Source	Categories of reproductive material			
	identified	selected	qualified	tested
Method of source selection	no selection	mass selection	individual selection	after the verification of genetic characteristics
Source of seeds	x			
Stand	x	x		x
Seed orchard			x	x
Parent of family			x	x
Clone			x	x
Clonal mixture			x	x


Fertility of Forest Species
and Crop Estimation

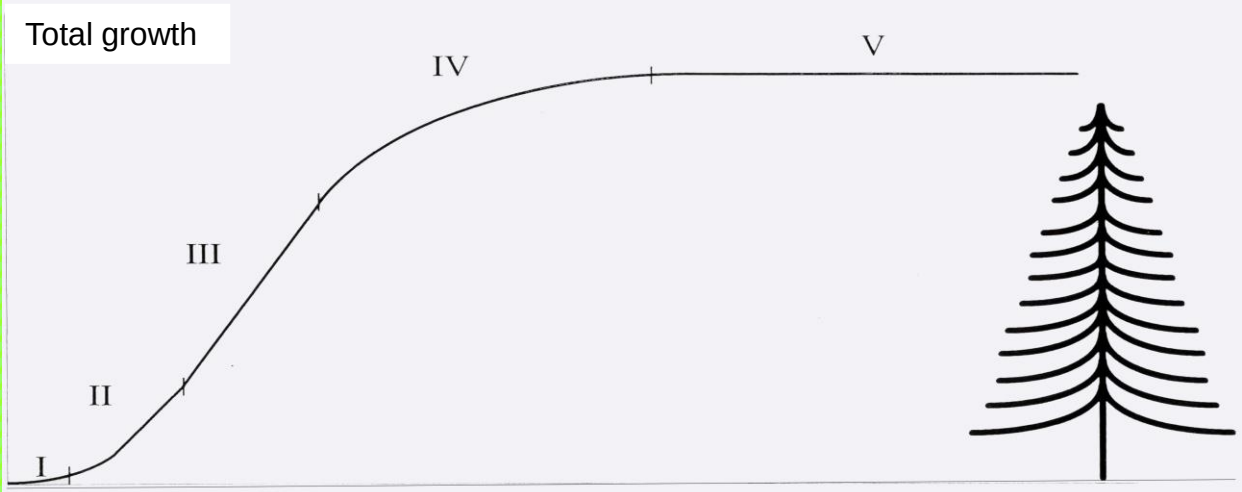
1. Fertility of forest species

= the ability to create seeds and fruits

1.1 Internal (endogenous) factors of fertility

1.1.1 Stage (grade) of development

Schematic classification of growth into phases of ontogeny



I. embryonal stage
II. juvenile stage
III. growth stage
IV. maturity stage
V. old age stage

Beginning of fertility

- **after the culmination of height and diameter increment**
- **after the transition from the growth stage to the maturity stage (adulthood)**

Culmination occurs earlier:

- in short-aged (fast-growing) species with small seeds

from 20-30 years: Betula, Populus, Salix, Pseudotsuga
from 40-50 years: Pinus silvestris, Picea abies, Larix...
from 50-70 years: Abies alba, Fagus sylvatica, Quercus

- in solitary trees (by 10 to 20 years)

Species	Start of fertility (age)	
	in the canopy	solitera
Robinia pseudoacacia	10 - 20	5 - 7
Pinus mugo	15 - 20	
Populus tremula	15 - 20	5 - 10
Betula sp.	20 - 30	10 - 15
Larix decidua	20 - 50	15 - 20
Acer platanoides	20 - 30	15 - 20
Pinus sylvestris	30 - 40	10 - 15
Picea abies	30 - 50	15 - 20
Tilia sp.	30 - 40	15 - 20
Fagus sylvatica	50 - 70	30 - 40
Quercus sp.	50 - 70	30 - 40
Abies alba	60 - 70	30 - 40
Pinuc cembra	60 - 70	30 - 40

- in individuals of a vegetative origin → seed orchards
(the graft is in the maturity stage)

1.1.2 genetic dispositions

- some individuals reproduce often, while others do not reproduce at all

1.3 Periodicity of fertility

= the occurrence of crops in „<u>seed years</u>“

intervals between seed years are regular

- **species reproducing almost every year (an interval of 1-2 years)** - Betula, Populus, Salix, Alnus, Sorbus

- **species with shorter periodicity (2-3 years)**
  - Larix, Pinus, Ulmus, Fraxinus, Tilia, Carpinus

- **species with longer periodicity (3 years and more)**
  - Picea, Fagus, Quercus

