Non-native Tree Species for European Forests - Experiences, Risks and Opportunities (FP1403)

Funded by the Horizon 2020 Framework Programme of the European Union

University of Natural Resources and Life Sciences, Vienna
Department of Forest- and Soil Sciences

Plantation of non-native tree species (NNT): ways forward and issues at stake

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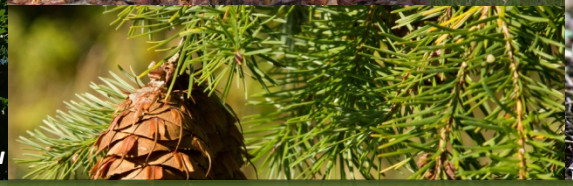
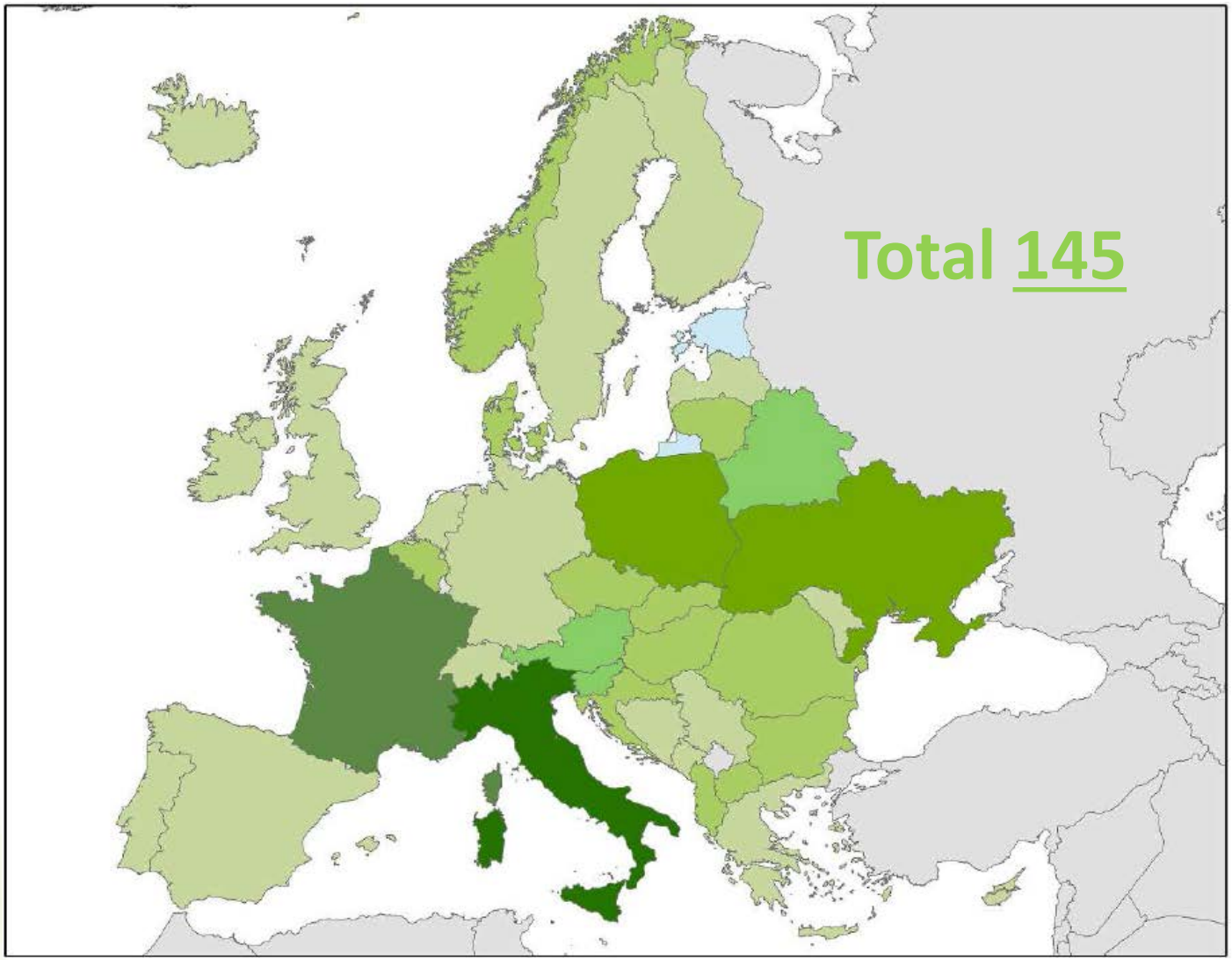
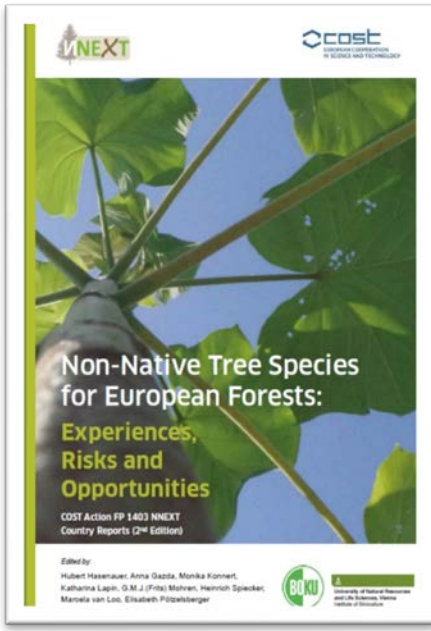
PLANTATION OF NON-NATIVE TREE SPECIES (NNT) CONTENT



