % of trees)	Depth of the root system (cm)	Size of the root system shape (as a % of the control)	Height (as a % of the control)
7 (control)	6	13	54	100	100
5	9	47	27	74	63

Success of regeneration in the altitudinal zone 7 depending on the planting stock used, 5 years after planting

Planting stock	Mortality (%)	Height (%)
beech 2+0	47	42
beech 1-1	27	100
beech 1-1-1	72	74

Success of regeneration in the altitudinal zone 7 depending on the planting stock used, 5 years after planting

Planting stock	Mortality (%)	Height (%)
beech 1-1	24	73
beech fv1	12	100
spruce 2+2	31	64
spruce fv1+v1	16	100

Mortality 3 years after planting (planting at altitudinal zone 7)

- **Spruce – nursery at altitudinal zone 4 – 78 %**
- **Spruce – nursery at altitudinal zone 7 – 15 %**

- **Beech – nursery at altitudinal zone 3 – 84 %**
- **Beech – nursery at altitudinal zone 6 – 22 %**

- **do not plant the spruce with flat branching (will be damaged by snow)**
- **up to altitude of 1 000 m - height transfer up to 200 m**
- **above 1 000 m – height transfer up to 100 m**
  - **the transfer depends on average temperature**
  - **do not transfer anything from lower altitudinal zones to the altitudinal zone 7**

REFORESTATION UNDER FOREST BORDERS *(limiting factor – the heat)*

- elevated sites are preferred (irregular spacing)
- elevated planting (hills) – near stumps
- the plants should not be sunk, should not be planted into humus,
- low number per 1 hectare – freely grown crown, well-developed root system
- additional soil if needed

- smaller clear-cut areas
- positive influence of surrounding stands

Regeneration in habitats with air pollution – the growth of the spruce 2+2 depending on the type of planting stock (forest altitudinal zone 7, endangered zone A – air pollution, quality planting stock

Type of planting	Mortality (%) after			Height increment (%) after the 3rd winter
	1st winter	2nd winter	3rd winter	
Elevated	7	11	12	160
Level	7	15	21	105
Below-level	14	27	43	73

The high mountain habitat after treatment of soil for reforestation

FOREST BORDERLINE – FREE AREAS

(limiting factors – wind, climate etc.)

Before planting, it is necessary to:

1. **reduce the speed of the wind (barriers, artificial obstacles)**
   - **lines of preparated species (shelter lines)**
2. **start from the places easiest to regenerate (nests)**
   - **these places need to be gradually extended in the direction against unfavorable wind to form "wedges"**
3. **planting preparated species**

→ ***BETULA PENDULA ssp. PENDULA***

→ ***BETULA PUBESCENC ssp. CARPATICA***

→ ***SALIX AURITA***

→ ***SORBUS AUCUPARIA ssp. GLABRATA***

→ ***ALNUS VIRIDIS***

- **underplanting target species**
    - **layering should be used (also in planted plants)**

- also: planting “at parent trees”

UNDERPLANTING (limiting factors – the heat, the light etc.)

- **should be used at sites where liquidation of the stand is not anticipated (erosion, avalanches) or where the site is difficult to access**

- ***Sorbus aucuparia, Betula pubescens ssp. carpatica, Picea abies, Pinus mugo*** **(lower: *Fagus sylvatica, Acer pseudoplatanus*) - should be cultivated in sheltered nurseries – shadowy tissues!**
- **up to 1 100 m above sea level (up to forest altitudinal zone 7)**
    - **reduce density of the prepared stand (40-60%)**
    - **full-area underplanting**

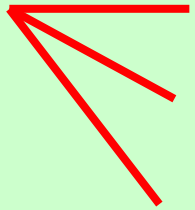
- above 1 100 m above sea level (upper part of the forest altitudinal zone 7 and above)
    - in groups – small clear-cut areas
    - if necessary: removal of several trees (light – heat)
    - small groups (max. to the height of the tree)
- do not remove the wood mass but keep it
    - in the east–west direction (best)
    - along the contour line
    - no hills but walls

- **natural regeneration on the trunks**
- planting into trunks or logs ("Saprofyt method")
- **planting into the protective zone provided by trunks, stumps, rock (such protection includes elimination of the effects of moving snow)**

General rules

- find best places for the nests
- establish the nests by sowing as well (under artificial covers)
- autochthonous stands show 4 times higher resistance
- it is necessary to know the local conditions, “standard” projects would not be successful
- eliminate moving snow

