Secondary succession and woody plants in non-forest areas of the Bohemian Forest

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Abstract

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Succession is the very important process leading to change as a community, as whole landscape. This process is visible in the contemporary Bohemian Forest (Šumava Mts.) within large areas, which were forest-free (mainly ploughed arable land, meadows, pastures) in the history.

Two levels were taken into account during the study: (A) landscape analyse within three landscape transects and (B) phytocoenological study in the selected ecosystems representing ecotonal and/or succession communities with tree species stands.

Edge communities overgrown by woody plants (balks) represent important landscape elements. Balks together with forest edges were mapped on the base of orthophotos in the transects S1 - Plechý Mt.-Boubín Mt. (length 40 km, width 2.5 km), S2 - Luzný Mt.-Rejštejn approximately along the axis of Vydra river (length 24 km, width 2.5 km) and SZP - the 1 km width buffer of Zlatý potok brook (MATĚJKA 2009a, 2010). Average length of the balks was determined around 45 m.ha-1, locally can be higher; median value was 34.7 m.ha-1 within forest-free localities. Maximum of the balk density was found in altitudes approximately 700 m. Forest edges are the next important line elements in the landscape. Maximal length of the forest edges was recorded in the middle altitudes near Zlatý potok brook (105.5 m.ha-1); median value was 25 m.ha-1.

Historical maps are an important background for understanding of the landscape development. Actual situation was described using the maps of stabile cadastre (first half of 19th century). Position of balks corresponds to occurrence of former pastures (example of the cadastral areas Frauenthal - Frantoly and Wessele -Veselka, former Prácheňský region). Lot of the actual forest plots is located in the former agricultural estates. This history influences contemporary environmental conditions (MATĚJKA 2009b).

Secondary communities with woody species (73 relevés) were classified by the TWINSPAN procedure using data on species composition of the herb layer; results were compared with agglomerative classification. Following basic groups were described:

Group a (TWINSPAN class *000, 7 relevés) - secondary forests on alluvial wet soils, *Alnus incana* and *Salix fragilis* prevails in the woody strata (*Alnus glutinosa* in lower altitudes). The potential vegetation belongs into the alliance *Alnion incanae*. It contains balks of the type *Alnus incana - Prunus padus*. Constant species with frequency 75% or more are represented by the group *Urtica dioica*, *Filipendula ulmaria*, *Carex brizoides* and *Angelica sylvestris*.

Group b (TWINSPAN class *0010, 15 relevés) - secondary cultivated forests with *Picea abies* or *Pinus sylvestris*. Regeneration of *Sorbus aucuparia* and *Fagus sylvatica* is common. Ground vegetation can be limited as the consequence of the high tree canopy density in some plots. Historical land-use is variable (pastures, arable land, meadows, and forests). Constant species are *Sorbus aucuparia*, *Mycelis muralis*, *Senecio ovatus*, *Oxalis acetosella* and *Vaccinium myrtillus*.

Group c (TWINSPAN class *0011, 21 relevés) - broadleaved balk communities on relatively rich soils, type *Acer pseudoplatanus - Corylus avellana* (3 relevés were classified as the type *Betula pendula - Agrostis capillaris*). Sites are localized on slopes, soils are often with stony boulders. Species *Acer pseudoplatanus*, *Betula pendula*, *Populus tremula*, *Fraxinus excelsior*, *Fagus sylvatica* and *Quercus robur* can be the tree dominant. Constant species are *Sorbus aucuparia* (regeneration), *Galium aparine*, *Urtica dioica*, *Geranium robertianum*, *Poa nemoralis*, *Acer pseudoplatanus* and *Corylus avellana* (mainly in the shrub layer).

Group d (TWINSPAN class *0100, 13 relevés) - heterogeneous group of secondary forest and balks on dry to moderately wet soils. Balk communities were classified into different types, mainly into type *Betula pendula - Agrostis capillaris*. Beside birch, *Picea abies*, *Pinus sylvestris* and *Salix caprea* were found as the tree dominants. Constant species are *Veronica chamaedrys*, *Agrostis capillaris*, *Festuca rubra* and *Potentilla erecta*. Localities were found in altitudes above 740 m a.s.l. Communities of this group are typical Norway spruce succession in the grasslands, where spruce is individually scattered within the plot.

Group e (TWINSPAN class *0110, 3 relevés) represents light balks in altitudes less than 730 m a.s.l., which are similar to the group d. Dominant tree species was *Betula pendula* or *Quercus robur*. *Luzula luzuloides*, *Fagus sylvatica*, *Acer pseudoplatanus*, *Campanula persicifolia*, *Prunus avium*, *Arrhenatherum elatius*, *Veronica chamaedrys* and *Agrostis capillaris* were found in the herb layer of all sites. This group was created by the well-developed balk communities of the type *Betula pendula - Agrostis capillaris*.