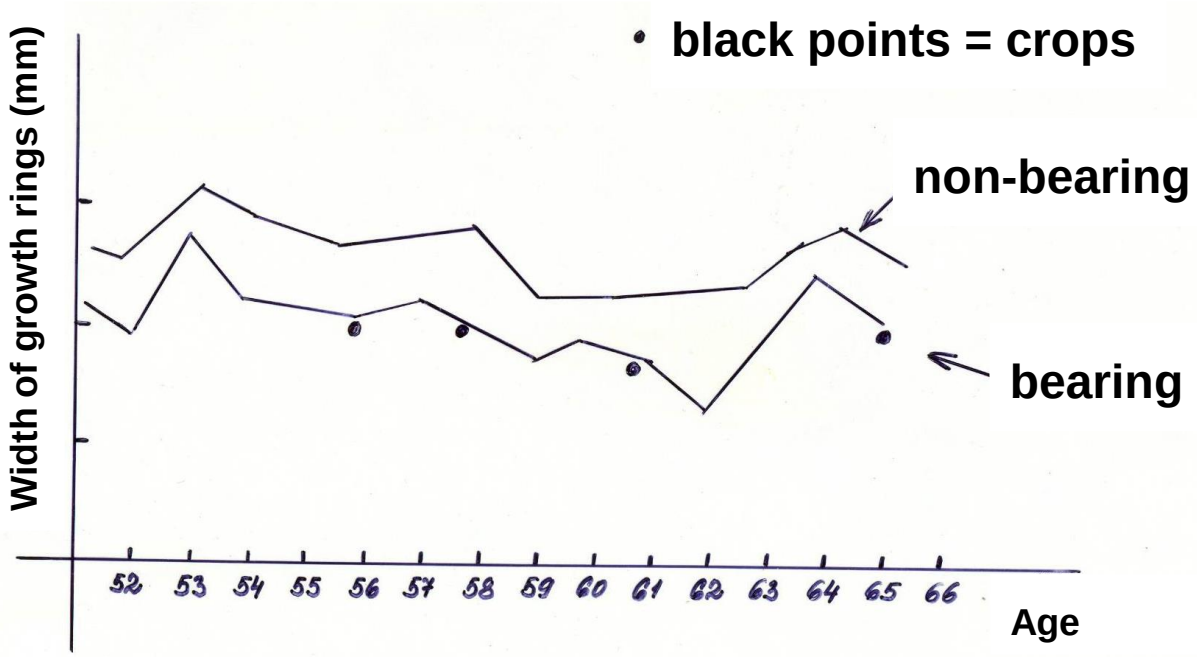
Generally

- species with smaller seeds reproduce more often
- light-demanding species reproduce more often than shade-demanding species

Causes of fertility periodicity

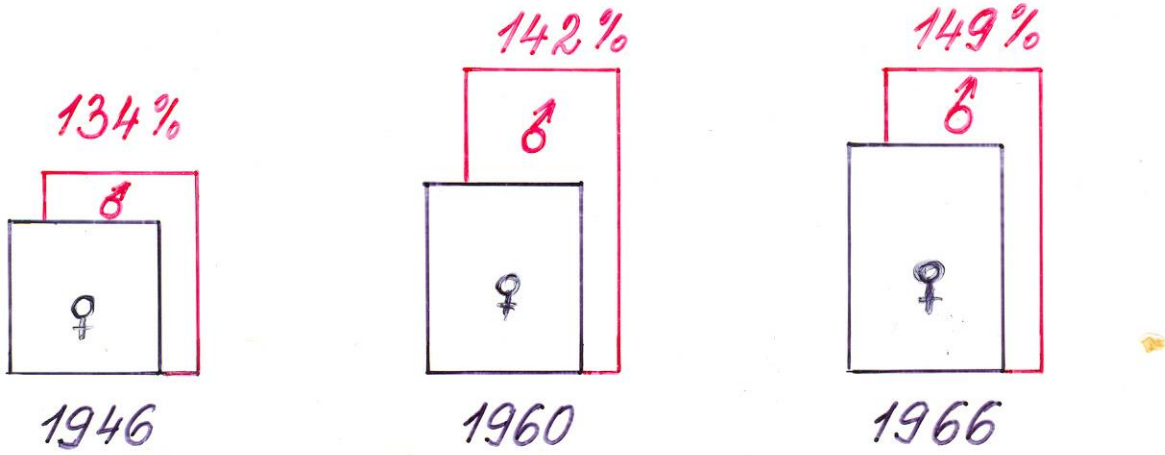
- **physiological**
  (exhaustion of food reserves)

Width of growth rings at bearing and non-bearing trees of Pseudotsuga menziesii in 1961-1965 (Tappenier 1969)

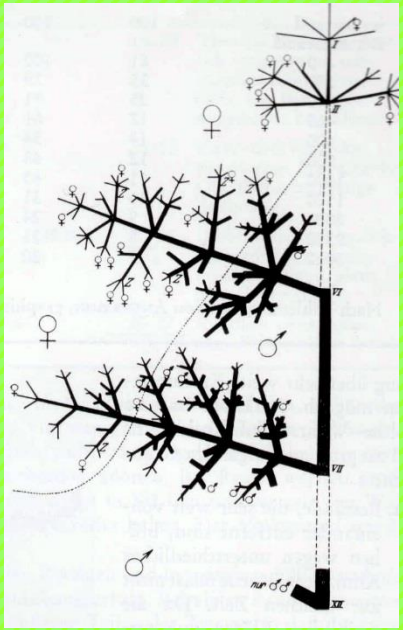


PRŮMĚRNÁ DŘEVNÍ PRODUKCE STROMŮ JASANU SE SAMČÍMI A STROMŮ JASANU SE SAMIČÍMI KVĚTY VE STÁŘÍ 55, 69 a 75 LET

(Rohmeder 1972)