TAKING CARE FOR YOUNG PLANTATION

- **Firstly: weeds mean**  **shadow**, **pressure**, **overlying**
- ***Calamagrostis* – intervention in July and August**
- **weeds should never overgrow the planting stock**
- **low weeds (*Vaccinium myrtillus, Nardus stricta, Calluna vulgaris*) is not to be removed**
- **cutting around – only individual, the stubble field should not be too low (scythe, short scythe, matchet)**
- **mulching cloth**
- **also: manual tearing off (by hand)**

- **it is necessary to repair impaired/damaged hills**
- **protection against game**
    - **fences on ropes**
- **careful work (hourly rate is preferred)**

A high mountain site at the forest boundary

A high mountain site at the forest boundary

Planting at a high mountain site at the forest boundary

Planting at a high mountain site

Elevated planting, hill-type, at a high mountain site

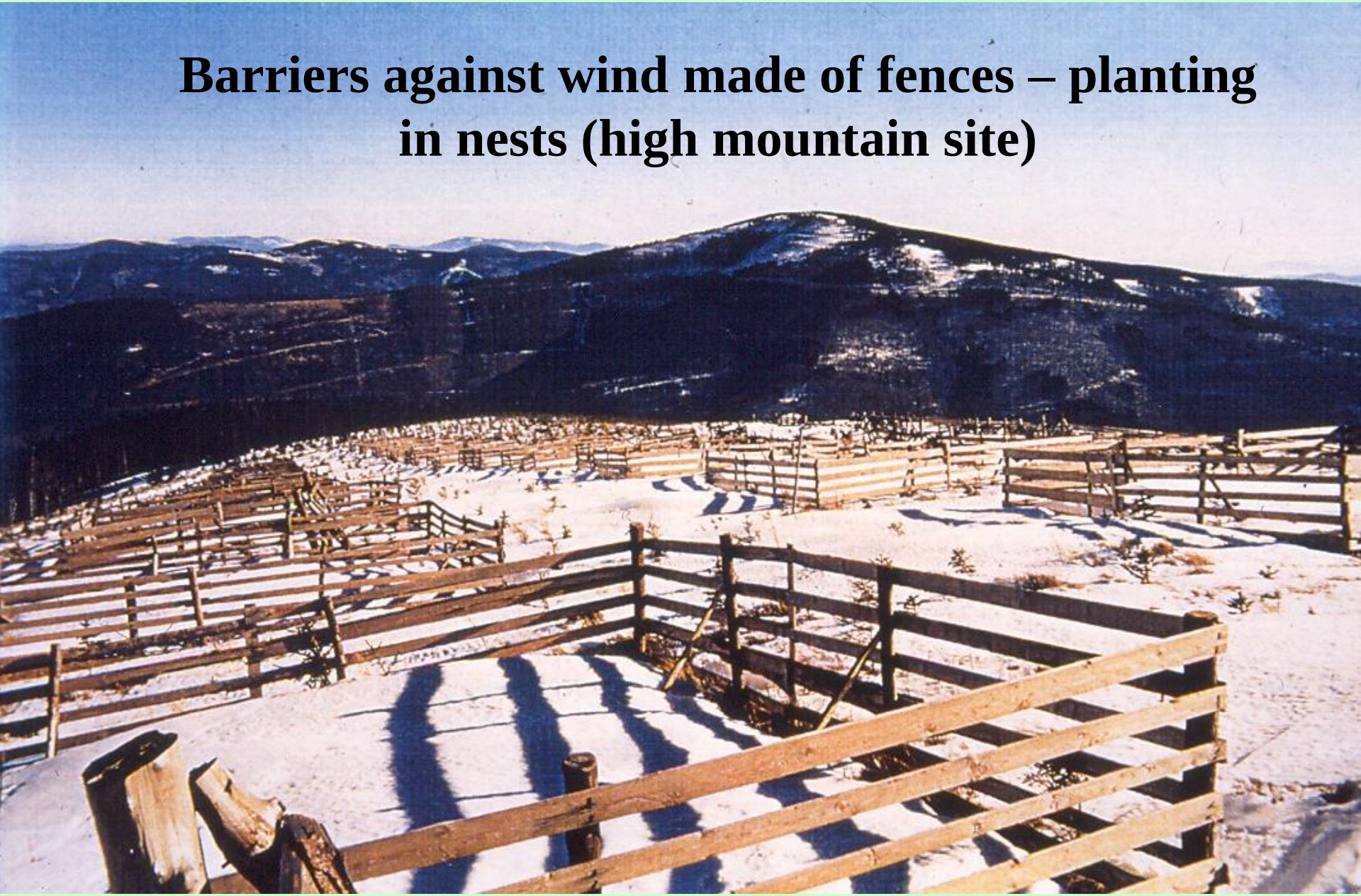
Elevated planting, hill-type, at a high mountain site