Group f (TWINSPAN class *0111, 5 relevés) was found in localities of grasslands of alliance *Arrhenatherion elatioris* with sparse woody species (*Crataegus* sp. div., *Quercus robur*, *Betula pendula*, *Picea abies*); altitudes less than 720 m a.s.l. (mainly less than 500 m a.s.l.). Soil is relatively rich comparing the previous group, often with stones. The sites are importantly sloped. Constant species are *Anthriscus sylvestris*, *Arrhenatherum elatius*, *Knautia arvensis*, *Poa pratensis*, *Plantago lanceolata*, *Achillea millefolium*, *Veronica chamaedrys*, *Agrostis capillaris* and *Festuca rubra*.

Both groups e and f represent sites in the lowest altitudes.

Group g (TWINSPAN class *10, 4 relevés) represents the succession of *Picea abies* or *Betula pendula* in the plots with moderately wet soil, prevailing in the Norway spruce altitudinal zone. Balks were classified as the *Picea abies - Calamagrostis villosa* type. Constant species were *Sorbus aucuparia* (regeneration in the herb layer), *Avenella flexuosa*, *Calamagrostis villosa*, *Melampyrum pratense*, *Vaccinium myrtillus*, *V. vitis-idaea*, *Vaccinium uliginosum* and *Trientalis europaea*.

Group h (TWINSPAN class *111, 3 relevés) represents successional stages on the soil type organosol. Birch *Betula pubescens* was dominant, *Pinus sylvestris* was presented. No rowan regeneration was observed here. Canopy is opened. Group of constant species: *Avenella flexuosa*, *Calluna vulgaris*, *Vaccinium uliginosum* and *Eriophorum vaginatum*. The communities can be classified in the alliance *Sphagnion medii*.

Communities of the groups d, g and h occupy localities in the highest altitudes (745 to 1160 m a.s.l.). Both groups g and h are the poorest in number of species. The last group of communities shows the lowest species diversity (Shannon-Wiener's index H=1.6 to 2.1).

These communities are commonly species-rich: 25, 36 and 327 species were found in the tree, shrub and herb layers, respectively. The rich communities prevail. Number of herb species vary between 5 and 52 in the relevé (average 28), Shannon-Wiener's index of diversity was from 1.0 to 4.5 (average 3.1). The highest values of species diversity were found in the groups b to f. These high values are caused by co-occurrence of species from different ecological groups. Grassland species are combined not only with forest species, but others groups are often present (species of clear-cut or ruderal communities).

There is important variability as in the spatial structure of the succession communities, so in the dynamics of these communities. Typical difference can be demonstrated between Norway spruce and birch succession, although these communities can be very similar in species composition in the ground vegetation (e.g. group d). While spruce trees appearance is in the form of individuals or small groups during a long-period succession, the birch entrance can be observed as a one-wave appearance (the tree age structure is relatively homogenous). Similar situation is known by *Alnus incana* and *Salix caprea*, which grow in even-aged stands. Importance of the locality history can be demonstrated on superposition of the historical cadastral maps, the orthophotos and the actual tree position mapping, as in the case of the plot Huťská hora (cadastral area Haidl - Zhůří), where spruce-tree density is higher in sites of former pasture comparing ploughed field.

References

Matějka K. (2009a): Vyhodnocení krajinných transektů Šumavy v historické perspektivě [The landscape transect evaluation with historical background]. – IDS, Praha, 24p. – URL http://www.infodatasys.cz/sumava/krajtrans2008.pdf

Matějka K. (2009b): Vývoj užití země jako zdroj diversity v krajině Šumavy [The land-use development as diversity source in contemporary landscape of Bohemian Forest Mts.]. - Příroda, Praha, 28: 140–161.

Matějka K. (20010): Management biodiversity v Krkonoších a na Šumavě - zpráva spoluřešitele za rok 2009 [Biodiversity management in the Krkonoše Mts. and Šumava Mts. - the associate's report on 2009]. - URL http://www.infodatasys.cz/biodivkrsu/IDSreport2009.pdf

Aim of the study & methods

Landscape analysis

GIS mapping of the line elements (balks, forest edges), identification of plots with scattered trees

Analyze of the historical maps of stable cadastre, superposition of these maps with layers of actual biotopes and forest typology

Phytocoenological study

Sampling in the line elements (balks, forest edges)