- **morphological**
  (lower number of buds for the initiation of floral primordia)



Production of seed material (kg)

	2010	2011	2012	2013	2014	2015	2016	2017	Indicative annual need of cones/seeds
Spruce	100,000	19,000	65,000	65,000	150,214	156,187	183,598	3,466	46,000
Pine	86,000	62,000	36,000	65,000	78,978	39,816	7,056	47,691	40,000
Fir	42,000	59,000	30,000	95,000	7,711	48,596	19,450	15,207	65,000
Beech	31,000	141,000	10,000	113,000	30,657	16,400	79,100	3,499	56,000
Oak	83,000	288,000	312,000	275,000	172,475	165,965	126,943	64,108	85,000

1.4 External (exogenous) factors of fertility

They affect:

- **the begining of fertility**

- **periodicity of fertility**
  - all factors that affect the culmination of increments and assimilation accumulation are applied
    - climate
    - light
    - nutrition (soil properties)

- **the quantity and quality of crops** - factors affecting the reproductive cycle are applied, i.e.
    - weather (temperature, precipitation)
    - light
    - pollutants
    - bionic factors

Stimulation of fertility in forest species

- fertilization
- irrigation treatment
- mechanical methods (ringing and strangulation, root system reduction, branch tying)
- change of microclimatic conditions (temperature, humidity)
- application of growth substances (growth stimulators)
- biotechnical interventions (shelterwood cutting)

2. Crop estimation

= action in which, according to certain signs, the amount of the seed or fruit crop is determined

Importance:

- **Planning of the collection of seed material**
- **Preparation for natural regeneration**

We can estimate crops:

- **in the year before to year of flowering** (according to periodicity, weather and the establishment of flower buds)
- **in spring** (according to flowering)
- **after flowering** (according to the developing fruits)
- **in the time of fruit maturity and falling down**
- **retrospectively (additionally)**

The closer to crop we perform the estimation, the more accurate it is.

2.1 Methods of crop estimation (evaluation)

2.1.1 Methods of relative crop evaluation

(evaluation during the creation of a crop - usually according to the developing fruits)

- **Phenological method**

(according to the amount of fruits on border trees and trees in the stand)

An overview of crop yields

Yield		Characteristic
0	no yield	trees do not reproduce
1	poor yield	small number of fruits on soliteras and border trees
2	medium yield	good to high fertility of solitery and border trees, lower fertility of trees inside the stand
3	rich yield	high fertility of free and border trees as well as trees inside the stand

- **Method of counting cones on the near side of the crown (spruce, fir)**

Yield evaluation according to the number of cones on the near side of the crown (for spruce, fir)

Yield		Average number of cones per 1 tree
0	no yield	0
1	poor yield	1 - 40 cones
2	medium yield	41 - 70 cones
3	rich yield	over 71 cones

- **Sample branch method** (counting of flowers or fruits on sample branches)

- **Aerial estimation method** (large forest complexes)

2.1.2 Methods of absolute crop evaluation

- they do not affect crop preparation, important for research only

- **Total inventory method**

  - counting all fruits from all trees in a specific area

- **Sample tree method**

  - counting all fruits from sample (selected) trees

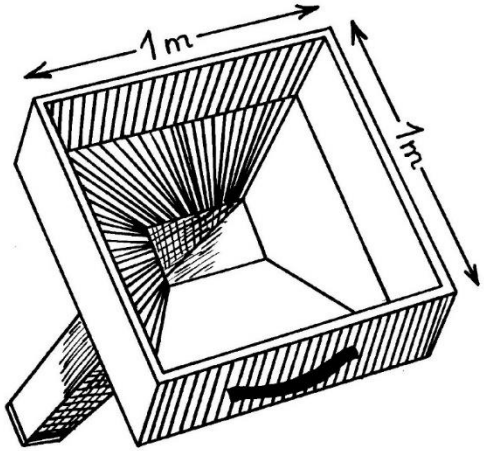
- **Fallen fruits inventory method**

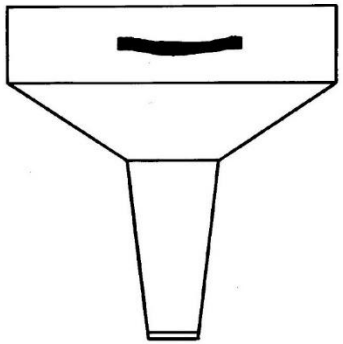
  Record area method

  - counting all fruits fallen in a stabilized, modified record area

  Seed counter method

  - counting all fruits that have fallen into special containers





SEMENOMĚR

2.1.3 Methods of retrospective crop evaluation

(important for research)

