Význam stanoviště v rostlinných invazích

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Global patterns in plant invasions

Table 1 Summary of some key generalizations in plant invasions related to geographical variables

Generalization	Scale	Source
Temperate mainland regions are more invaded than tropical mainland regions	Global	Rejmánek (1996a), Lonsdale (1999)
There is no difference in invasibility of temperate and tropical islands	Global	Rejmánek (1996a), Lonsdale (1999)
Islands are more invaded than the mainland	Global	Rejmánek (1996a), Lonsdale (1999)
Number of naturalized species in temperate regions decreases with latitude	Continental: Europe	Sax (2001)
Geographical ranges of naturalized species in temperate zone increase with latitude	Continental: Europe	Sax (2001)
Number of naturalized species on islands increases with temperature	Southern Ocean islands	Chown *et al.* (1998)
Naturalized species contribute to floristic homogenization	Continental: North America	Rejmánek (2000b), McKinney (2004c)
Clonal species increase their representation in alien floras with latitude	Global	Pyšek (1997)

Only results documented by statistical analyses of data are presented. Size of data sets: Lonsdale (1999) 184 regions; Rejmánek (1996a) 63 island and 52 mainland sites; Sax (2001) 3000 species; Rejmánek (2000b) 10 US states; Chown *et al.* (1998) 25 Southern Ocean islands; Pyšek (1997) 19 regional floras.

Based on numbers of alien species in individual regions or states …

BUT: regions differ in the structure of habitats they harbour … and individual habitats differ in how many alien species they harbour

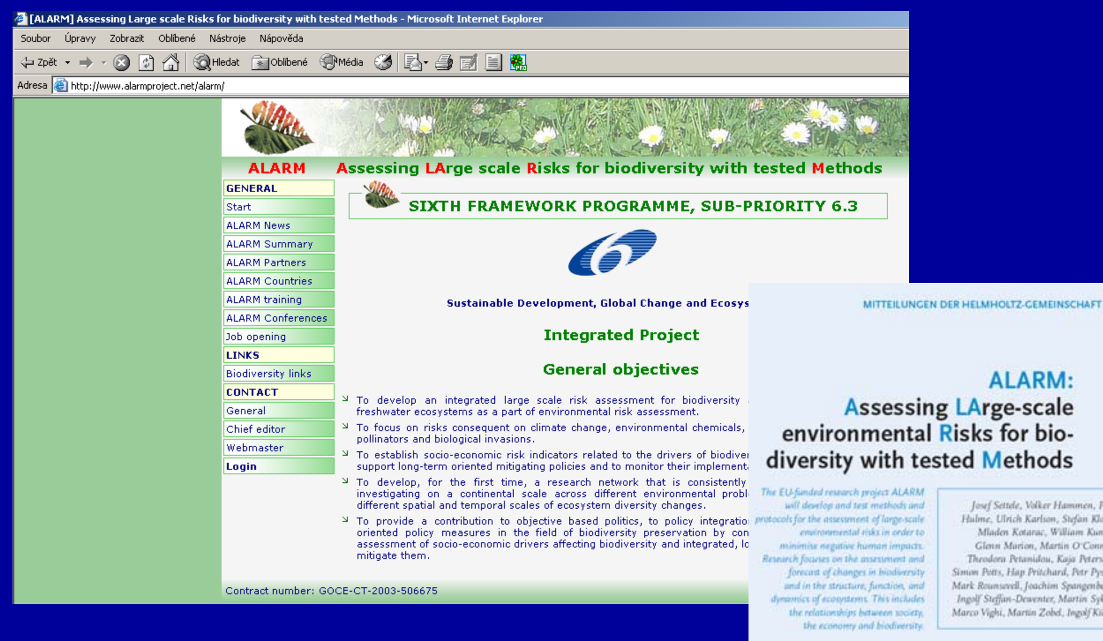
Pyšek P. & Richardson D. M. 2006. The biogeography of naturalization in alien plants. J. Biogeogr. 33: 2040–2050.

Invasibility of habitats

Limitation no. 1:

Quantitative information on how alien species are distributed in particular habitats is very scarce

If there are no data, collect them yourself ☺



www.alarmproject.net

Invasibility vs. Level of Invasion

Limitation no. 1:

Quantitative information on how alien species are distributed in particular habitats is scarce

Limitation no. 2:

Majority of data in the literature concern the level of invasion (sensu Hierro et al. 2005)
= how many alien species are present in a region/habitat

Distinguish level of invasion from "real invasibility" !

Hierro J.L., Maron J.L. & Callaway R.M. 2004. A biogeographical approach to plant invasions: the importance of studying exotics in their introduced and native range. Journal of Ecology 93:5–15.

Theoretical model of community invasibility (Lonsdale's equation)

number of alien species

no introduced species

survival rate

$$E = I \times S$$

$$I = I_a + I_i$$

accidentally

intentionally

$$S = S_v \times S_h \times S_c \times S_m$$

competition

herbivory

chance events

maladaptation

To invade, the species must survive the effect of all these factors

Lonsdale W. M. 1999. Global patterns of plant invasions and the concept of invasibility. Ecology 80: 1522–1536.

Theoretical model of community invasibility (Lonsdale's equation)

Level of Invasion = Propagule Pressure × Invasibility

If we want to compare invasibility of two habitats, we need to compare *S* – a habitat is more prone to invasions if alien species, introduced by means of propagule pressure, survive better than in another habitat with lower *S*

„Looking for real differences in invasibility requires looking at the residuals from the relationship between invasion success and propagule pressure.“ (Williamson 1996)

Invasibility vs. Level of Invasion

Large fraction of the variation in alien species richness among sites can be attributed to propagule pressure, i.e. the rate of influx of alien propagules into the target site

To answer the question why some habitats are more invaded than others, one must separate the effects of habitat properties from

- **those of propagule pressure and**
- **other potentially confounding factors (climate)**

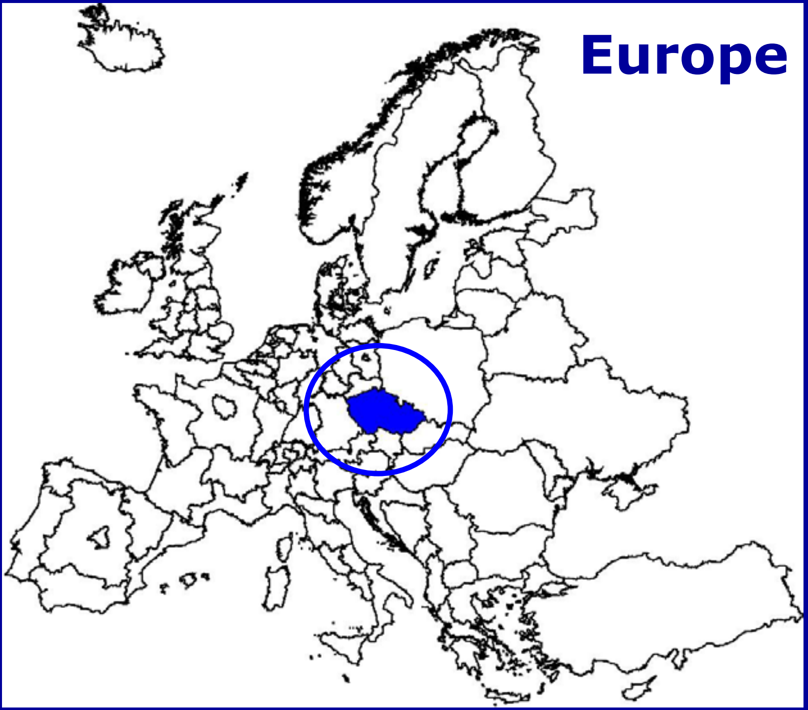
- **seed addition experiments confined to a single site → do not explain between-habitat differences**

- **observational studies: restricted to few habitats, few species, limited number of replicates**

- **large databases of vegetation survey plots – do not take into account variation in propagule pressure between habitats**

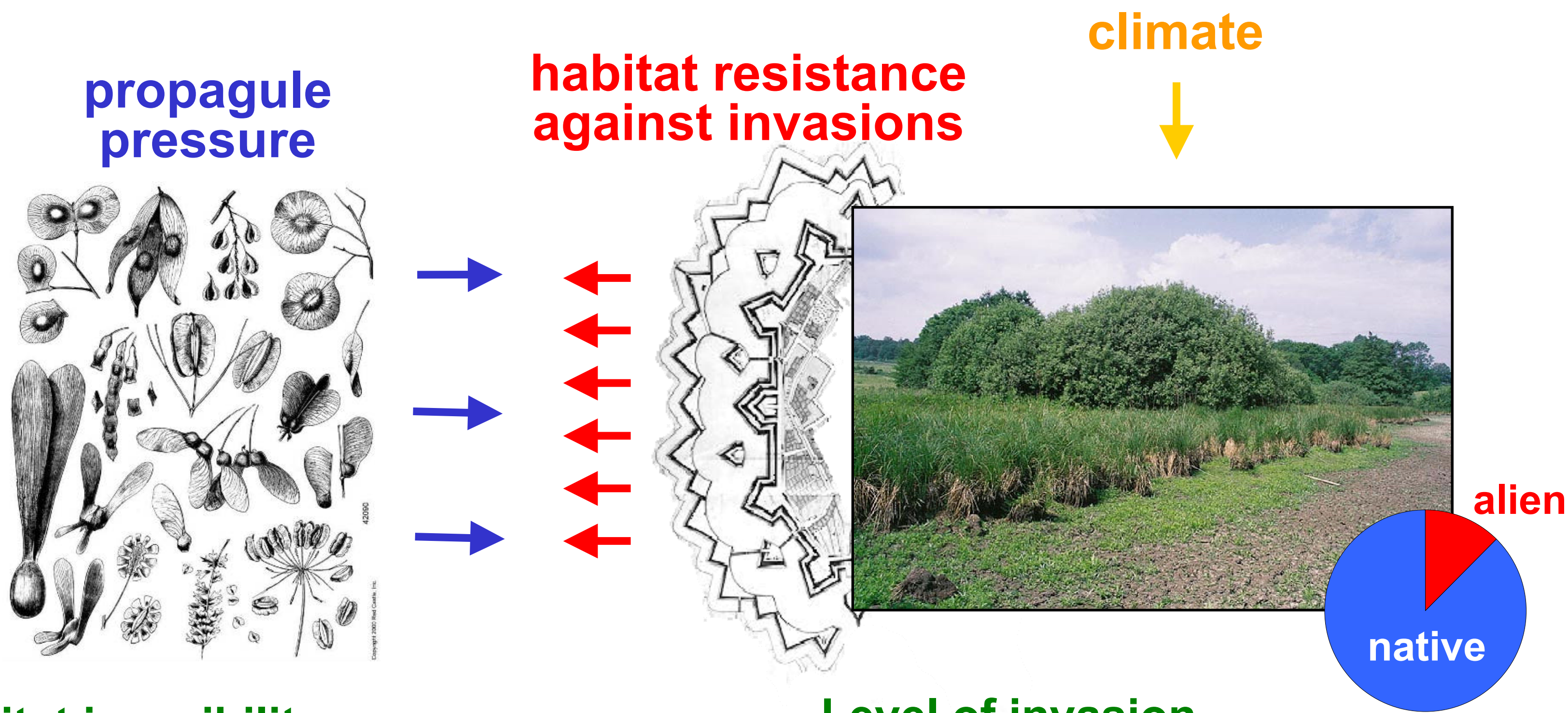
Invasibility vs. Level of Invasion: Study area

regional scale of the Czech Republic (78,000 km²) – data valid for Central Europe