Elevated planting, hill-type, at a high mountain site

Barrier against wind (high mountain site)

Barrier against wind (high mountain site)

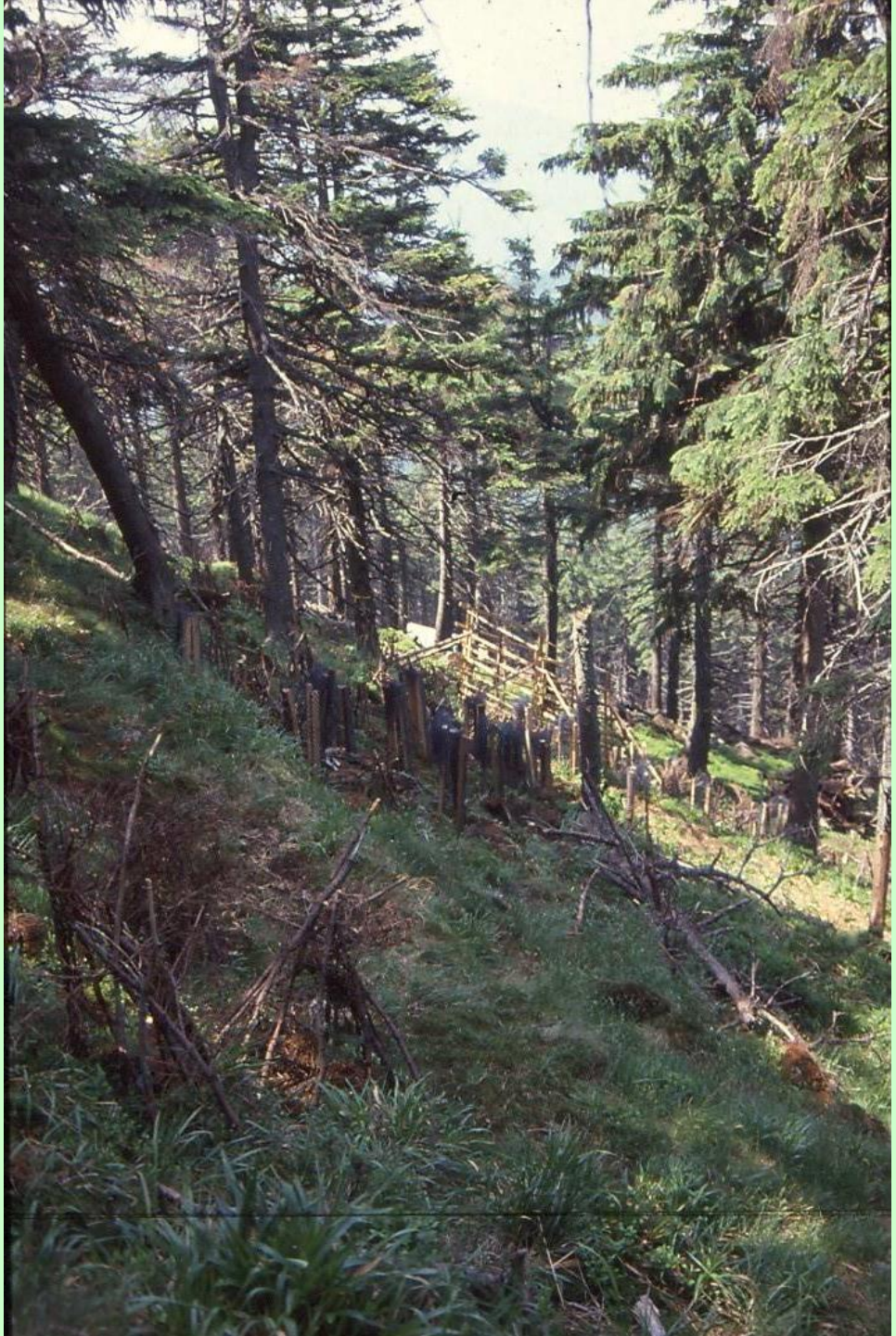
Barriers against wind made of fences – planting in nests (high mountain site)