- **Method of determining the age and amount of seedlings**

- **Sample branch methods (spindle, scars)**

  - counting scars after fallen fruits

2.2 Crop evaluation dates

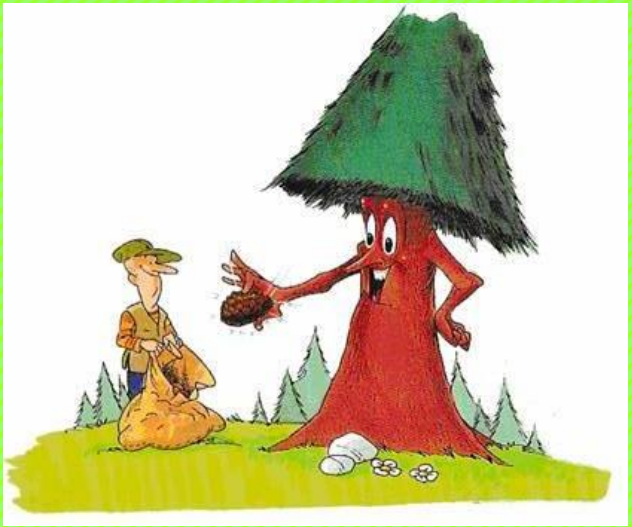
1st May	ulmus, populus tremula
15th June	betula
30th July	others (picea, pinus, fagus, quercus…)


Collection of seeds and fruits
of forest species

1. Seed and fruit collection plan

- based on the need for seeds of individual species for the certain year and the intervals without any crops, the number of plants needed and the yield of seeds

- collection site (stands)
- time and method of collection
- amount
- number of workers (finances)
- collection centre and transition storage houses



Advantages of collection in the course of a big crop (seed year)

- **better quality of fruits and seeds**
(higher amount of full seeds)
- **lower losses of crops caused by birds and other pests**
- **lower cost of collection**

The quality of seeds is the best immediately after reaching maturity

May be affected by:

- **time of collection (maturity)**
- **handling of seed material after harvesting**
- **method of processing seed material**
- **seed storage method**

2. Time of collection

- **during seed maturation:**
  - **changes in colour**
  - **increase in saccharides, fats and proteins content**
  - **decrease in growth regulator activity**
  - **decrease in respiration**
  - **changes in water content**
  - **changes in germination capacity**
  - **increase in specific weight**

Changes of water content in beechnuts during maturation (Messer, 1960)

Date of sample collection	Average water content (%)
1st July	79.9
10th July	77.0
1st August	77.1
10th August	61.8
1st September	49.3
10th September	41.6
1st October	31.3
10th October	27.8

The relationship between the time of collection, seed weight and germination capacity of spruce seeds
(Nobe ex Rohmeder, 1972)

Time of collection	Weight of 1000 seeds (mg)	Germination capacity (%)
15th July	3.64	0
1st August	3.29	41
15th August	4.89	61
1st September	5.76	75
15th September	5.66	72
1st October	5.12	84
1st November	5.39	88

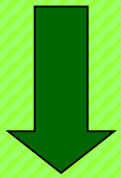
- **maturity stage**

  - milky maturity

  - waxy maturity

  - morphological (hard) maturity

  - physiological maturity



collect seeds during morphological maturity

the time of maturity reaching depends on the species and weather

2.1 Time of collection in the Czech Republic (ČSN 48 1211)

Ulmus sp.	20. V.

Betula sp.	15. VII.

Pseudotsuga menziesii	IX.
Pinus mugo	IX.
Pinus cembra	IX.
Pinus strobus	IX.
Sorbus aucuparia	IX.
Alnus glutinosa	IX.
Acer platanoides	IX.
Abies alba	15. IX.

Fagus sylvatica	X.
Quercus sp.	X.
Carpinus betulus	X.
Acer pseudoplatanus	X.

Picea abies	XI.
Tilia sp.	XI.
Fraxinus excelsior	XI.
Pinus nigra	XI.
Pinus sylvestris	15. XI.

Larix decidua	XII.

The falling of seeds and fruits after maturation

immediately: populus, salix, ulmus, quercus, fagus, abies alba, pinus strobus, betula…

after several weeks: tilia, carpinus, fraxinus, acer…

after a longer time (months): picea abies, pinus sylvestris, larix decidua…

When we collect immature fruits and seeds

- difficult seed extraction from immature cones
- slow germination and incomplete germination capacity of seeds
- low vitality of seedlings
- a greater occurrence of abnormal seedlings and their sensitivity to diseases
- reduced preconditions of seed for long-term storage

2.2 Premature collection

= collection before the date determined by standard ČSN 48 1211

- species in which the period from maturation to falling is short (*Abies alba, Pseudotsuga menziesii, Pinus strobus*)



- recommendations by the Forest Research Institute
- ensure post-crop maturation
- seed extraction must not follow immediately

2.3 Collection of „green seeds“

- **dormant species (hornbeam, lime, ash)**
  - collection during wax maturity
  - seeds must not dry out or steam up
  - sow immediately
  - the seeds cannot be stored

dates:	*Fraxinus*	end of VIII / start of IX
	Tilia	end of VIII / start of IX
	Carpinus	end of IX