Chytrý M., Jarošík V., Pyšek P. et al. (2008) Separating habitat invasibility by alien plants from the actual level of invasion. Ecology (in press)

Invasibility vs. Level of Invasion: Model

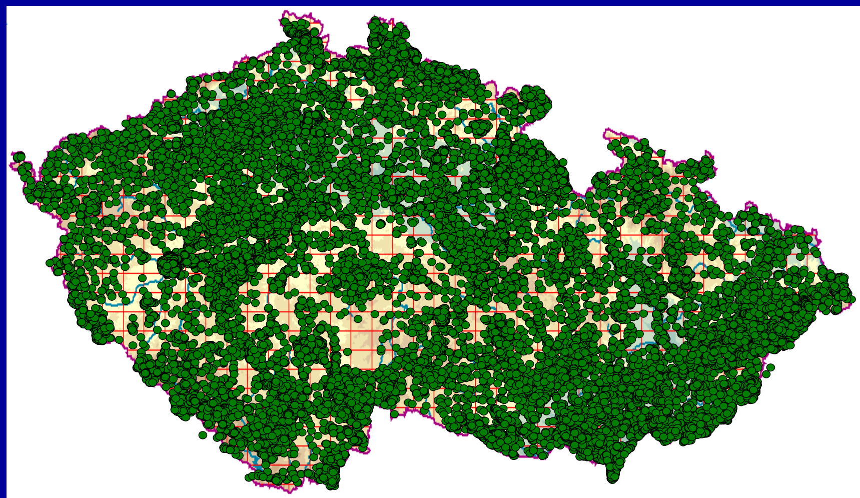


Habitat invasibility
= proportional number of aliens when the effects of propagule pressure and climate are held constant

Level of invasion
= proportion of aliens to all species

Habitat invasibility = Level of invasion | Propagule pressure | Climate

Invasibility vs. Level of Invasion: Data



20,468 vegetation plots
from the Czech Republic (Central Europe)
(Czech National Phytosociological Database)

GIS digital maps
(climate, elevation model, land cover, floristic regions, population density)

Taxon	Fam	Stat	Res	1st	Landuse	Landscape
Lepidium perfoliatum L.	Bra	cas	neo	1872	H	TM
Lepidium ruderale L.	Bra	nat*	arR		H	TM
Lepidium sativum L.	Bra	cas	neo	1874	H	TM
Lepidium virginicum L.	Bra	cas	neo	1936	H	TM
Leptochloa chinensis Nees	Gra	cas	neo		H	M
Leptochloa fascicularis (Lamk.) A. Gray	Gra	cas	neo		H	M
Leptochloa filiformis (Lamk.) P. B.	Gra	cas	neo	1961	H	M
Lepyrodiclis holosteoides (C. A. Meyer) Fisch. et Mey.	Car	cas	neo	1967	H	T
Leucanthemella serotina (L.) Tzvelev	Com	cas	neo		N	T
Leucosinapis alba (L.) Spach	Bra	nat	neo	1875	H	TM
Leucosinapis dissecta (Lag.) Zelený	Bra	cas	neo	1953	H	M
Levisticum officinale Koch	Api	cas	neo	1809	H	T
Leymus arenarius (L.) Hochst.	Gra	cas	neo		N	T
Linaria arvensis (L.) Desf.	Scr	nat*	ar		H	T
Linaria maroccana Hooker	Scr	cas	neo		H	TM
Linaria repens (L.) Mill.	Scr	cas	neo	1934	NSH	TM
Linaria vulgaris Mill.	Scr	nat*	ar		SH	TM
Lindernia dubia (L.) Pennell	Scr	cas	neo	1989	S	T
Linum usitatissimum L.	Lin	cas	ar		H	TM
Lithospermum arvense L. subsp. *arvense*	Bor	nat*	arN		SH	T
Lithospermum arvense subsp. *caerulescens* (DC.) Rothm.	Bor	cas	neo	1867	H	T
Lobelia erinus L.	Cam	cas	neo		H	TM
Lobularia maritima (L.) Desv.	Bra	cas	neo	1963	H	M
Lolium loliaceum (Bory et Chaub.) Hand. - Mazz.	Gra	cas	neo		H	M
Lolium multiflorum Lamk.	Gra	nat	neo	1883	H	TM

National catalogue of alien plants

(Pyšek et al. 2002)

Modelling habitat invasibility

Invasibility vs. Level of Invasion: Variables

Response variable:
percentage of alien species in each vegetation plot (n=20,468)

Archaeophytes (n = 219)
arrived before 1500, mainly from the Middle East and Mediterranean

Example: *Centaurea cyanus*

Neophytes (n = 171)
arrived after 1500, mainly from North America and Asia

Example: *Amaranthus retroflexus*

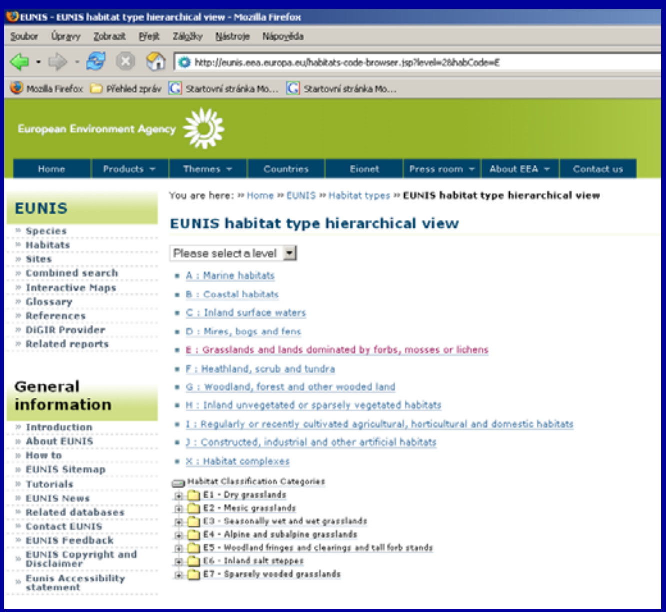
… plus native species (n = 1451)

Invasibility vs. Level of Invasion: Variables

Predictor variables:

1. Habitat properties

- habitat type (based on EUNIS hierarchical habitat classification; 32 categories)
- vegetation cover (%)



http://eunis.eea.europa.eu/habitats.jsp

Table 1. Overview of the EUNIS habitat types used in this study.

EUNIS code	Habitat name	Number of plots
C1	Surface standing waters	1028
C2	Surface running waters	254
C3	Littoral zone of inland surface waterbodies (combined with D5 - Sedge and reedbeds, normally without free-standing water)	2891
D1	Raised and blanket bogs	75
D2	Valley mires, poor fens and transition mires	375
D4	Base-rich fens	49
D6	Inland saline and brackish marshes and reedbeds	32
E1	Dry grasslands	2508
E2	Mesic grasslands	1698
E3	Seasonally wet and wet grasslands	2251
E4	Alpine and subalpine grasslands	94
E5.2	Thermophile woodland fringes	369
E5.4	Moist or wet tall-herb and fern fringes and meadows	734
E5.5	Subalpine moist or wet tall-herb and fern habitats	218
E5.6	Anthropogenic forb-rich habitats	800
E6	Inland saline grass and herb-dominated habitats	151
F2	Arctic, alpine and subalpine scrub habitats	24
F3	Temperate and mediterraneo-montane scrub habitats	102
F4	Temperate shrub heathland	228
F9.1	Riverine and lakeshore [Salix] scrub	20
F9.2	Salix carr and fen scrub	48
G1	Broadleaved deciduous woodland	1660
G1.C	Highly artificial broadleaved deciduous forestry plantations	27
G3	Coniferous woodland	385
G3.F	Highly artificial coniferous plantations	207
G4	Mixed deciduous and coniferous woodland	855
G5	Lines of trees, small anthropogenic woodlands, recently felled woodland, early-stage woodland and coppice	491
H2	Screes	50
H3	Inland cliffs, rock pavements and outcrops (including walls)	236
H5.6	Trampled areas	777
I1	Arable land and market gardens	1441
X	Annual ruderal vegetation	390

Invasibility vs. Level of Invasion: Variables

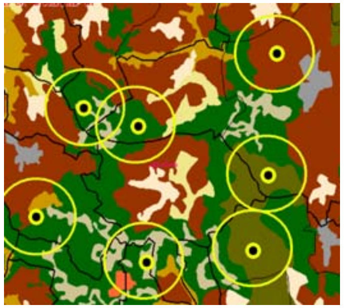
Predictor variables:

1. Habitat properties

- habitat type (based on EUNIS habitat classification; 32 categories)
- vegetation cover (%)

2. Propagule pressure proxies

- proportional area of surrounding urban/ industrial/agricultural landscape
- human population density in the region
- altitudinal floristic regions
- distance from a river