Reforested gap with individual protection against game (high mountain site)

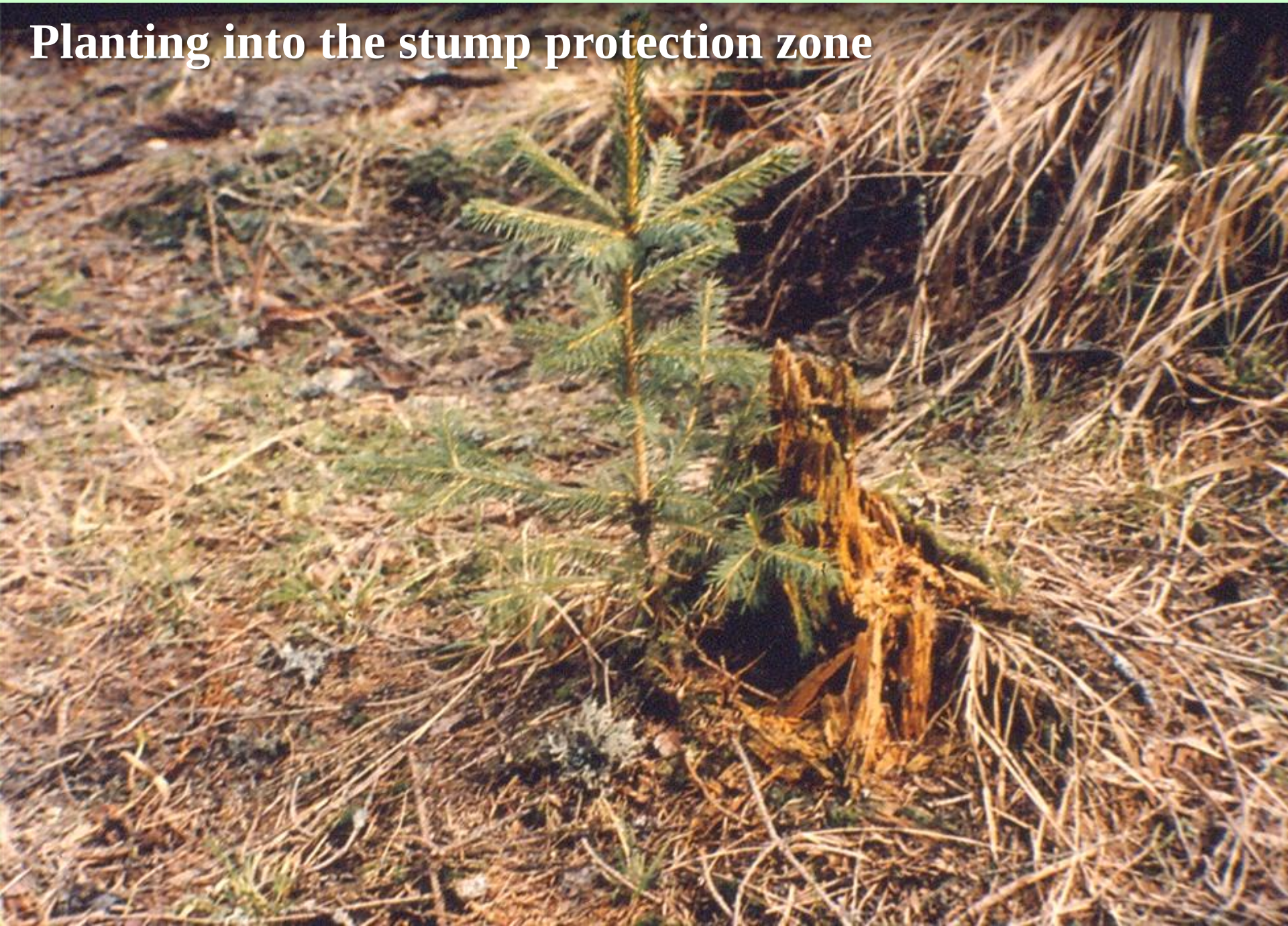
Reforested gap with individual protection against game (high mountain site)

Reforested gap with individual protection against game (high mountain site)



Planting at a high mountain site with individual protection of the trees against game

Planting into the stump protection zone



Planting into the trunk protection zone

REFORESTATION OF WET HABITATS

REFORESTATION OF WET SOIL

- Occurs everywhere in Europe and at any altitudinal zone (not so much in the valleys)
- cause
  - high level of ground water (light and medium heavy soil, peat)
  - stagnant surface water (heavy soil, tangles)