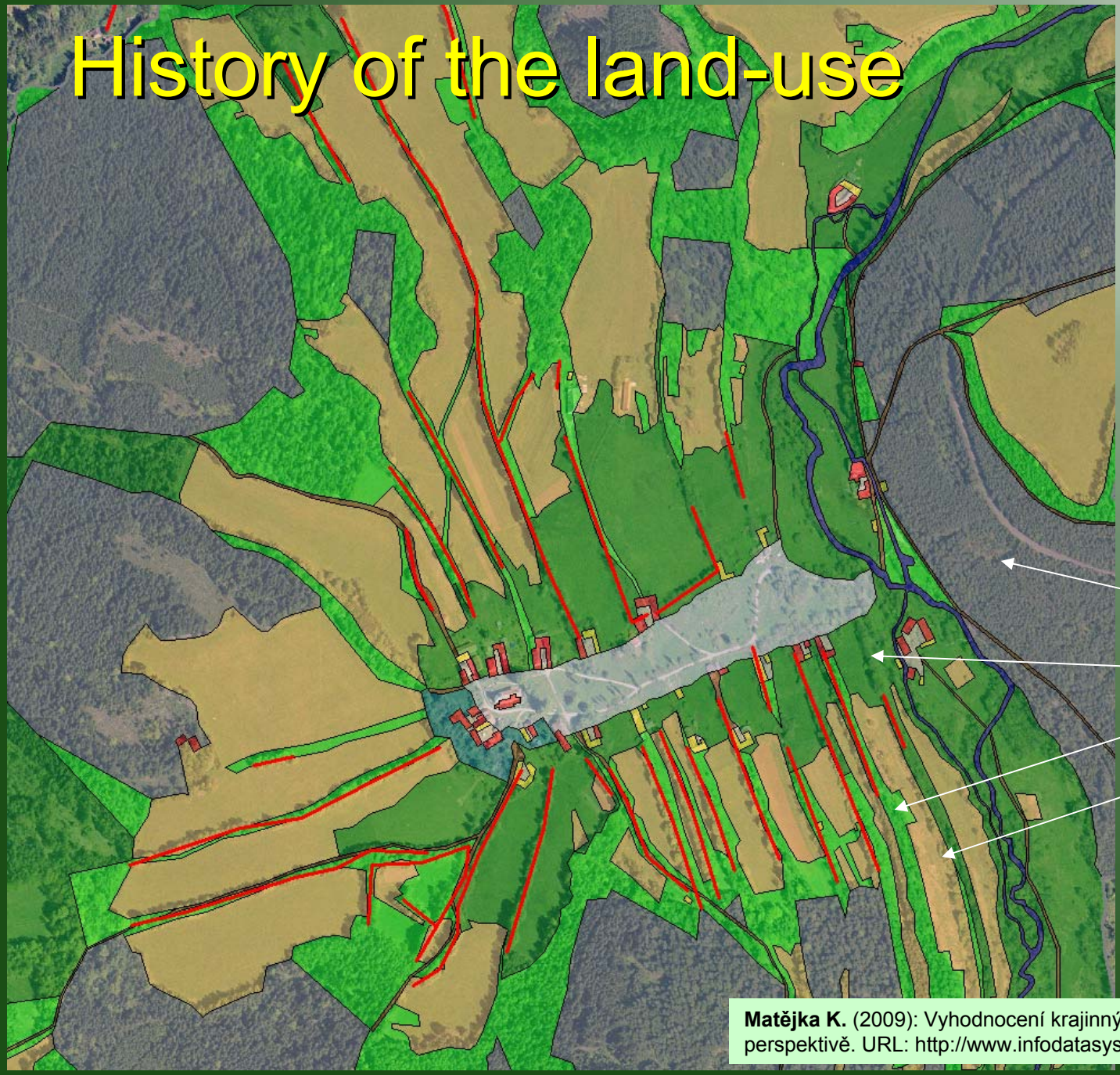
Sampling in sites with Norway spruce succession, including study of the stand spatial structure

Sampling in parallel forest plots with different history of land-use (forest – meadows – pastures – ploughed land)

Data processing

GIS **TopoL**; relevés in **DBreleve**, **CANOCO**, **TWINSPAN**, **PC-ORD**, **PlotOA**

History of the land-use



Frantoly

Actual balks (red) are mapped on the base of orthophoto overlaid by the historical land-use map

- forest
- meadow
- pasture
- ploughed field

Matějka K. (2009): Vyhodnocení krajinných transektů Šumavy v historické perspektivě. URL: http://www.infodatasys.cz/sumava/krajtrans2008.pdf

Balk vegetation – basic types

Alnus incana - Prunus padus

wet sites near streams and water reservoirs / potential vegetation *Alnion incanae*

Carex brizoides, *Angelica sylvestris*, *Cirsium palustre*, *Myosotis nemorosa*, *Filipendula ulmaria*, *Phalaris arundinacea*; *Impatiens noli-tangere*; *Galium aparine*, *Urtica dioica*, *Aegopodium podagraria*