3. Climate variables

- mean annual temperature
- annual precipitation
- altitude

Invasibility vs. Level of Invasion: Statistics

Statistical methods:

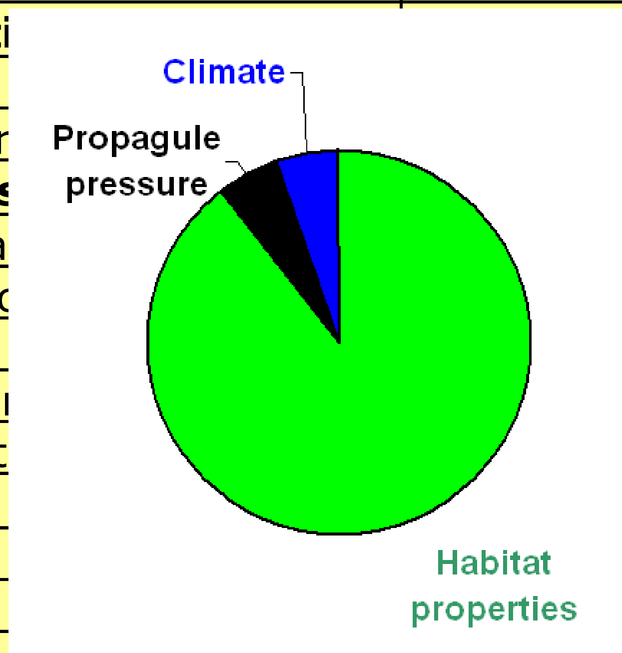
- **Regression Trees using binary recursive partitioning (CART)**
- **Finding optimal tree**
- **Cross-validation on random 20% of data**
- **Total variance explained by the tree = R^2 = 1 – resubstitution relative error**
- **Level of invasion was compared among habitats after removing all variables except habitat properties**

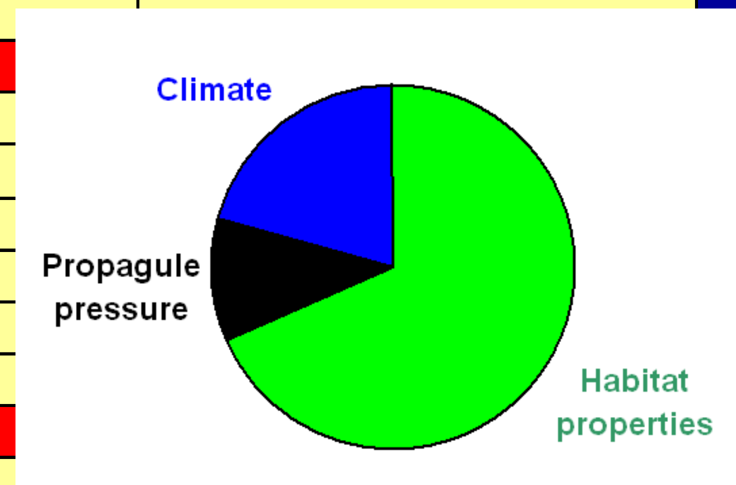
Technically, between-habitat comparisons of invasibility was done in statistical models, in which habitat was the predictor variable and residuals from the regression of alien richness on the confounding variables (climate and propagule pressure) the response variable

Invasibility vs. Level of Invasion: Predictors

Table 2. Predictors of proportional representation of archaeophytes and neophytes expressed in terms of the improvement values of the optimal regression trees. All predictors are in percentages of the total variance explained by the model and are obtained by adding all values of each predictor for the model

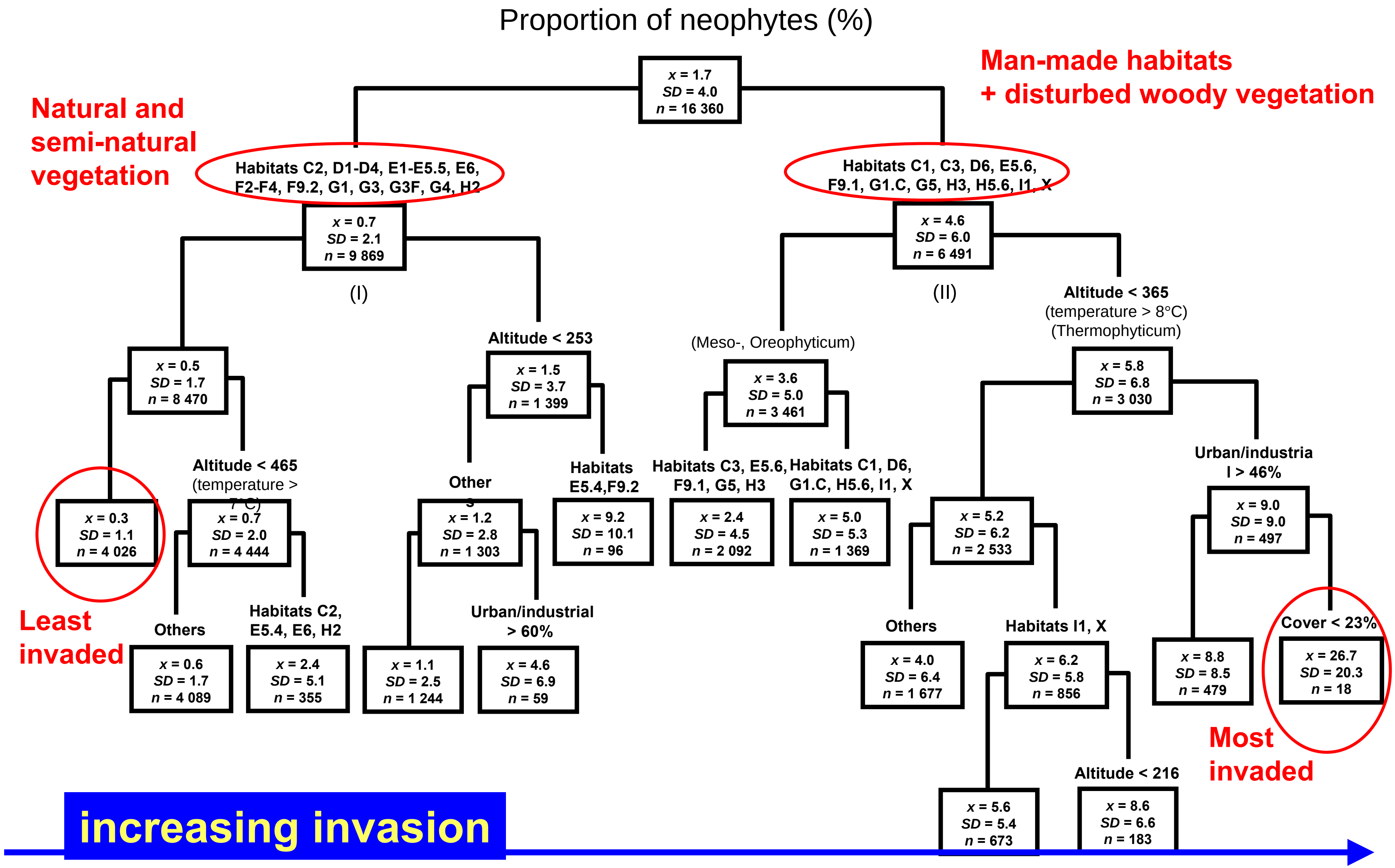
Predictor	Archaeophytes	Neophytes
Habitat properti		
Habitat type	7	
Vegetation cover	5	
Propagule press		
Surrounding urba		
Surrounding agric	5	
Human density	1	
Distance from a r		
Altitudinal florist	9	
Climate		
Altitude	3	5.9
Temperature	1	–
Precipitation	2.1	–
Total	86.4	28.3





Chytrý M., Jarošík V., Pyšek P. et al. (2008) Separating habitat invasibility by alien plants from the actual level of invasion. Ecology (in press)

Invasibility vs. Level of Invasion: Predictors



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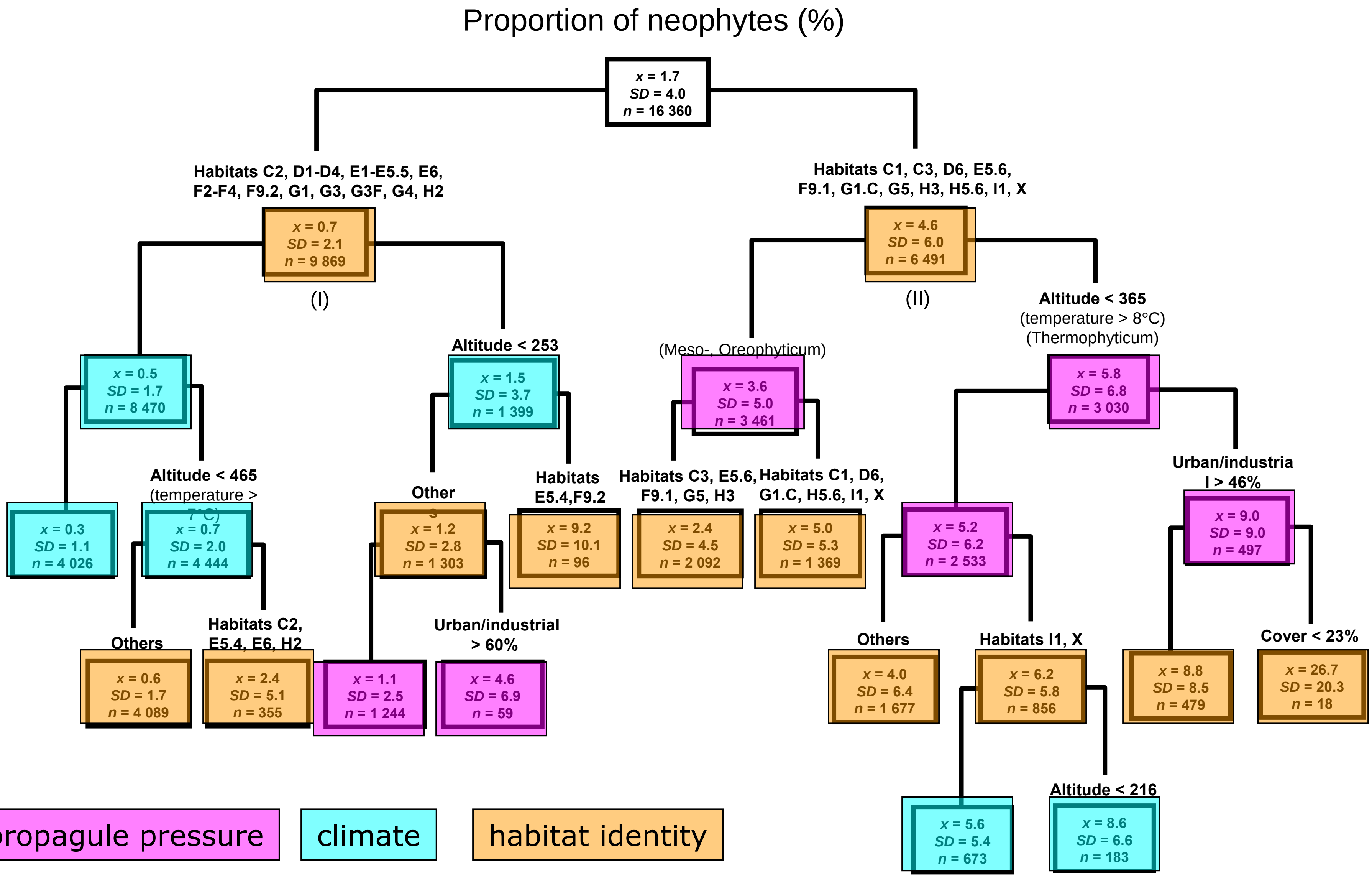
Invasibility vs. Level of Invasion: Predictors