1. Current state (species, distribution, importance)
2. Drivers for potential changes in importance
3. Recommendations for a ‚good NNT‘

REPORTED NUMBER OF NNT PER COUNTRY PRESENT IN EUROPEAN FORESTS





Hasenauer et al. 2017

Brus et al. (2019) Extent, Distribution and Origin of Non-native Forest Tree Species in Europe. **Scandinavian Journal of Forest Research (accepted)**

MAIN NON-EUROPEAN NNT

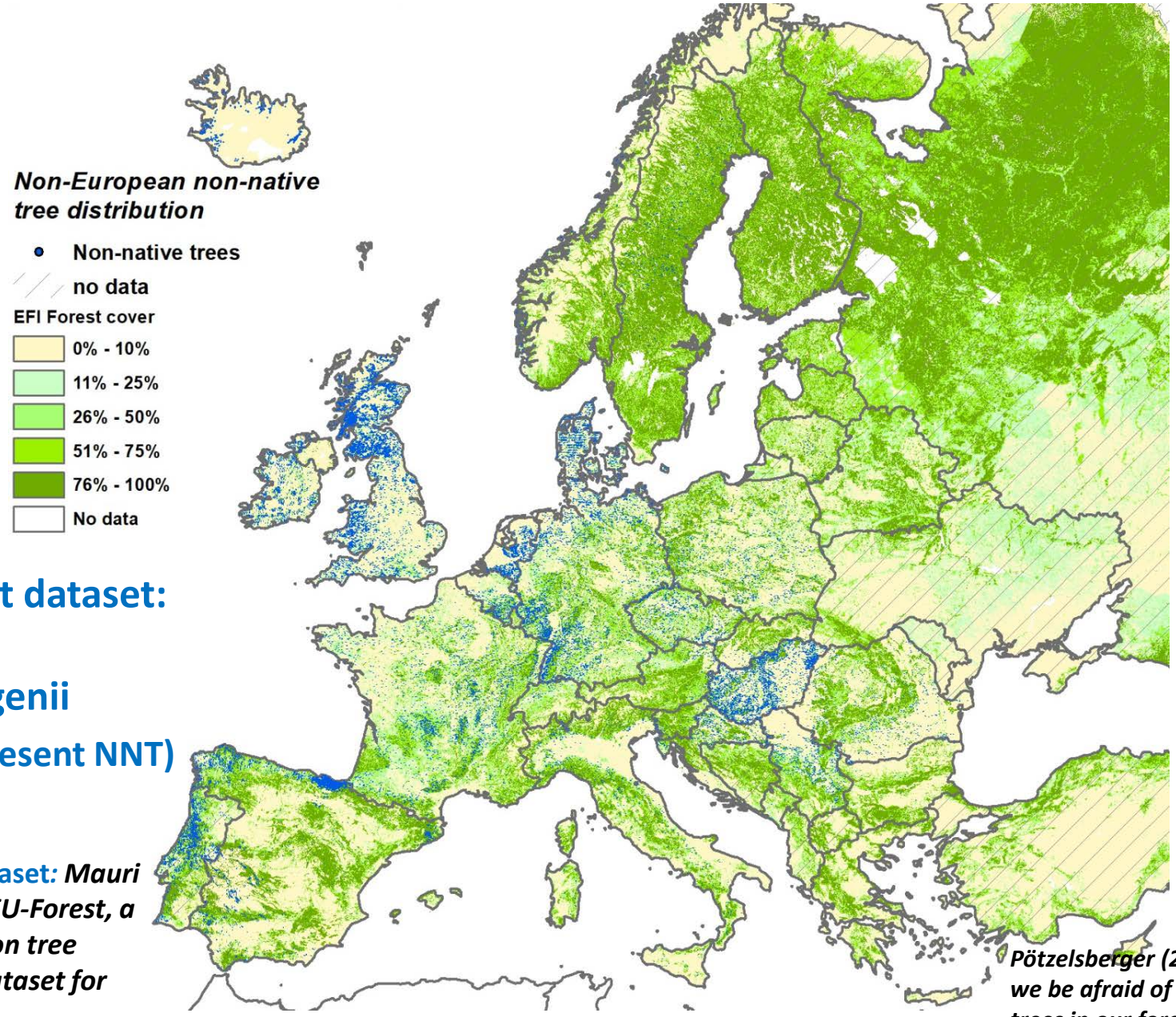
Common name	Scientific name	Origin	Year of introduction	Area (x 1000 ha)	No. of countries
Black locust	***Robinia pseudoacacia***	Eastern North America	1601 (FR)	2,438	29
Eucalyptus / gum tree	***Eucalyptus sp.* (mainly *E. globulus, E. camaldulensis*)**	Australia	1774 (UK) (*E. obliqua*), ~1850 (ES) (*E. globulus*)	1,538	6
Sitka spruce	***Picea sitchensis***	Western North America	1831 (UK)	1,160	13
Douglas fir	***Pseudotsuga menziesii***	Western North America	1827 (UK)	831	32
Lodgepole pine	***Pinus contorta var. latifolia***	Western North America	1845 (IT)	736	11
Poplars incl. hybrids	***Populus sp.***	Northern hemisphere	1750 (FR) (P. x canadensis)	620	13
Larch incl. hybrids	***Larix sp.* (mainly *L. kaempferi, L. x marschlinsii*)**	Northern hemisphere	1861 (UK) (L. kaempferi)	404	7
Northern red oak	***Quercus rubra***	Eastern		345	24
Monterey pine	***Pinus radiata***	W		257	3
Eastern white pine	***Pinus strobus***			70	19
Atlas cedar	***Cedrus atlantica***			23	5
Noble fir	***Abies procera***			13	4
Japanese red-cedar	***Cryptomeria japonica***	Ja		11	3
Grand fir	***Abies grandis***	Weste		10	11
Black walnut	***Juglans nigra***	Eastern North	29 (UK)	8	14
Tree of heaven	***Ailanthus altissima***	China	1740 (FR)	7	18
Box elder	***Acer negundo***	Central and eastern North America	1688 (UK)	5	16
Others				58	
Total				~ 8,500	