- why the areas are wet

natural conditions - terrain configuration, climate, soil conditions, floods

human activities - **poor maintenance of drainage systems, calamity or thinning of forest stands, unsuitable tree species = the soil gets flattened and compacted**

- **<u>Critical factors: water – ecologic conditions</u>**
  - **lack of O_2**
  - **limited microbial activity**

  } **→ death of trees**
  - **accommodation of raw humus → the tree species are surviving not developing**
  - **changes in the morphology of the root system, decay → windfalls of trees**
  - **also: effects of frost and weeds**

The areas periodically wetted *(inundation areas)*

- excessive water by inundation activity of water streams
- standard flooding in the spring but also in the autumn
- these are mostly floodplain forests, altitudinal zones 1 through 4 (management set of stands 19)
    - rich soil - fluvial earth, heavily weeded
- reforestation is not possible during floods or afterwards (muddy soil)
- drainage trenches are needed at all times
    - stagnant water is worse than water flowing
- PRINCIPLE - the plant (or at least its part) should be above the water at all times
- if the entire plant is under the water: max. 1 week, in deep dormancy, water temperature less than 6°C, flowing water

- **afforestation concept:**

1) **reforestation before the flooding**
2) **reforestation after the flooding**

1) reforestation before the flooding

- **in autumn, in winter, in early spring**
- **Large-sized plants or elevated planting prepared before (hills, ridges – not in localities where rainstorm may occur)**
    - the above-ground part must be above the water, at least a little
    - **both bare-rooted and containerized planting stock**
- **sowing oak from boats**
- **damage caused by ice (even in older plants)**

2) reforestation after the flooding

- **containerized planting stock (sprouted/budded plants)**

General rules

- **species corresponding to the management set or forest altitudinal zone**
  - **Broadleaves → able to regenerate easily**
- **planting agricultural plants - yes, grassing - no**
- **maintenance of draining systems and elevated planting**
- **controlled flooding (scheduled date, locality, water level; flooding with water only)**

Periodically flooded locality

Periodically flooded locality

Periodically flooded locality

Periodically flooded locality (flood-plain forest)

Periodically flooded locality (flood-plain forest)

Periodically flooded locality (flood-plain forest)

Periodically flooded locality (flood-plain forest with trench)

Permanently wet areas

- **Cause** - **increased level of ground water**
  - **wet around the year**
  - **stagnant surface water**
    - **wetting periods - spring, autumn, after heavy rain periods**

We need to know the cause!

- ***Classification of soils:***
  - **muddy soils - gley podzols (stagnant surface water)**
  - **peat soils - peat gley (stagnant surface water, litter up to 30 cm)**
  - **peaty soils (increased water level, litter up to 50 cm)**

- ***afforestation concept:***

a) mechanical adjustment of the water regime + afforestation

b) biological adjustment of the water regime + afforestation

c) the root system should be placed beyond the reach of the water (elevated planting)

!! d) do not allow the water appear – maintained network of drainage trenches, natural regeneration, underplanting

ADJUSTMENT OF THE WATER REGIME

- parallel adjustment of the air regime and microbial activity

a) **Biological procedure**

- *prepared stand* - tree species with high transpiration capacity
    - *Salix* at the height of 12 m will transpire 1 tonne of water per day
    - 30 pieces of *Salix* will transpire the same as 1 hectare of grass
- in lower altitude: *Alnus glutinosa*, *Betula*
- in higher altitude: *Alnus incana* (resistant to frost), *Betula*

- ***Alnus*** **- planting strong, two-year old plants**
  - **if the weed is not high: directly in the sod (otherwise: spots 30x30 cm)**
  - **liming (Ca) before planting**
  - **dense spacing – 60x100 cm → fast integration**
- ***Betula*** **- the same as *Alnus* or sowing**
  - natural seeding of birch works well

- to reduce the water level you need to reconstruct the stand

- **but this should not be full-area → the water will increase again**

- **at "less" wet soil: parallel planting of target species is possible**
- **level planting**

b) Mechanical method (up to CZK 60 000/ha)

- excessive water drained through a network of open trenches
- the level decreased to 0.8 to 1.2 m
    - for afforestation: 0.4 m will be sufficient
- level planting (hill-sod type)

c) Combined method (biological + mechanical)