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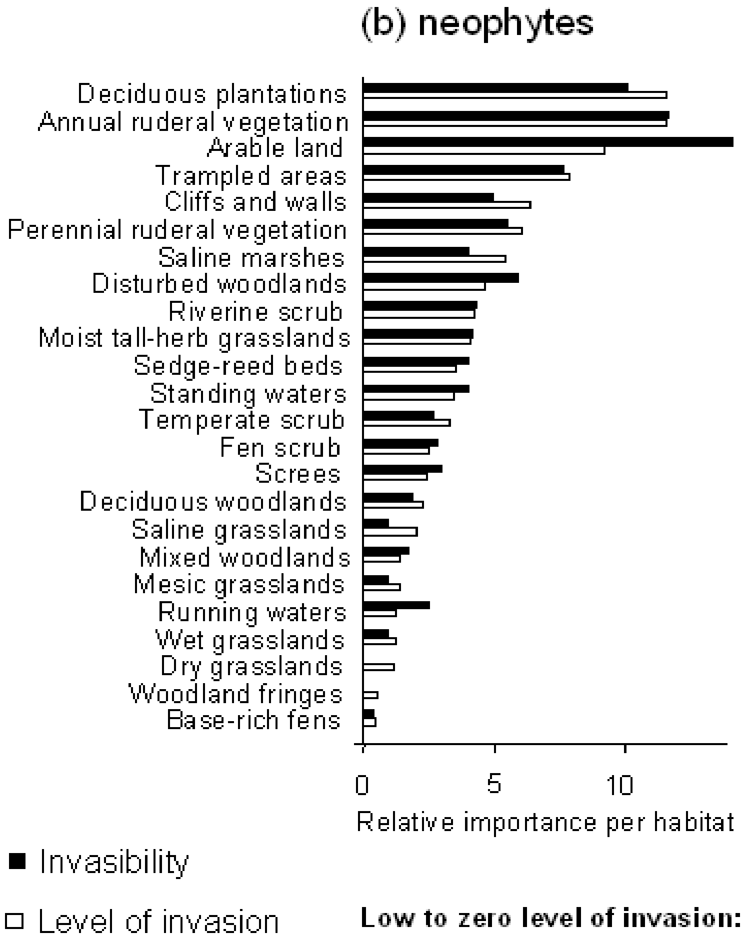
Invasibility vs. Level of Invasion: Neophytes

Invasibility
(residuals of alien proportions after subtracting the effects of propagule pressure and climate)

Level of invasion
(actual proportion of aliens)

Fig. 2. Comparison of the level of invasion and invasibility of Czech habitats by neophytes. Level of invasion is defined as the mean proportion of archaeophytes or neophytes to all species encountered in the vegetation survey plots belonging to particular habitats. Invasibility is defined as the same measure provided that propagule pressure and climate are constant across the plots; it was quantified by using residuals of the linear model that subtracted the effects of propagule pressure and climate from the relationship between the level of invasion and invasibility. To make both measures comparable, they were relativized to equal sum across all the habitats Based on data reported in Chytrý *et al.* (2008a).



Low to zero level of invasion:
Alpine grasslands, Bogs, Coniferous plantations, Coniferous woodlands, Poor fens, Subalpine scrub, Subalpine tall forbs, Temperate heaths

Pyšek P., Chytrý M. & Jarošík V. 2008. Habitats and land-use as determinants of plant invasions in the temperate zone of Europe. In: Perrings C., Mooney H. A. & Willimason M. (eds.), Bioinvasions and globalization: Ecology, economics, management and policy, Oxford University Press, Oxford.

Invasibility vs. Level of Invasion: Summary

Habitats	alpine & subalpine grasslands, bogs, conifer woodlands	meadows and pastures broadleaf woodlands, cliffs and outcrops	man-made habitats, ruderal vegetation, arable weeds
Level of invasion	low	medium	high
Propagule pressure	low	high	high
Invasibility	probably low	low	high
Nutrient availability	low, stable	low to high, stable	usually high, fluctuating
Disturbance regime	rare	rare or of medium frequency and moderate intensity	frequent and strong

complete removal of above-ground biomass on arable land; strong and frequent disturbances in ruderal habitats; tree felling in forest clearings; afforestation of previously deforested land; floods in riverine willow stands

Invasibility vs. Level of Invasion: Summary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TEMPORARY INCREASE IN RESOURCE AVAILABILITY: fertilization of arable land; nutrient input into ruderal vegetation in human settlements; sedimentation of nutrient-rich mud after floods; increased light availability after opening the woodland canopy

Invasibility vs. Level of Invasion: Summary

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disturbances in perennial grasslands do not result in such increase in nutrient availability: vegetation is never disturbed completely, rapid uptake of free nutrients to support fast regrowth

Increase of available resources:

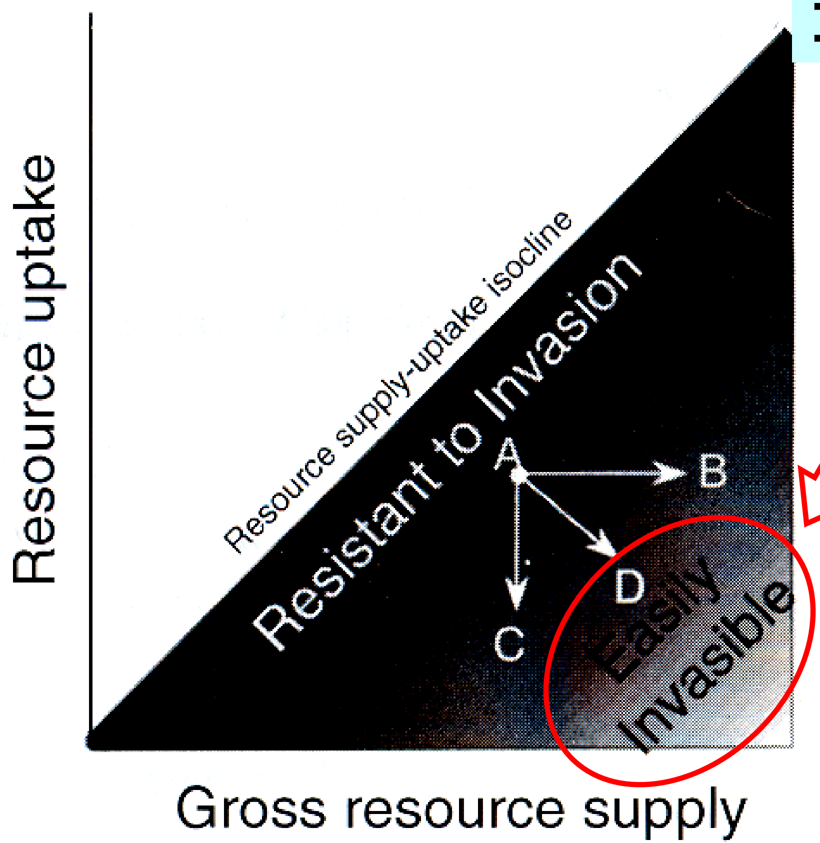


Fig. 1 The theory of fluctuating resource availability holds that a community's susceptibility to invasion increases as resource availability (the difference between gross resource supply and resource uptake) increases. Resource availability can increase due to a pulse in resource supply (A→B), a decline in resource uptake (A→C) or both (A→D). In the plot shown, resource availability, and hence invasibility, increases as the trajectory moves further right and/or below the supply/uptake isocline (where resource uptake = gross resource supply).

B = Increased supply

C = Decreased uptake

D = Both

1. Resource level fluctuates in space and time

2. Community invasibility increases with increase in available resources

Davis M.A., Grime J.P. & Thompson K. 2000. Fluctuating resources in plant communities: a general theory of invasibility. Journal of Ecology 88:528–534.