Acer pseudoplatanus - Corylus avellana

typical balks on relatively rich sites / potential vegetation *Eu-Fagenion*

Dactylis glomerata; *Dryopteris filix-mas*, *Asarum europaeum*, *Poa nemoralis*, *Fragaria vesca*, juvenile *Sorbus aucuparia*; *Anthriscus sylvestris*, *Galium aparine*, *Geum urbanum*, *Urtica dioica*, *Aegopodium podagraria*, *Geranium robertianum*, *Rubus idaeus*

Betula pendula - Agrostis capillaris

forest edges on relatively poor sites / potential vegetation *Luzulo-Fagion*

Potentilla erecta, *Achillea millefolium*, *Campanula rotundifolia*, *Phleum pratense*, *Hypericum maculatum*, *Agrostis capillaris*, *Veronica chamaedrys*, *Knautia arvensis*, *Arrhenatherum elatius*, *Galium album*; *Fragaria vesca*, *Luzula luzuloides*, *Melampyrum pratense*

Picea abies - Calamagrostis villosa

spruce succession in high elevated sites / potential vegetation *Piceion excelasae*

Bistorta major, *Luzula multiflora*, *Rumex acetosa*, *Holcus mollis*, *Veronica officinalis*, *Nardus stricta*, *Carex pilulifera*, *Potentilla erecta*, *Festuca rubra*, *Hypericum maculatum*; *Vaccinium myrtillus*, *V. vitis-idaea*, *Calamagrostis villosa*, *Avenella flexuosa*, *Melampyrum pratense*

Processing of all relevés together

Subsets:

Line elements (balks, forest edges)

Norway spruce succession

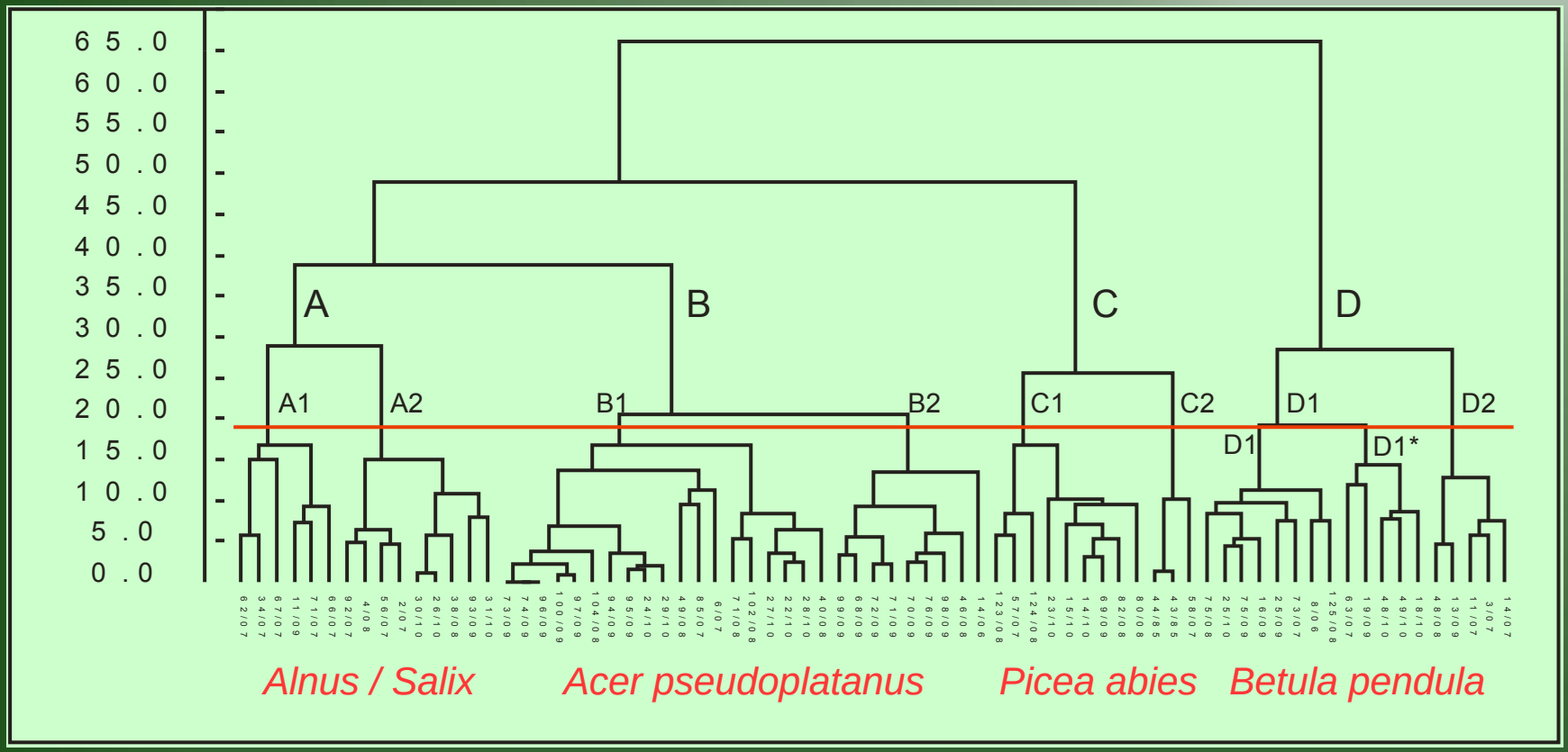
Parallel forest plots with different history of land-use (forest – meadows – pastures – ploughed land)