- at sites with permanently stagnant water

+ at sites with extreme climatic conditions

  - 900 m above sea level or above
  - sites exposed to frost

+ if it is better to eliminate the weeds in this way

d) Elevated planting (approx. eur 1 000/ha)

- direct planting of target species
- also at sites exposed to frost, after draining
- also at sites with persistent weeds, after draining
- usually the hill type method is applied (approx. 2.0-2.5 thous. of hills/ha)
    - the rest is planted directly (sod planting)
- or furrowing (ridges) – in winter

After draining: chemical treatment of soil

- **mainly: pH, P, K**
- **depending on the soil analysis**
- **preferably local treatment – not for weed?!**

Heavy weed (*Deschampsia caespitosa, Carex* sp., *Juncus* sp. …)

- **cannot be completely removed → increased water level**
- **no chemicals**
- **acceptable solutions - small-scale mechanical protection**
  - **bio cloth (bark)**
  - **elevated planting**
  - **biological treatment - *Alnus, Betula, Sorbus***

PLANTING STOCK

- the strongest planting stock with well-developed root system

- prepared species – bare-rooted

- target species – containerized (fast growth, longer afforestation time)

- after mechanical draining: planting next year

SPECIES COMPOSITION *(target species)*

- depending on the altitude - *Quercus, Fraxinus, Pinus, Picea, Abies, Larix, Acer pseudolatanus* (*Fagus, Carpinus*… amelioration tree species)

- preferred:

- **deeply rooted**
- **not sensitive to water**
- **not sensitive to frost**

- it is necessary to fix the stands (fir, pine, beech, larch change the architectonics of the root system!)

Gley habitat

Fir

Spruce

TAKING CARE FOR YOUNG PLANTATION

- maintenance of the draining system
- weed elimination
- protection against game
- elevated planting – maintenance of hills

! DO NOT ALLOW THE WATER APPEAR

- NATURAL REGENERATION
- UNDERPLANTING
- STABILIZATION OF THE STANDS

Very intensive tending and level tending – strong root system

WET SPOTS ARE NOT PRESENT ONLY AT PLANES!!!