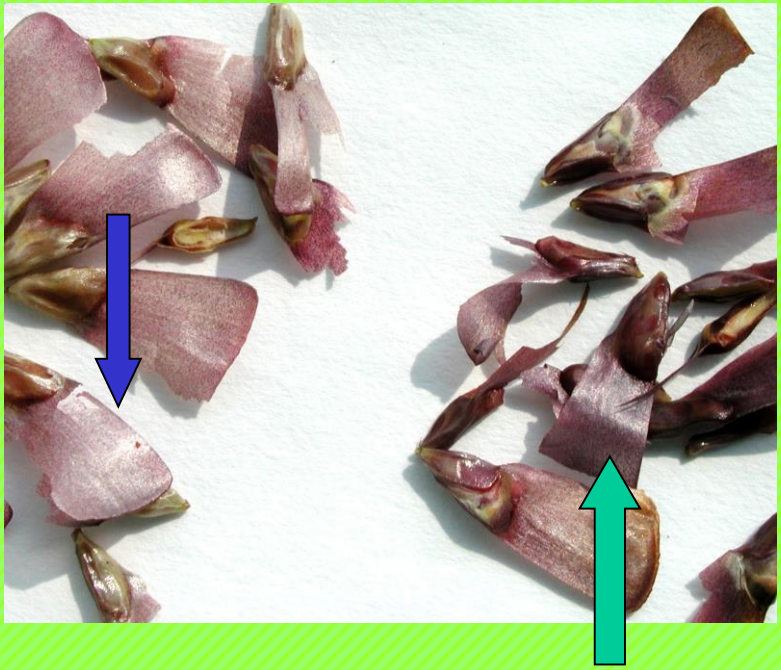
3. Collection of seed material

3.1 Informative determination of amount of seeds in cones and strobiles at a tangential cone cut

- count full seeds on one half of a cone cut in the centre, running along the spindle
- test at least 10 cones from 5 diferent trees

Evaluation of the maturity of cones

Wing colouration



Length of the embryo

Spindle lignification

Evaluation of tangential cone cuts
(Data from Bavaria, 1994)

Tree species	The number of full healthy seeds in a cone cut (%)	Amount of seeds in cones (% by weight)
Fir	**25 – 30**	**12.0 – 15.0**
Larch	**3 – 5**	**5.0 – 7.0**
Spruce	**20 – 25**	**3.0 – 4.5**
Pine	**4 – 6**	**1.6 – 3.4**
Douglas fir	**4 – 5**	**0.7 – 1.0**
Alnus glutinosa	**more than 10**	**12.0 – 16.0**

3.2 Informative determination of the amount of seeds in fruits (Data from Bavaria, 1994)

- test 50 seeds of beech and oak and 100 seeds of other species from a tree determined for collection

Species	% cuts	Number of seeds in infructescens (pcs)	Weight of seeds (kg per 1 tree)
Acer pseudoplatanus	80	1 - 2	25
Fagus sylvatica	60	1 - 3	10 - 15
Fraxinus excelsior	70 - 80	15	30
Oak	70	1	30 - 50
Sorbus	50 - 75	2 - 5	1
Tilia cordata	60 - 70	3 - 6	5 - 10

3.3 Basic ways and methods of collecting fruits and seeds

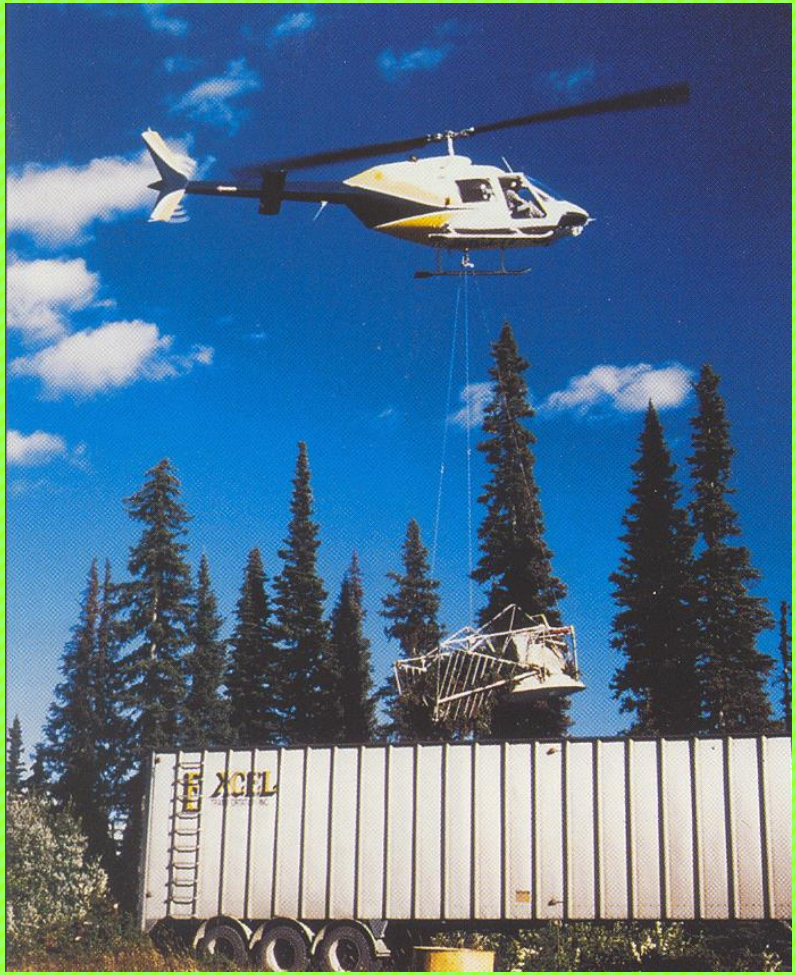
3.3.1 from standing trees and shrubes

3.3.2 from felled trees

3.3.3 fallen to the ground

3.3.1 Collection from standing trees and shrubs

a) use of mechanisation (helicopters, harvesters, platforms, balloons)