Habitat invasibility at continental scale

Data sets: neophytes in plant communities

Catalonia (Mediterranean climate)
Czech Republic (subcontinental climate)
Great Britain (oceanic climate)

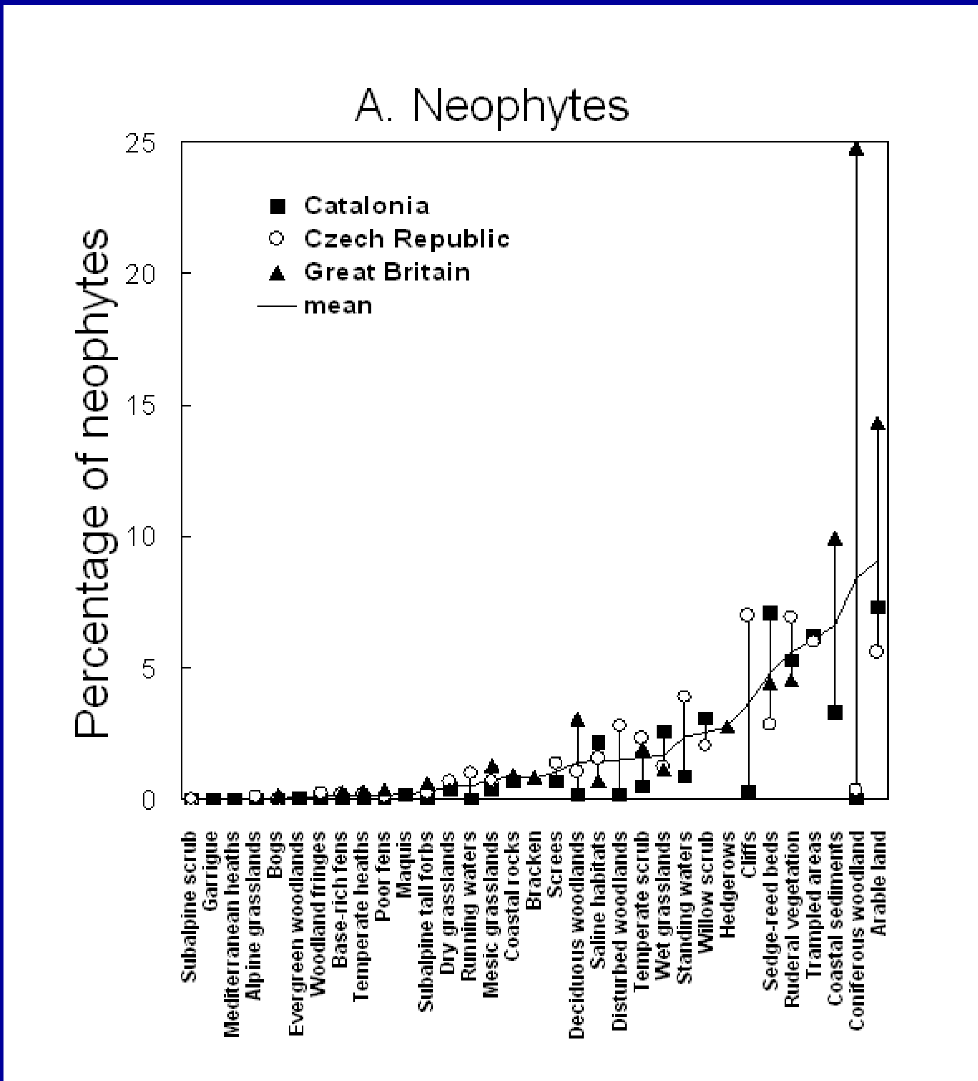
Table 1. Selected characteristics of the studied regions and numbers of vegetation plots. Numbers of alien species are given with casual species excluded (sources: Bolòs *et al.* 1993; Preston *et al.* 2002; Pyšek *et al.* 2002; Pino *et al.* 2005).

	Catalonia	Czech Republic	Great Britain
Area (km^2)	32,106	78,865	229,979
Altitude (m a.s.l.)	0–3,150	115–1,602	0–1,343
No. of native species in the region's flora	ca. 2,950	2,256	1,455 [1]
No. of archaeophytes in the region's flora	– [2]	258	151
No. of neophytes in the region's flora	264	229	259
No. of plots used in the current study	15,650	20,468	16,362

[1] Including 46 species with doubtful status (native or alien).
[2] Archaeophytes are included among native species.

Chytrý M., Maskell L., Pino J., Pyšek P., Vila M., Font X. & Smart S. 2008. Habitat invasions by alien plants: a quantitative comparison between Mediterranean, subcontinental and oceanic regions of Europe. Journal of Applied Ecology 45: 448–458

Habitat invasibility at continental scale



Large difference in species composition, but consistent patterns of habitat invasions between regions

Extreme habitats with low nutrients little invaded × frequently disturbed habitats with fluctuating resource availability highly invaded

Inter-regional consistency of the habitat invasion patterns - habitats are good predictor for **invasion risk analysis**

Chytrý M., Maskell L., Pino J., Pyšek P., Vila M., Font X. & Smart S. 2008. Habitat invasions by alien plants: a quantitative comparison between Mediterranean, subcontinental and oceanic regions of Europe. Journal of Applied Ecology 45: 448–458

Mapping invasions by using habitats

EUNIS habitat categories transferred to spatial CORINE landcover classes (proportional contribution of relevant habitat categories estimated for each landcover class)

	EUNIS habitat category																														
CORINE lancover class	A2.5&D6&E6 Saline habitats	B1&B2 Coastal sediments	B3 Rock cliffs	C1 Surface standing waters	C2 Surface running waters	C3&D5 Sedge and reedbeds	D1 Raised and blanket bogs	D2 Fens and transitional mires	D4 Base-rich fens	E1 Dry grassland	E2 Mesic grassland	E3&E5.4 Wet grasslands	E4 Alpine and subalpine grasslands	E5.1 Anthropogenic herb stands	E5.3 Pteridium aquilinum fields	F2 Arctic, alpine and subalpine scrub	F3 Temperate scrub	F4 Temperate shrub heathland	F5 Maquis	F6 Garrigue	F7 Spiny mediterranean heaths	F9 Riverine and fen scrub	FA Hedgerows	G2 Broad-leaved evergreen woodland	G3 Coniferous woodland	G1&4 Broadleaved deciduous and mixed woodland	G5 Disturbed woodland	H2 Screes	H3 Cliffs	H5.6 Trampled areas	I1 Arable land and gardens
111 Continuous urban fabric														50																50	
112 Discontinuous urban fabric										10	10			30													10			20	20
121 Industrial or commercial units										15	15			30																40	
122 Road and rail networks and associated land										15	15			30																40	
123 Port areas										10	20			30																40	
124 Airports										30	30			20																20	
131 Mineral extraction sites														50														20	20	10	
132 Dump sites														100																	
133 Construction sites														70																30	
141 Green urban areas										10	30			15													30			15	
142 Sport and leisure facilities										10	30			15													20			25	
211 Non-irrigated arable land																															100
212 Permanently irrigated land																															100

Chytrý M., Pyšek P., Wild J., Maskell L. C., Pino J. & Vilà M.: Habitat-assessed level of invasion as a basis for mapping risks from alien plants in Europe. Diversity and Distributions (in review)

Mapping invasions by using habitats

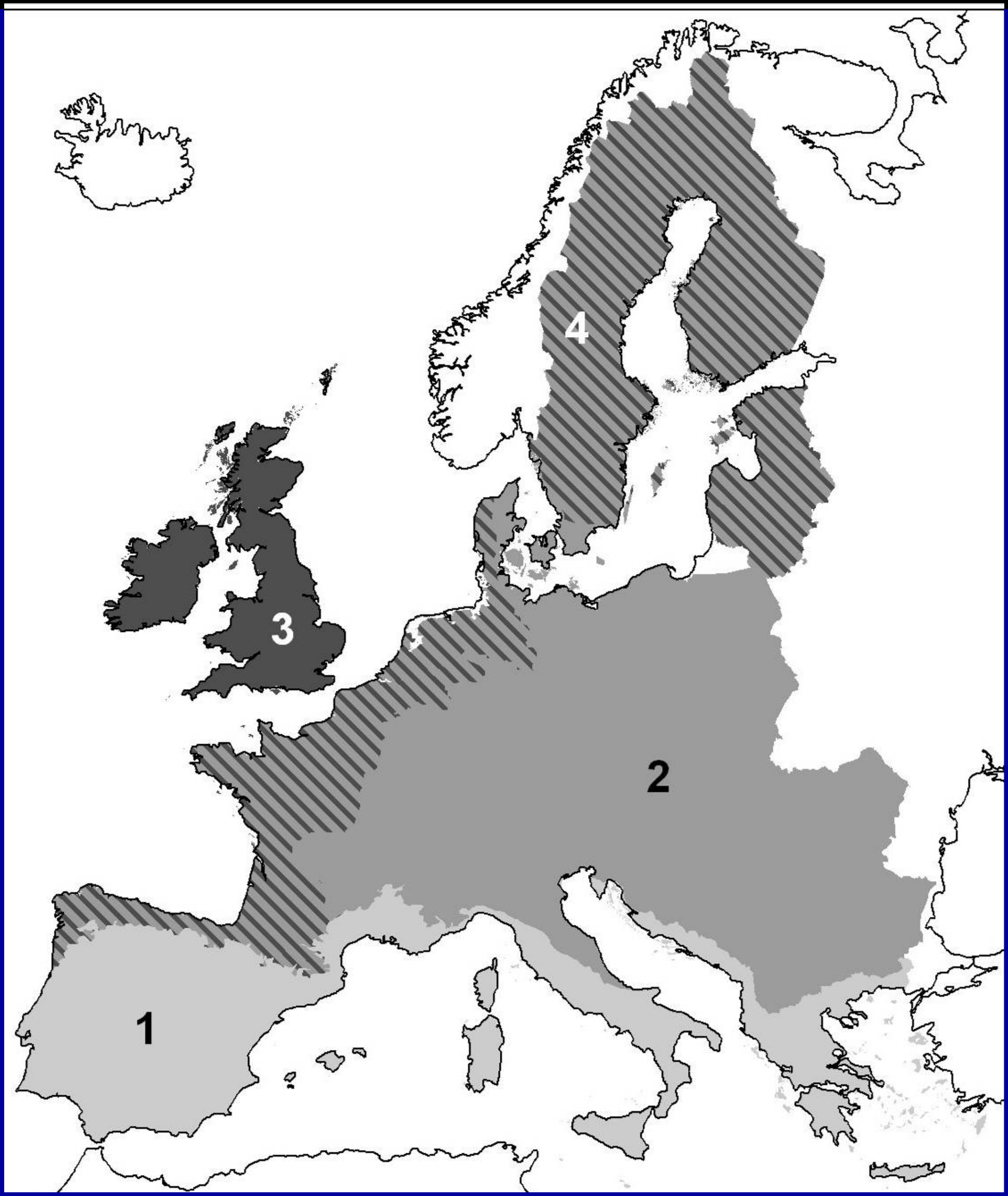
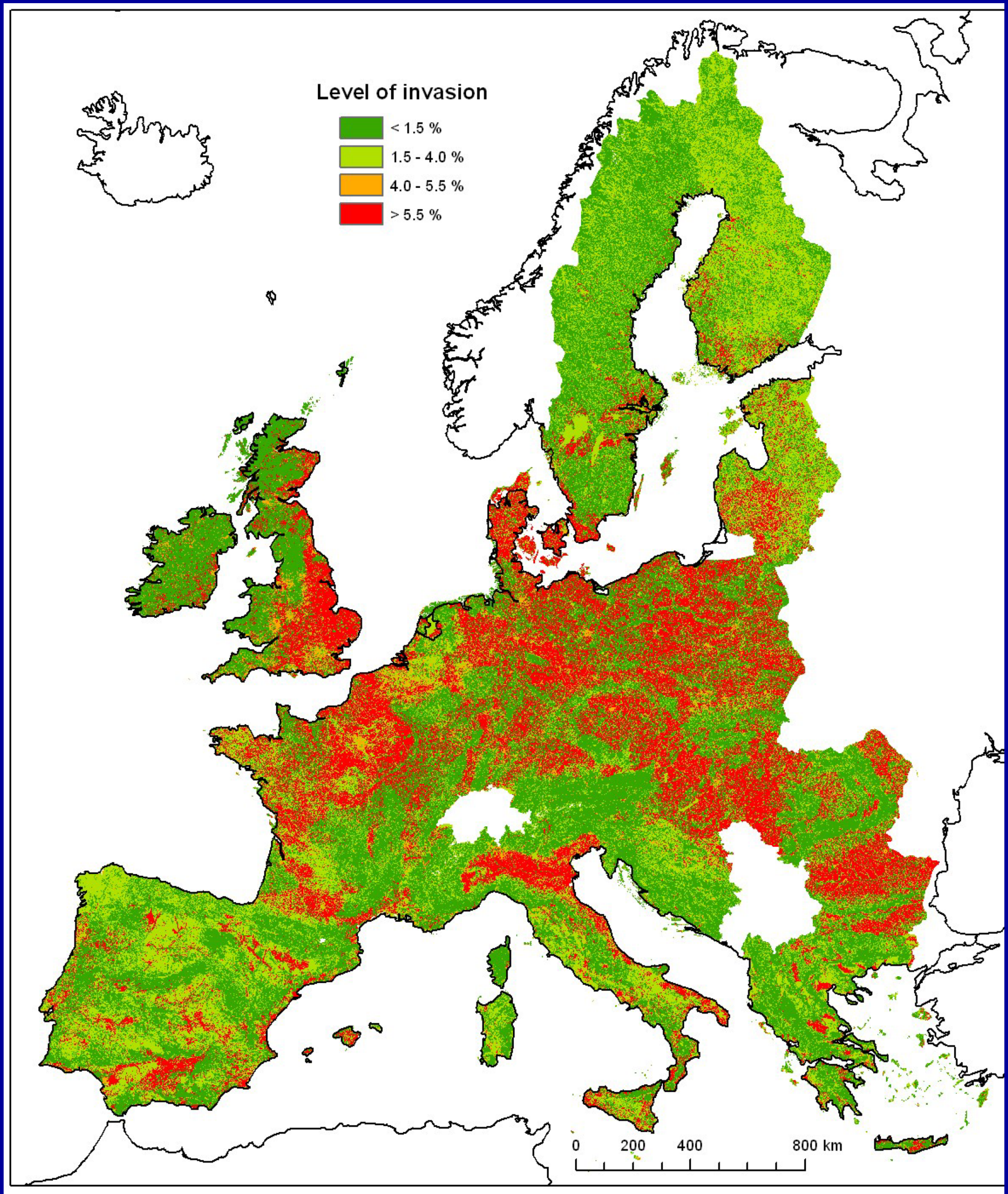