TWINSPAN classification

- * (n=73)
  - *0 (n=65)
    - *00 (n=43) *Dryopteris filix-mas* 1 *Senecio ovatus* 1
      - *000: **Group a** (n=7) *Carex brizoides* 1 *Filipendula ulmaria* 1 *Angelica sylvestris* 1
        - *0000 (n=3) *Crepis paludosa* 2
          - *00000 (n=1) *Bistorta major* 1
          - *00001 (n=2)
        - *0001 (n=4)
          - *00010 (n=2) *Thalictrum aquilegiifolium* 1
          - *00011 (n=2)
      - *001 (n=36) *Acer pseudoplatanus* 1
        - *0010: **Group b** (n=15) *Dryopteris dilatata* 1
          - *00100 (n=2) *Salix cinerea* 1
          - *00101 (n=13)
        - *0011: **Group c** (n=21) *Poa nemoralis* 1 *Geranium robertianum* 1 *Galium aparine* 1 *Aegopodium podagraria* 1 *Geum urbanum* 1
          - *00110 (n=8) *Aegopodium podagraria* 1 *Asarum europaeum* 2 *Senecio ovatus* 1
          - *00111 (n=13)
    - *01 (n=22) *Agrostis capillaris* 2 *Veronica chamaedrys* 1 *Festuca rubra* 1 *Achillea millefolium* 1
      - *010 (n=14)
        - *0100: **Group d** (n=13)
          - *01000 (n=7)
          - *01001 (n=6) *Sorbus aucuparia* 1
        - *0101 (n=1) *Agrostis stolonifera* 1
      - *011 (n=8) *Arrhenatherum elatius* 1
        - *0110: **Group e** (n=3) *Luzula luzuloides* 1
          - *01100 (n=2) *Betula pendula* 1
          - *01101 (n=1)
        - *0111: **Group f** (n=5)
          - *01110 (n=4)
          - *01111 (n=1) *Anthoxanthum odoratum* 1
  - *1 (n=8) *Vaccinium uliginosum* 1 *Avenella flexuosa* 1 *Eriophorum vaginatum* 1 *Vaccinium vitis-idaea* 2
    - *10: **Group g** (n=4) *Calamagrostis villosa* 1
      - *100 (n=2) *Calluna vulgaris* 1
      - *101 (n=2)
    - *11 (n=4)
      - *110 (n=1) *Luzula luzuloides* 1
      - *111: **Group h** (n=3)
        - *1110 (n=2)
        - *1111 (n=1) *Betula pendula* 1

cut-levels:
1: >0%
2: >1%
3: >10%
4: >31.62%
5: >56.23%

Hierarchical classification (Ward‘s method)



data transformation x‘ = log(1+x)

squared Euclidean distance

Main succession/community types

number of relevés in the combination of classification classes

Alnus incana

Acer pseudoplatanus
(*Poa nemoralis-Aegopodium podagraria*)

		TWINSPAN classification								
		a	b	c	d	e	f	g	h	Sum
Ward's classification	A1	3			2					5
	A2	4		5						9
	B1		5	11	1	1	1			19
	B2		8	1						9
	C1		2	1	1			4		8
	C2								3	3
	D1			3	4	1				8
	D1*				5					5
	D2					1	4			5
	Sum	7	15	21	13	3	5	4	3	71

Picea abies
planted (rich)

Picea abies
succession

Sphagnion medii

Betula pendula
succession

Quercus robur-Betula pendula
succession

Altitude as main environmental variable

		TWINSPAN classification								
		a	b	c	d	e	f	g	h	
Ward's classification	A1	600-872			745-769					600-872
	A2	454-750		612-792						454-792
	B1		655-838	563-832	781	495	717			495-838
	B2		637-756	699						637-756
	C1		870-930	712	1160			745-1127		712-1160
	C2								746-906	746-906
	D1			737-958	773-1064	725				725-1064
	D1*				766-961					766-961
	D2					715	435-634			435-715
		454-872	637-930	563-958	745-1160	495-725	435-717	745-1127	746-906	435-1160

Balks of the type *Alnus incana - Prunus padus*

releve 4/08, 576 m a.s.l.; *Salix fragilis* stand, heavily ruderalized

Balks of the type
Acer pseudoplatanus - Corylus avellana

relevé 27/10, 656 m a.s.l.