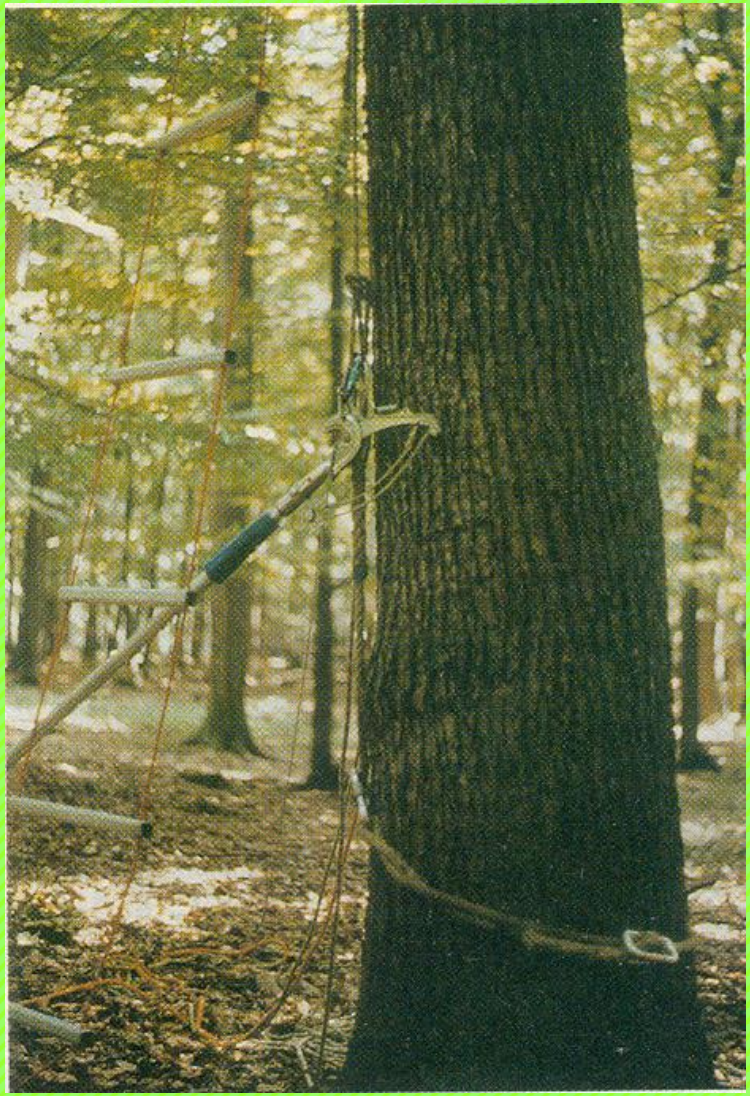
Shaker

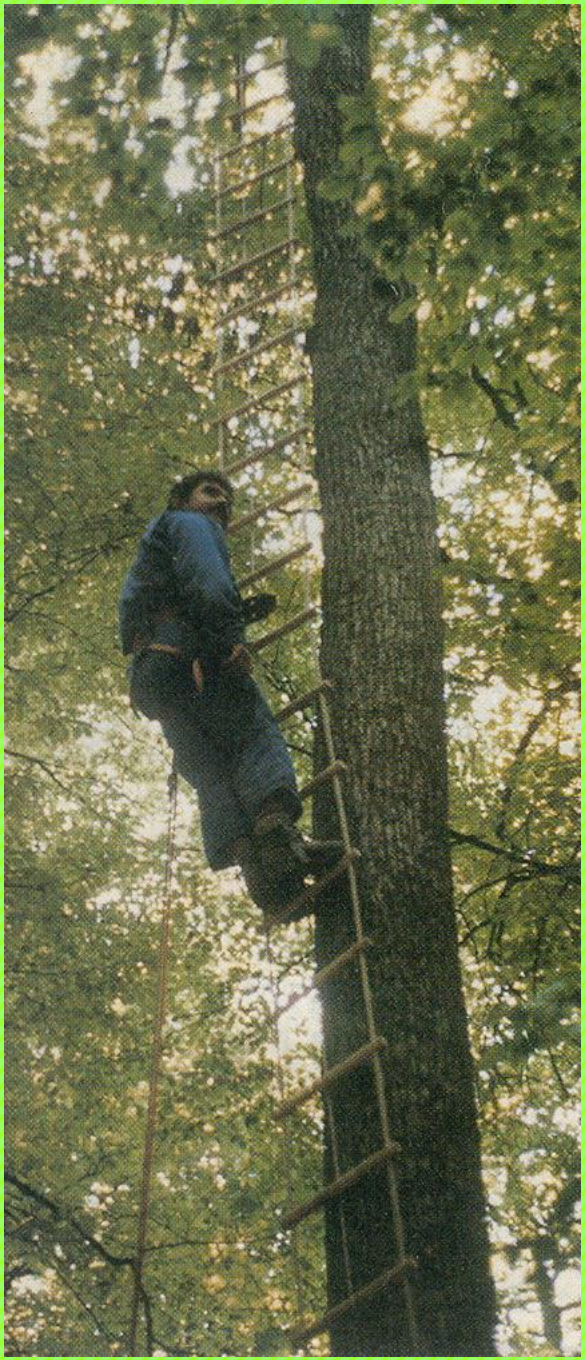
Cover under the tree

Platforms

b) Ladder - single, double
Set of Swedish ladders (ladder´s system)

c) Rope ladders





d) Climbing equipment
- set of Wolfgang climbing irons

Steel tips

Picker equipment

Climbing to the tree crown

Damage to the trunk after climbing up and down

d) Climbing equipment

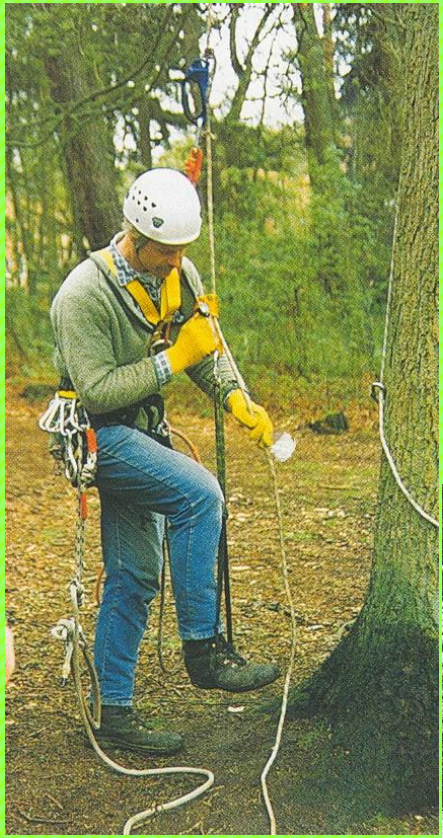
- **Baumwelo climbing irons**