Fig. 1. Delimitation of areas where the invasion risk was mapped based on different data sources: 1 – Catalonian data, 2 – Czech data, 3 – British data, 4 – mean of Czech and British data. Boundaries between the areas follow the map of European biogeographic regions (European Topic Centre on Biological Diversity, 2006).

Chytrý M., Pyšek P., Wild J., Maskell L. C., Pino J. & Vilà M.: Habitat-assessed level of invasion as a basis for mapping risks from alien plants in Europe. Diversity and Distributions (in review)

Mapping invasions by using habitats



least invaded

most invaded

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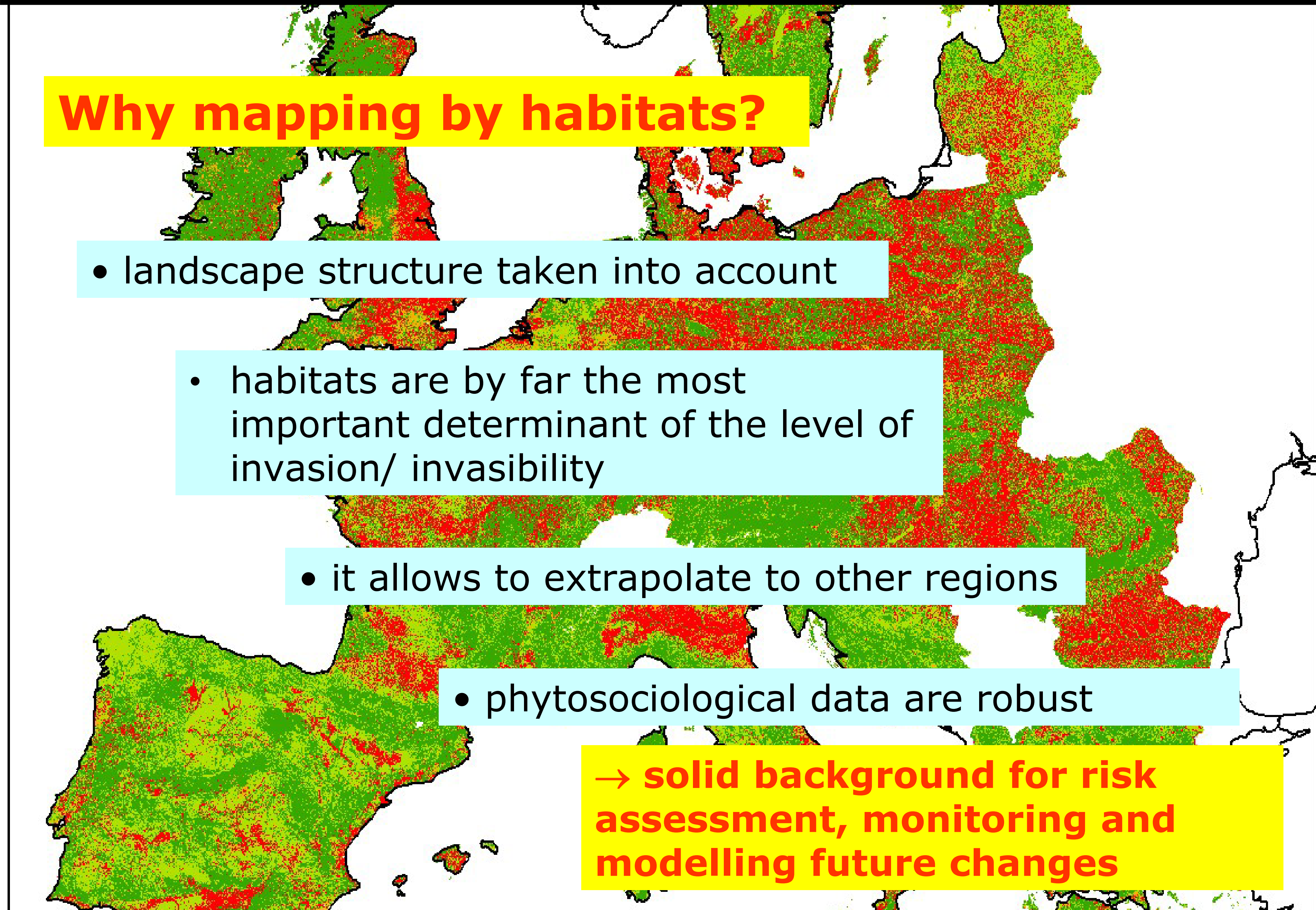
Mapping invasions by using habitats



Why mapping by habitats?

- landscape structure taken into account
- habitats are by far the most important determinant of the level of invasion/ invasibility
- it allows to extrapolate to other regions
- phytosociological data are robust