Balks of the type
Acer pseudoplatanus - Corylus avellana

relevé 31/10, 670 m a.s.l.

Edges of the type Betula pendula - Agrostis capillaris

relevé 25/10, 737 m a.s.l.

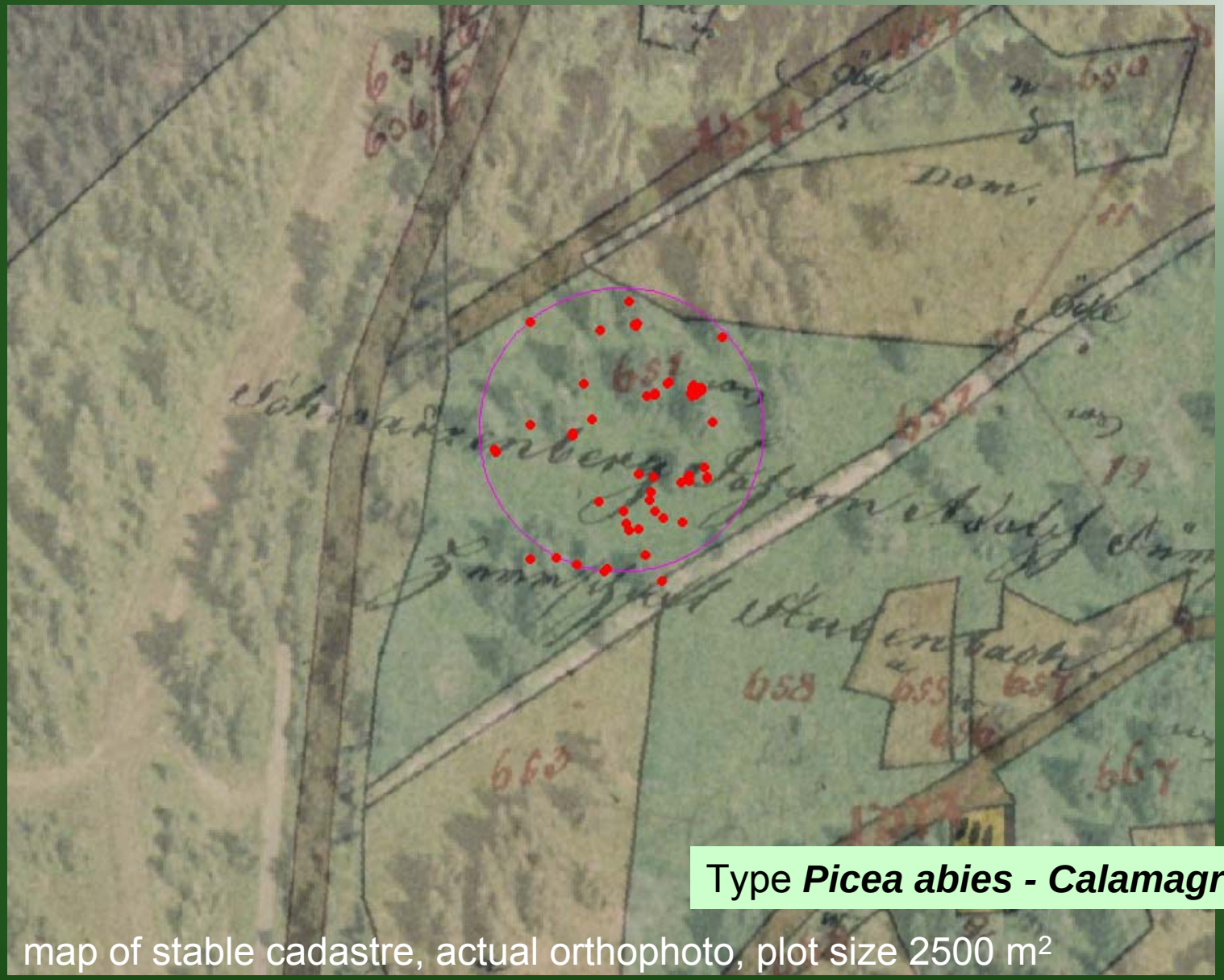
Succession of the type
Picea abies - Calamagrostis villosa

relevé 67/07, 769 m a.s.l.; a limit subtype - wet site is dominated by *Avenella flexuosa*, surrounded by *Carex brizoides*