e) Mountain climbing technique - climbing ropes

Crossbows

Treemouse

It is possible to climb on branches or using loops and ascenders



Hand ascender

Foot ascender

Rope loops

Exhibition in the deparment's corridors...

Methods of separating fruits and seeds from trees

Tearing – Picea, Pinus, Larix, Abies

Pruning – Betula, Carpinus, Fraxinus, Tilia, Acer

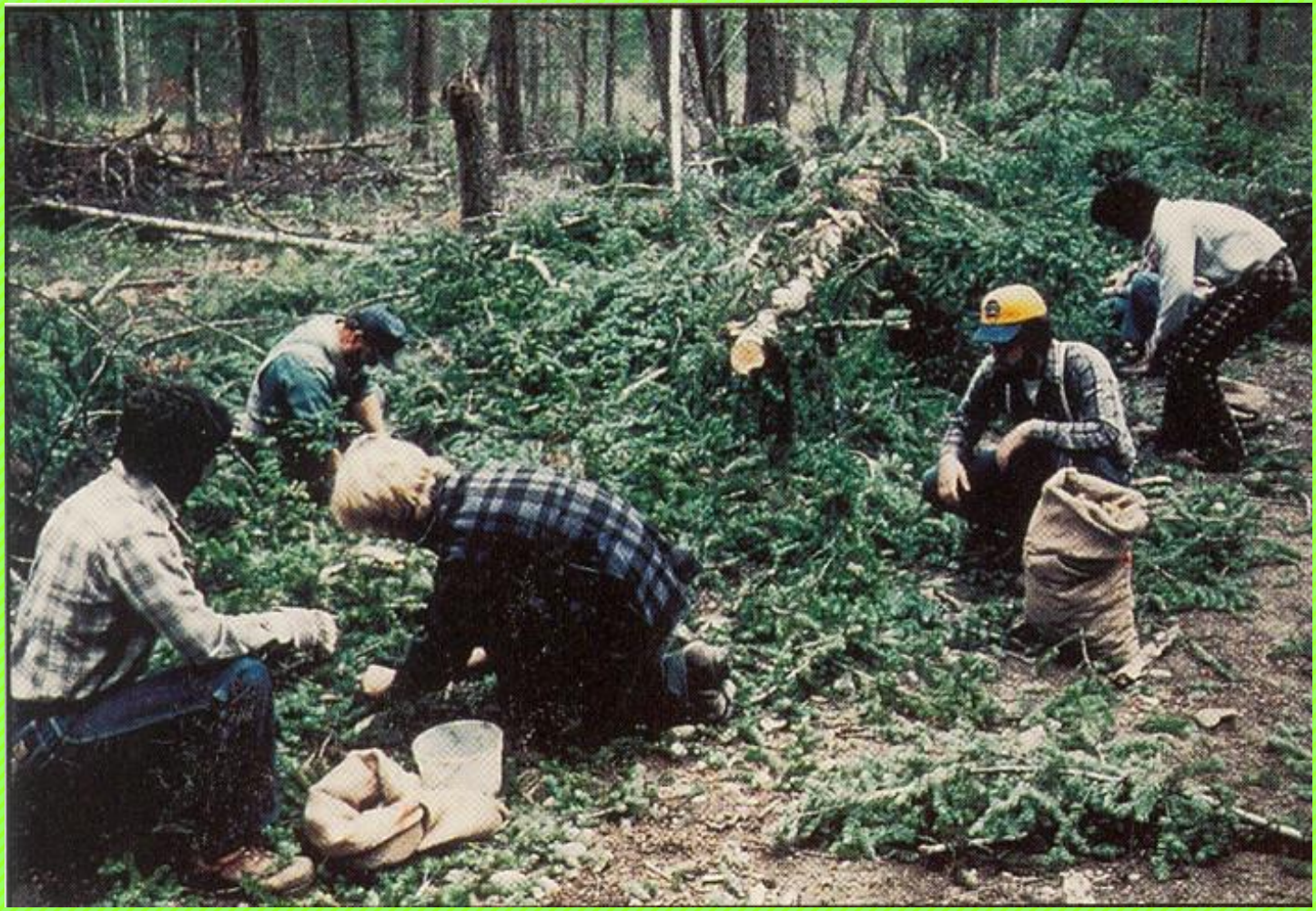
Shaking – Quercus, Fagus, Juglans, Tilia, Fraxinus