→ solid background for risk assessment, monitoring and modelling future changes

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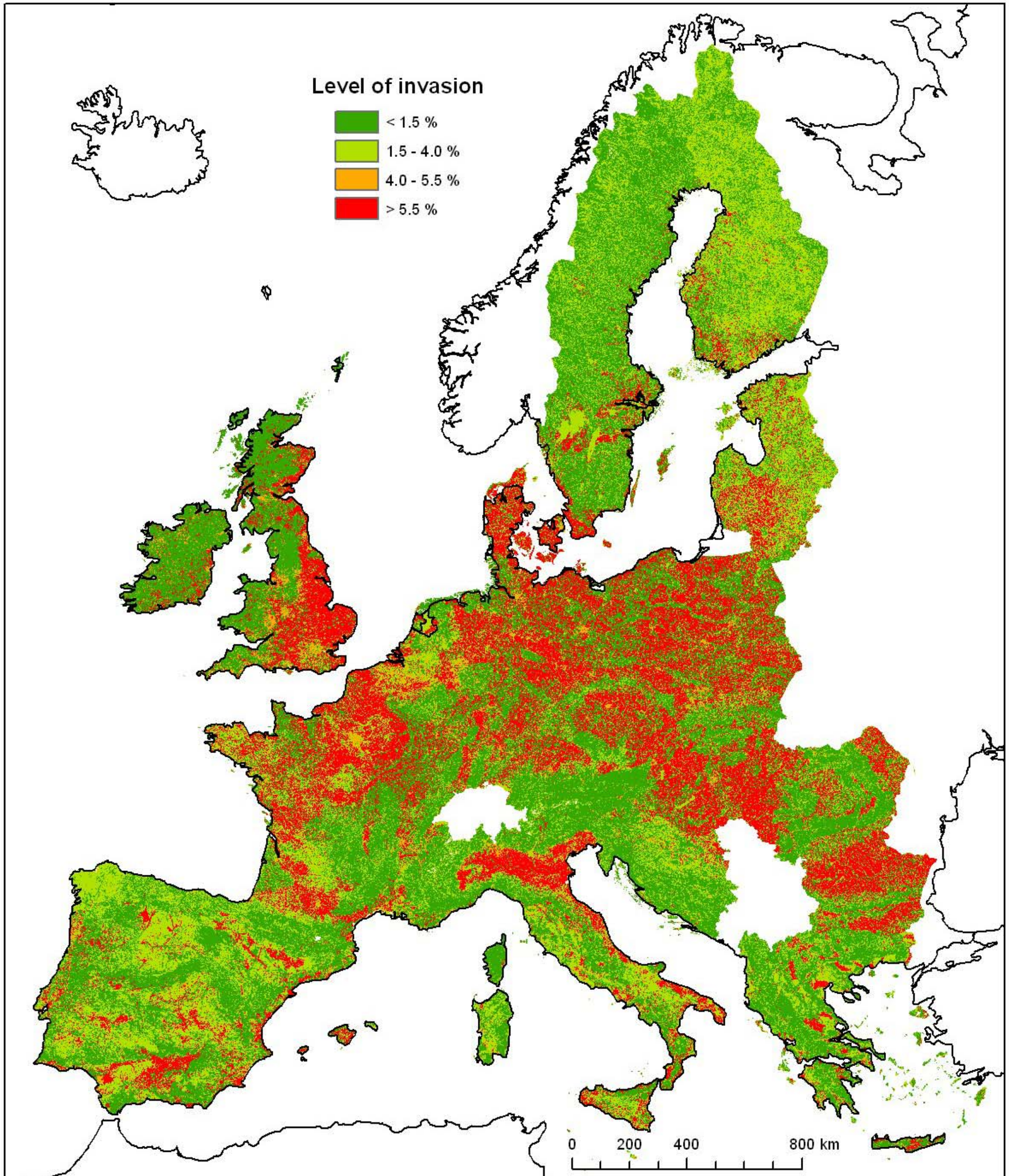
Jiří Danihelka

& other ALARM and DAISIE project colleagues

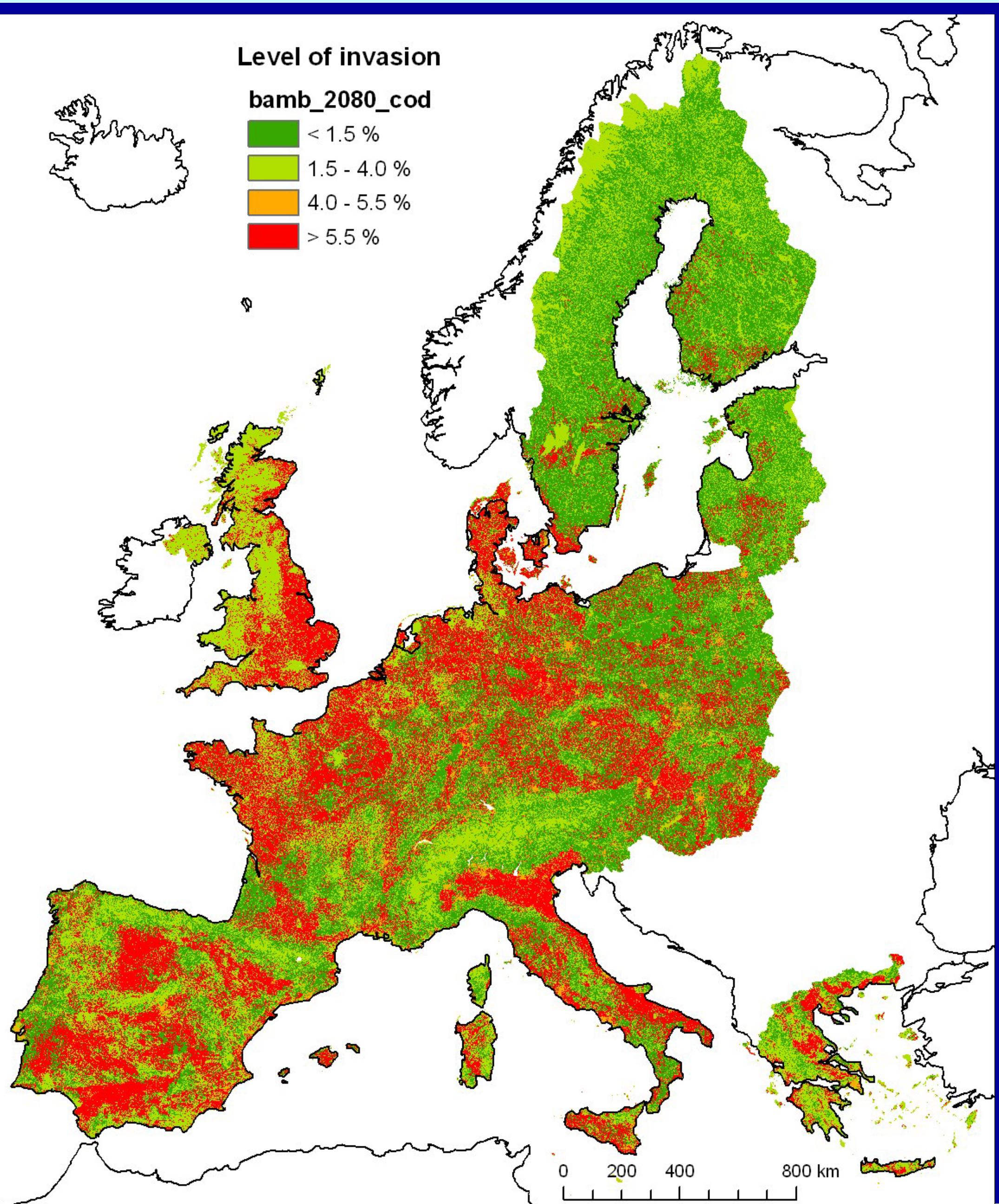
ALARM

Delivering Alien Invasive Species Inventories for Europe



Deliverable 3.2.3:
Report on results of predictive modelling of invasion in different habitats under climate and land-use change
(WP 3.2)

Deliverable 3.2.3: Predictive modelling of invasion in different habitats under climate and land-use change (WP 3.2)

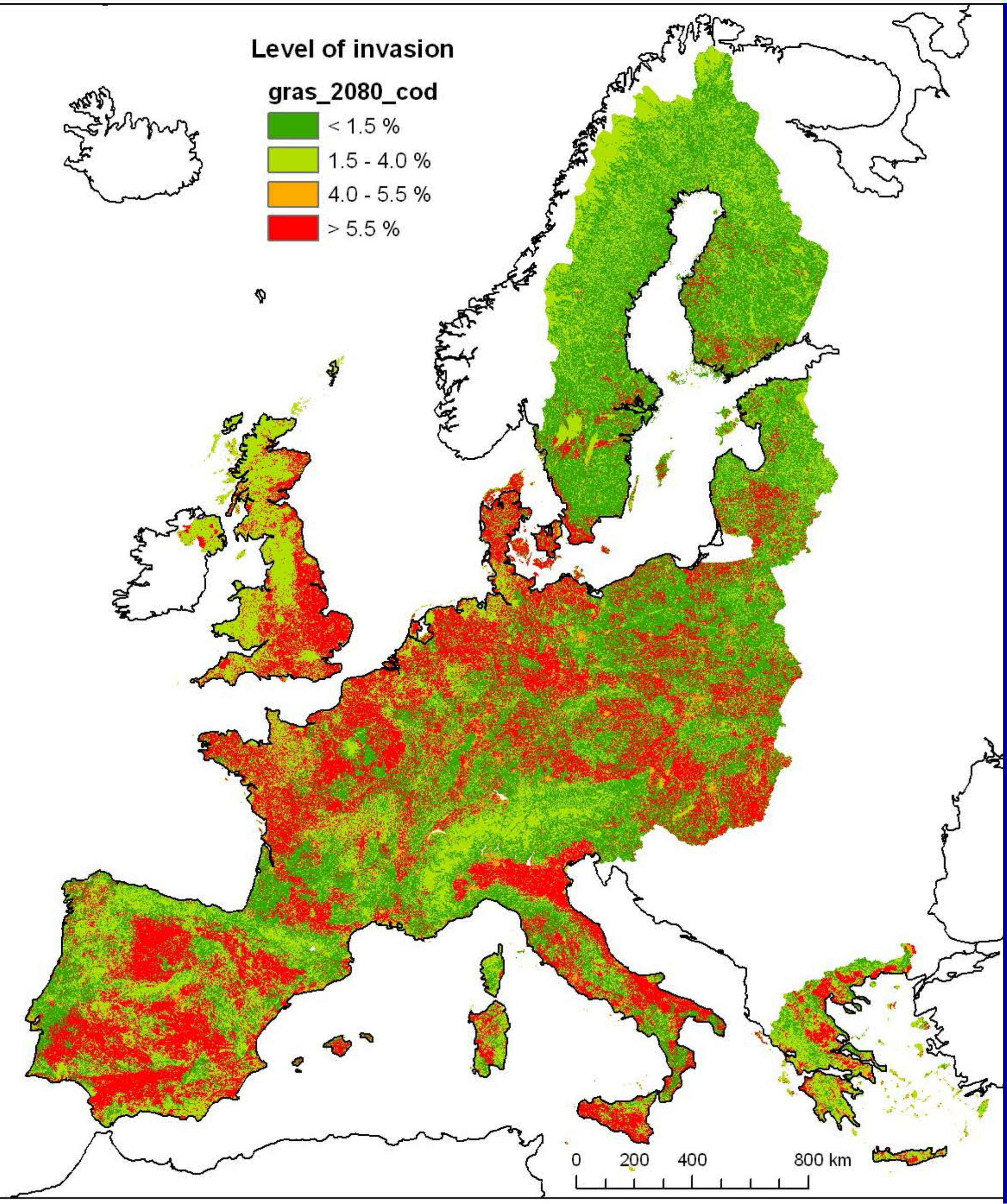


BAMBU
Business-As-Might-Be-Usual

Policy decisions already made in the EU are implemented and enforced. At the national level, deregulation and privatisation continue except in "strategic areas". Internationally, there is free trade. Environmental policy is perceived as another technological challenge.