Succession of the type
Picea abies - Calamagrostis villosa

relevé 14/10, 1127 m a.s.l. (Zelená hora); subtype *Vaccinium myrtillus*

Picea abies succession – Zelená hora 1



Type ***Picea abies - Calamagrostis villosa***

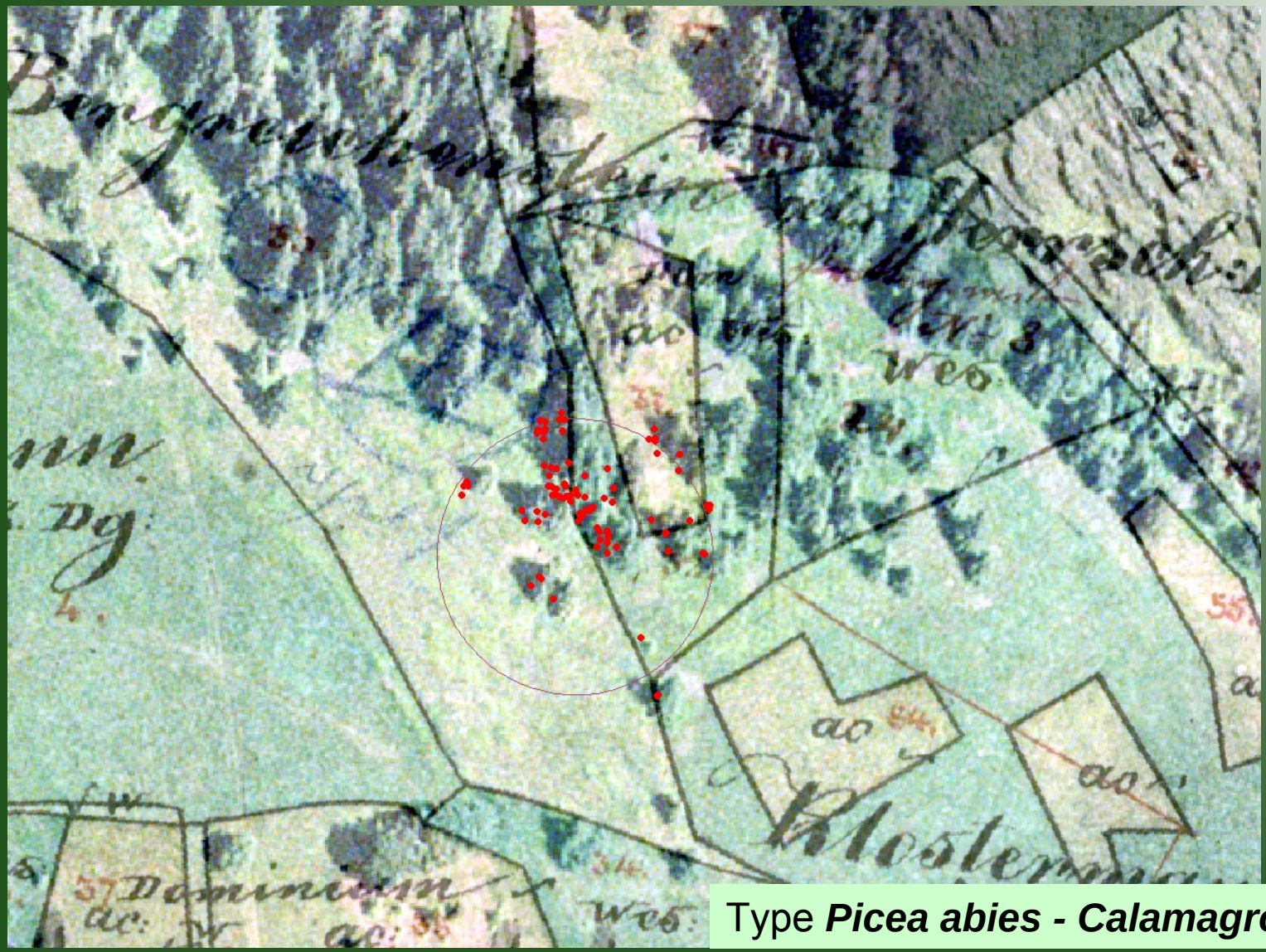
map of stable cadastre, actual orthophoto, plot size 2500 m^2