Waterlogged weeded locality

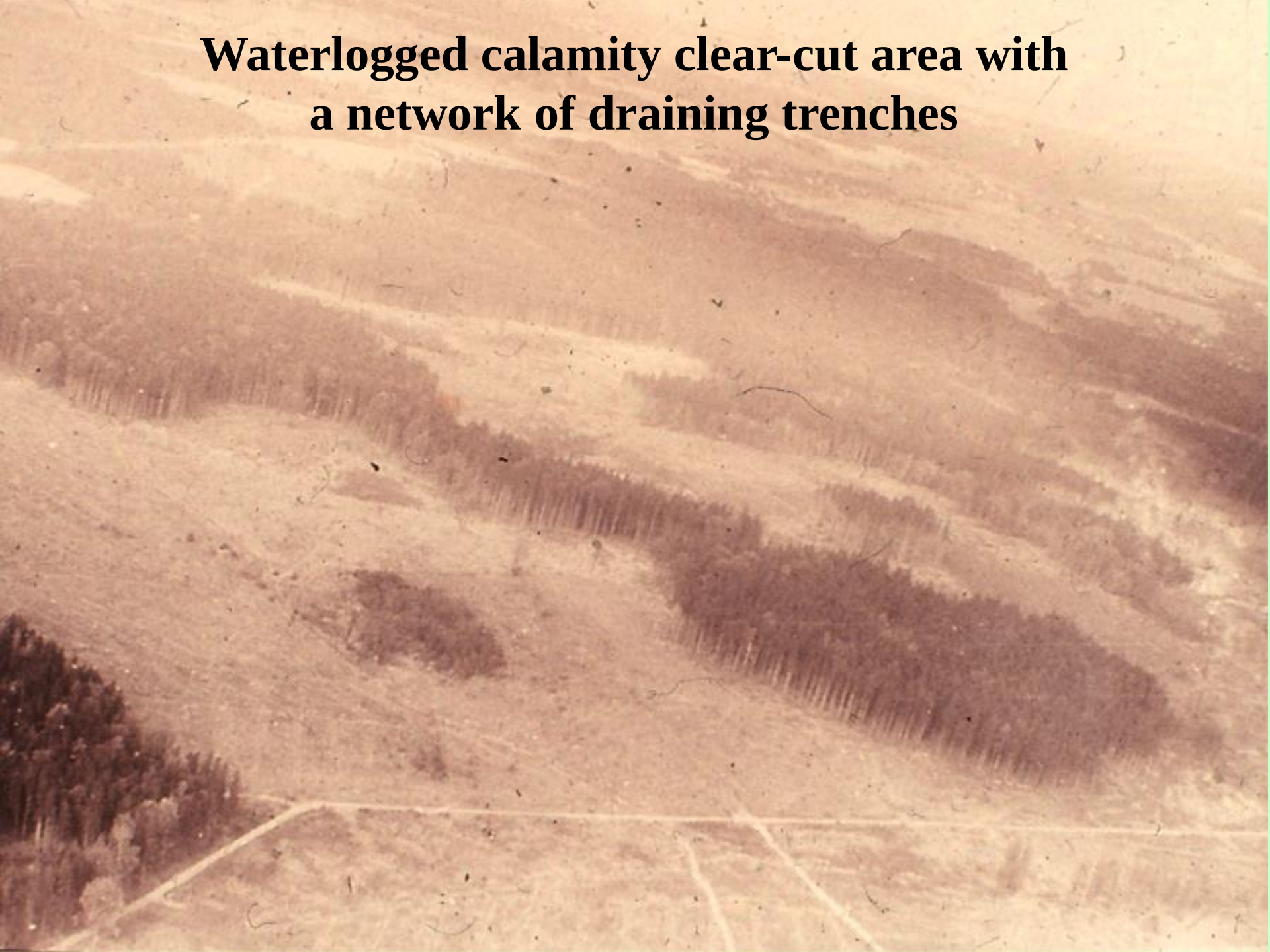
Waterlogged weeded locality

Waterlogged locality (water appears in the footprints)

Waterlogged weeded locality

Waterlogged locality with a network of draining trenches

Waterlogged calamity clear-cut area with a network of draining trenches



Waterlogged calamity clear-cut area with a network of draining trenches

Draining trenches in a waterlogged locality

A draining trench in a waterlogged locality

Draining trenches in the waterlogged weeded locality (culvert)

Draining trench


Draining trench

Preparatory stand in a waterlogged locality

A draining trench being made in a waterlogged locality

Treatment of soil (ridges, drain network) in a waterlogged locality

Elevated planting of hill type, spruce, in a waterlogged locality

Elevated planting of hill type, spruce, in a waterlogged locality

Elevated planting of hill type, spruce, in a waterlogged locality

Planting the spruce at a waterlogged site

Planting the spruce at a waterlogged site

ALTERNATE FOREST AND AGRICULTURAL CROPS

ALTERNATE FOREST AND AGRICULTURAL CROPS

= parallel planting of forest tree species and agricultural crops

- use — **sands**, **flood-plain forests**, **after peat mining**, **seed orchards** → **not to be used somewhere else: danger of soil degradation!**

- aim — **eliminate the weed**, **enrich the soil**, **enhance the growth of forest species**

- cost savings related to care – but **full-area treatment by ploughing + fencing is necessary**

- **Example: Above-ground part of *Juglans nigra* 2 years after sowing**
  - **without agricultural crops: 53 cm**
  - **with potatoes: 71 cm**
  - **with maize: 118 cm**

ORGANIZATIONAL ARRANGEMENTS

- planting agricultural crops after afforestation!

- the areas for agricultural crops must remain complete (all clear-cut area) – do not allow any isolated “islands”

- the tree species in the in-between row must be hoed manually

- planting agricultural crops: not longer than for 3 years!

- do not allow any chemicals

BIOLOGICAL ASPECTS

- **do not allow widened spacing or modification of the species composition!**
- **the agricultural crops should be the root crops**

Beetroot

- takes the nutrients most of all

=> at the same site: 1 year only (or in the year 1 and in the year 3)