Prediction for 2080

Deliverable 3.2.3: Predictive modelling of invasion in different habitats under climate and land-use change (WP 3.2)

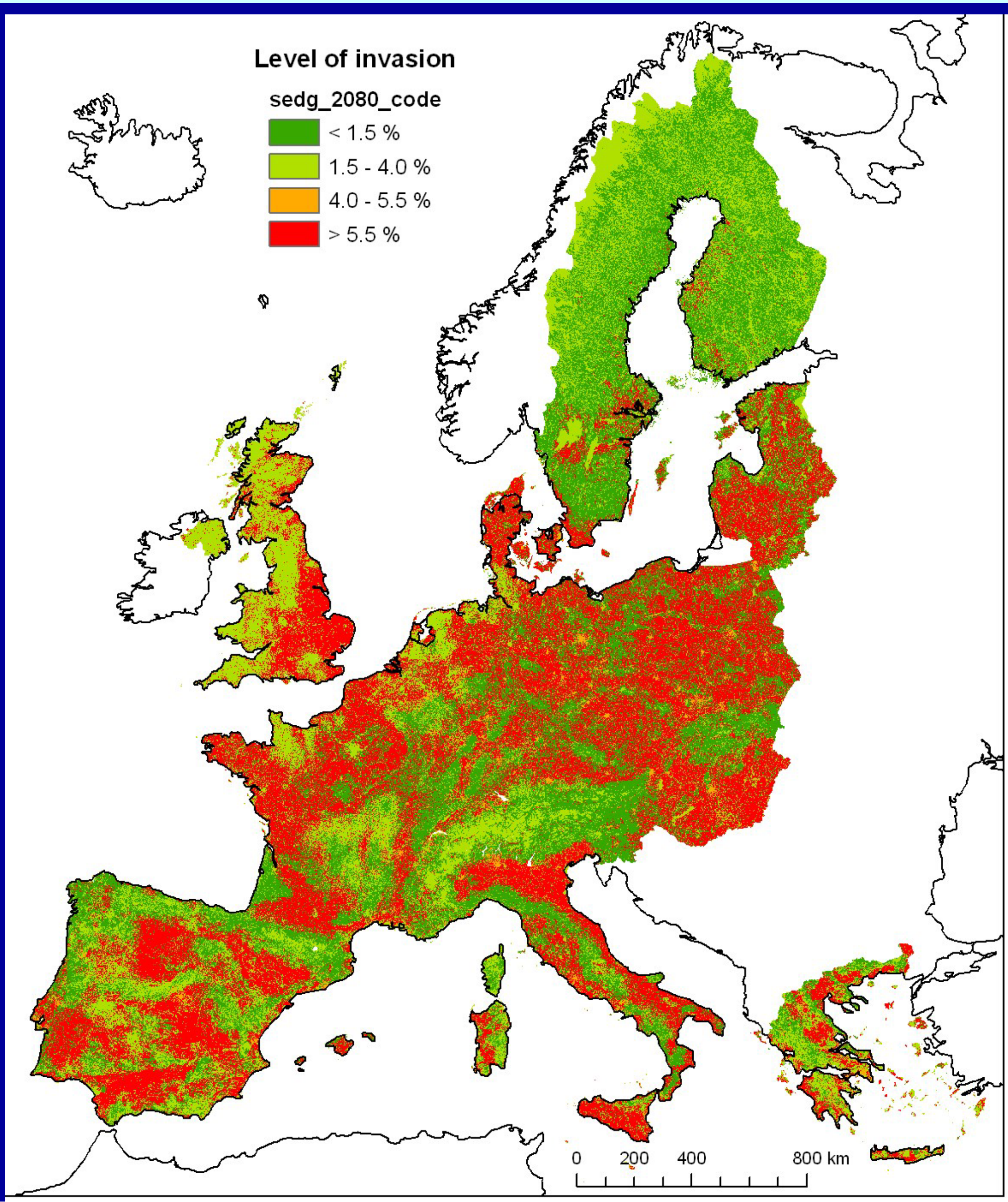


GRAS
Growth Applied Strategy

Deregulation, free trade, growth and globalisation will be policy objectives actively pursued by governments. Environmental policies will focus on damage repair and limited prevention based on cost-benefit-calculations. No emphasis on biodiversity.

Prediction for 2080

Deliverable 3.2.3: Predictive modelling of invasion in different habitats under climate and land-use change (WP 3.2)

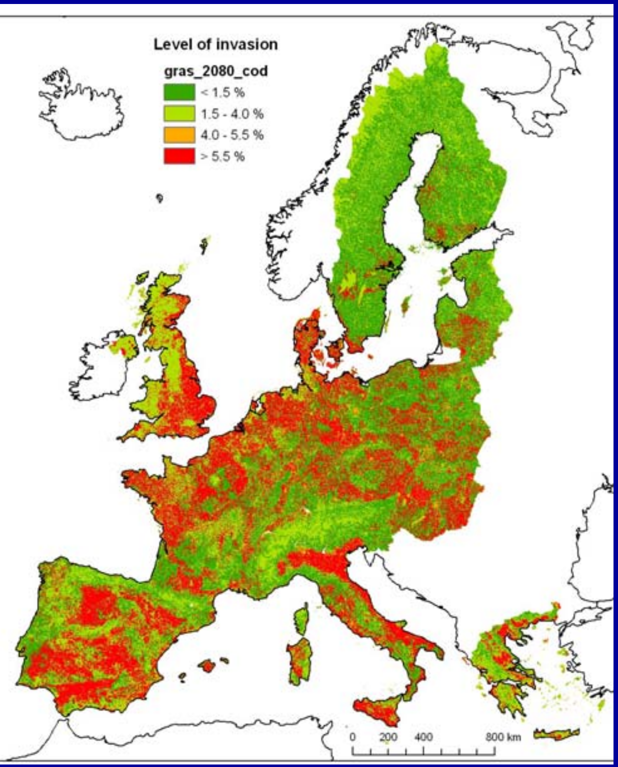


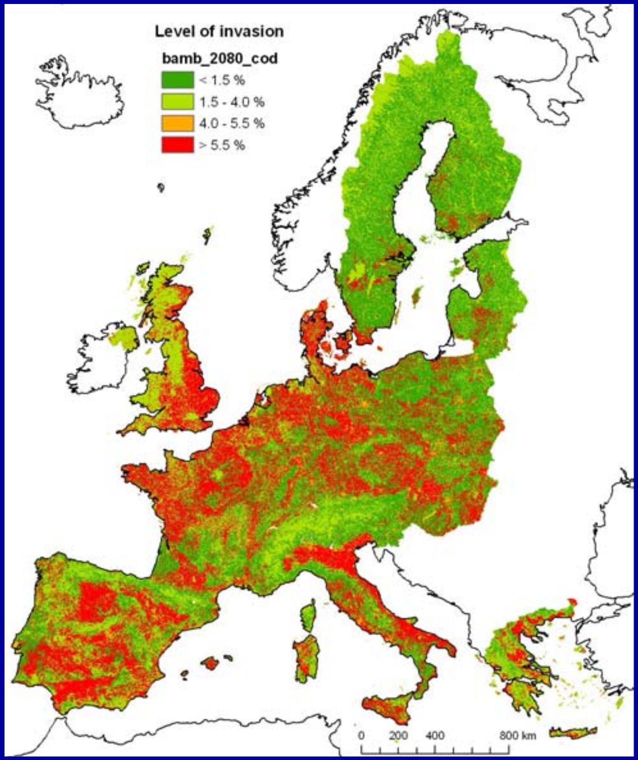
SEDG
Sustainable European Development Goal

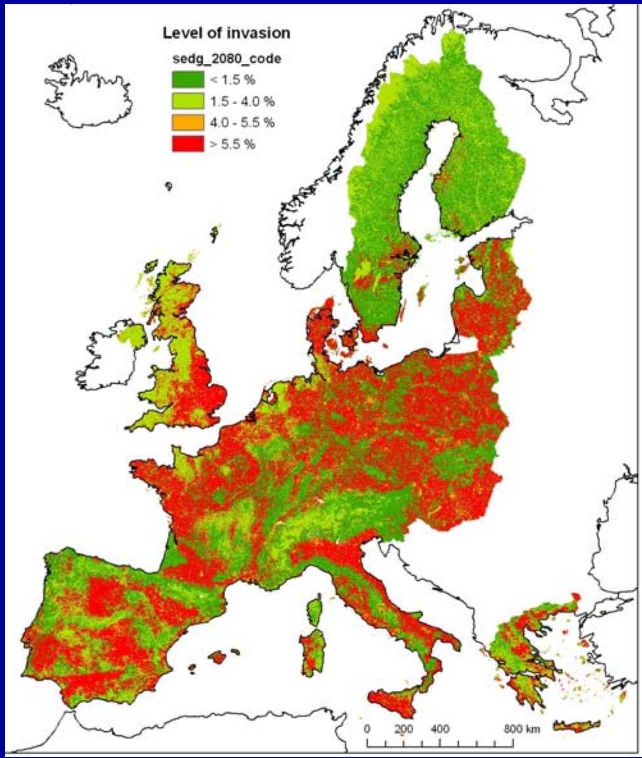
Enhancing the sustainability of societal development by integrated social, environmental and economic policy. Aims for a competitive economy and a healthy environment, gender equity and international cooperation. A normative scenario with stabilisation of GHG emissions.

Prediction for 2080

Deliverable 3.2.3: Predictive modelling of invasion in different habitats under climate and land-use change (WP 3.2)







GRAS 2080

BAMBU 2080

SEDGE 2080

increasing "friendliness to biodiversity"

generates higher levels of invasion in Europe!

Deliverable 3.2.3: Predictive modelling of invasion in different habitats under climate and land-use change (WP 3.2)

Alien species are predicted to decrease under GRAS (e.g. in Poland and Baltic countries) but increase under SEDG and BAMBU.

This is because GRAS predicts abandonment of uneconomic arable land (highly invaded habitat) and expansion of forest (less invaded habitat), while SEDG and BAMBU predict that agricultural land will be maintained to a large extent.

The more free capitalism and environmental ignorance, the less invasive species in the future European landscape?!