Picea abies succession – Zelená hora 2

Type ***Picea abies - Calamagrostis villosa***

map of stable cadastre, actual orthophoto, plot size 2500 m^2

Picea abies succession – Huťská hora



Type ***Picea abies - Calamagrostis villosa***

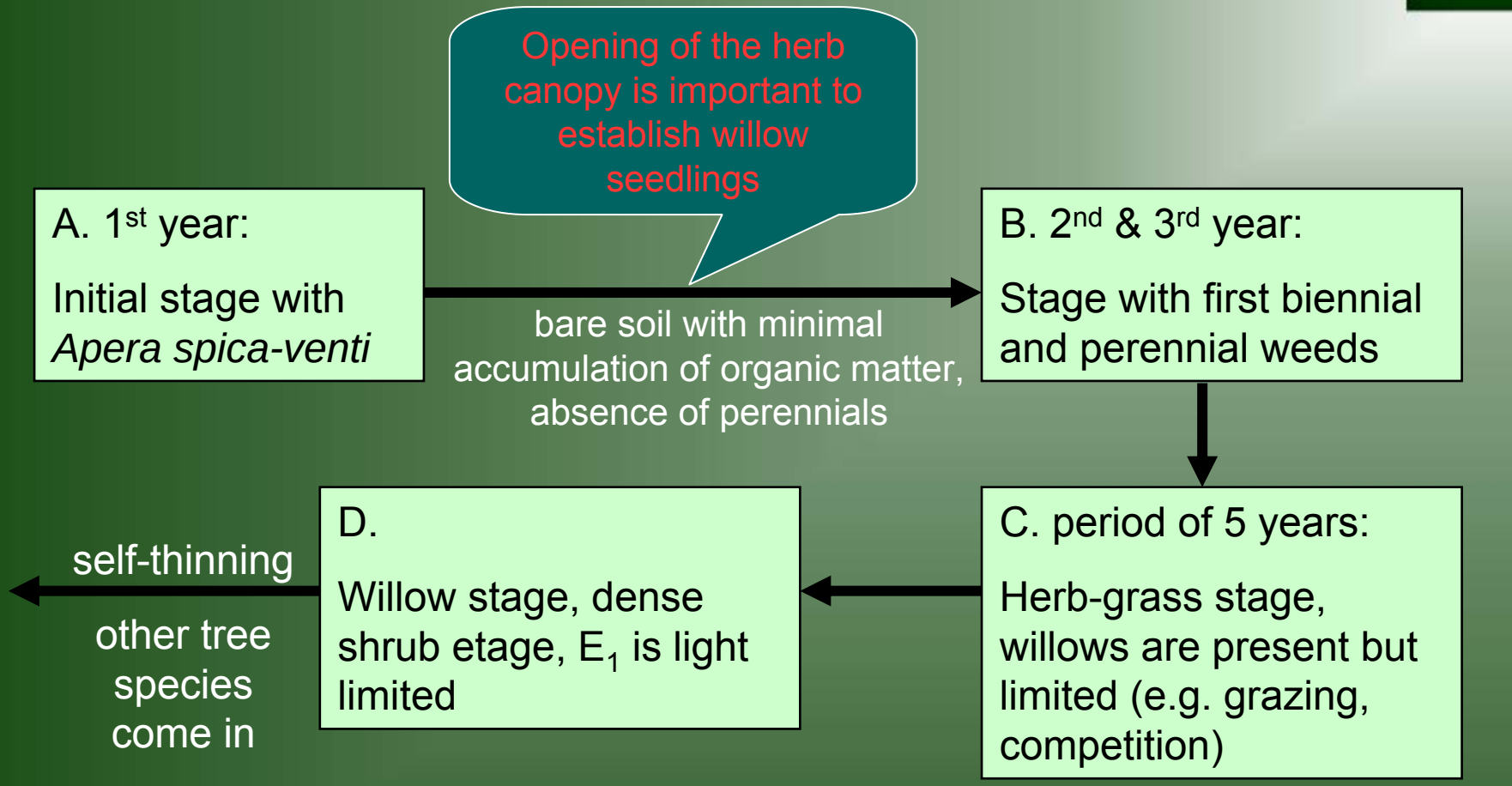
map of stable cadastre, actual orthophoto, plot size 2500 m^2

Salix caprea succession in the Chelčice AF research plot – model of homogenous invasion

Matějka K. (1990): Struktura a funkce společenstev primárních producentů ve vztahu k půdní složce ekosystémů.. URL: http://www.infodatasys.cz/public/dis/default.htm

Matějka K. (1998): Vývoj vegetace na opuštěných polích v oblasti Chelčic. In: Križová, E., Ujházy, K. [eds.], Sekundárna sukcesia II. - TU, Zvolen, pp. 75-93.

Salix caprea succession on abandoned field



Similar mechanism with the homogenous whole-herb-layer opening can be supposed for succession of *Betula pendula* and *Alnus incana* (example of big flood disturbance)

Different succession types

Betula pendula (*Salix*)

Initial conditions:

lot of gaps

homogenous environment

microsites are not differentiated

seedlings enter in one time wave

typical biotope: ploughed field

Resulting community:

dense tree stand

equal tree age

spatial heterogeneity is constant

Picea abies

Initial conditions:

few gaps

heterogeneous environment

microsites are important

seedlings enter during long time

typical biotope: grassland

Resulting community:

trees are scattered

unequal tree age

spatial heterogeneity increases

Project

Biodiversity management in the Giant Mts. (Krkonoše) and Bohemian Forest (Šumava) (BiodivKrŠu)

2006-2011

Ministry of Education, Youth and Sports

www.infodatasys.cz/biodivkrsu