Bouncing and knocking – Fraxinus, Acer, Tilia

Cutting of branches is prohibited!!!

3.3.2 Collection from felled trees

- requires no special equipment



3.3.3 Collection of seeds fallen to the ground

a) manually

b) using pneumatic vacuum collectors

Kaláb's vacuum collector

German vacuum collector

Adapted municipal waste vacuums

c) Using covers or nets

The advantages of net collection

- can be used in medium and poor yields
- all seeds can be collected
- seeds do not come into contact with the soil
- allows for a correct evidence of origin

The disadvantages of net collection

- difficulties in placing the nets on slopes or in stands with natural regeneration
- need to clean immediately after collection

Average daily harvest performance for medium to rich crops in accordance with a standard (informative)

Ulmus	10 - 25 kg of samaras
Betula	25 - 60 kg of material with leaves
Fagus	30 - 50 kg of beechnuts
Quercus	30 - 80 kg of acorns
Carpinus	15 - 25 kg of material
Sorbus	30 - 80 kg of pomes
Acer	15 - 35 kg of samaras
Fraxinus	30 - 70 kg of samaras
Tilia	10 - 15 kg of material
Populus tremula	10 - 30 kg of aments

Safety principles of collection

Collection from standing trees

- men 18-60 years old, with the exception of trainees in training
- health certificates
- completion of the picker man course, qualification certificate
- a minimum of three group members

- tested harvesting equipment
- the picker man must not hang (climbing irons)
- permanent rope protection
- do not jump from crown to crown
- do not collect during fog, wind, or when snowing
- the temperature must be at least -8 °C

Collection from short trees using ladders

- **adults only**
- **ladder must overlap the prop point by at least 70 cm**
- **secure against slipping**

Collection from felled trees or from the ground

- youth, part-time workers and women
- collection at least 100 m from the harvesting group
- protective equipment against thorny shrubs
- collection after the expiry of the withdrawal period if the stand was chemically treated

3.4 Rules for the collection of seeds and fruits

- **do not collect during rainy and permanently humid weather (risk of steaming up)**

- **collection during humid conditions is possible:**
  - **for seeds with a higher water content (Fagus, Quercus)**
  - **hypermature lugumes that crack in dry weather (Robinia…)**
  - **fruits moist on the surface that can be easily over dried**

3.5 Regulations relating to collection in the Czech Republic

- licence from the Ministry of Agriculture
- report the intended collection to the authorized person 15 days prior (according to § 5a of Act No. 232/2013 Coll.)
- written authorisation of the resource owner with an official certified signature
- a certificate of origin must be issued for each seed lot (issued by the authorized person)
- the authorized person is required to keep the register of seed lots

- the **identified** reproductive material of **Fagus sylvatica**, **Quercus robur** and **Quercus petraea** must come from at least **10 trees** of the certified unit

- the **selected** reproductive material of **Picea abies**, **Pinus sylvestris**, **Larix decidua**, **Fagus sylvatica**, **Quercus robur, Quercus petraea** must come from at least **20 trees** of the certified unit

- in **seed orchards of Picea abies, Pinus sylvestris, Larix decidua,** the crop must consist of **50% clones**

- in **seed orchards of other species** – the crop must consist of **30% clones**

Certification of origin

Accompanying document

Packing of reproductive material

Sealing pliers

Thanks for your attention