- 40 cm far from the trees

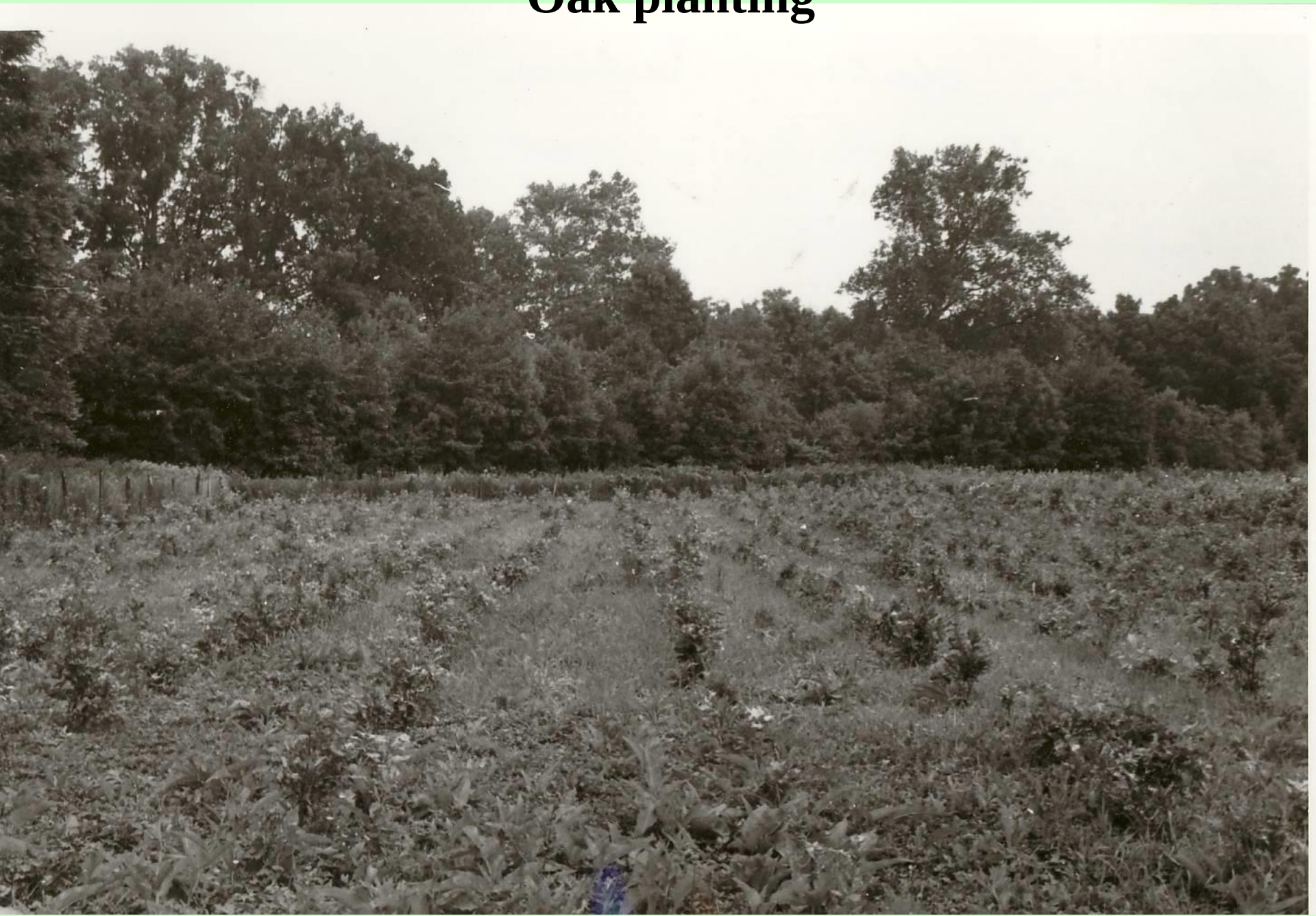
Potatoes

- 50 cm far from the trees

Maize

- 50 cm far from the trees
- in the year 2 after the afforestation
- should be removed when — frost, sunstroke
- do not allow lodging plants which do not require cultivation - pumpkins, creeping gourds, beans etc.
- onion, garlic, vegetables, flowers – all these must be 40 cm far from the trees
- not suitable in *Populus* (no alternate poplar and agricultural crops)

Oak planting



Oak planting, in-between row after harvesting the maize

Planting wall-nut trees without agricultural crops

Planting wall-nut tree after harvesting the maize

Planting of oak with maize

Planting of walnut with maize

Planting of walnut with maize

Planting of walnut with maize

Planting of oak with sunflower


Planting of oak
with potatoes

Planting of oak with beetroot


Planting of oak with pumpkins

Planting of oak prepared for agroforestry

Planting of oak with beetroot

Planting of oak with beetroot

Planting of oak with cabbage

Planting of oak with beetroot and beans

Planting of oak with several crops (carrot, beetroot…)

Planting of oak with several crops (sunflower…)

Planting of walnut with maize

Planting of oak with beetroot

Planting of oak after harvest of maize

Planting of oak after farm harvest

Planting of poplar with vegetables