90%

4% of European forest area

Brus et al. (2019) Extent, Distribution and Origin of Non-native Forest Tree Species in Europe. Scandinavian Journal of Forest Research (accepted)

CURRENT DISTRIBUTION OF NNT



EU-Forest dataset:
48 NNT
+ 7 NTT genii
(~ 1/3 of present NNT)

EU-Forest dataset: ***Mauri et al. (2016) EU-Forest, a high-resolution tree occurrence dataset for Europe.***

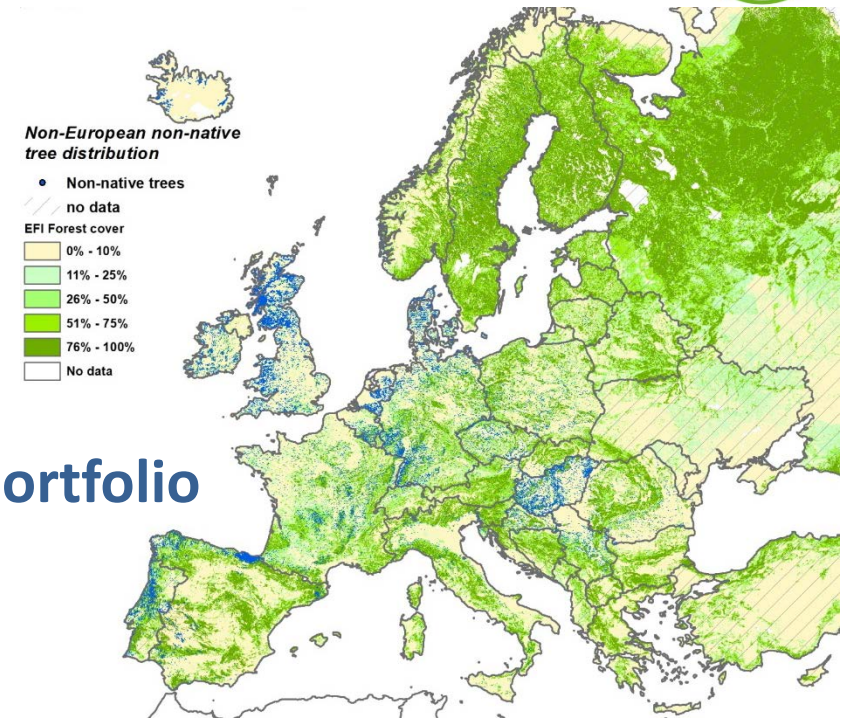
Pötzelsberger (2018) Should we be afraid of non-native trees in our forests?

WHY ARE NNT APPRECIATED?

Importance of established NNT:

- Higher productivity
- Different timber properties
- Production on difficult sites
- Other ES services (e.g. honey)

→ **Addition to the native tree species portfolio**



~4 % of the forest area,
150 NNT used and tested

Brus et al. 2019, Pötzelsberger 2018

Conditions:

- Few native tree species (due to ice age, especially in northern Europe)
- Loss/decreased productivity of native species due to pests and climate change (CC)
- Harsh growing conditions e.g. in degraded areas, coastal areas, dry sandy soils, CC!

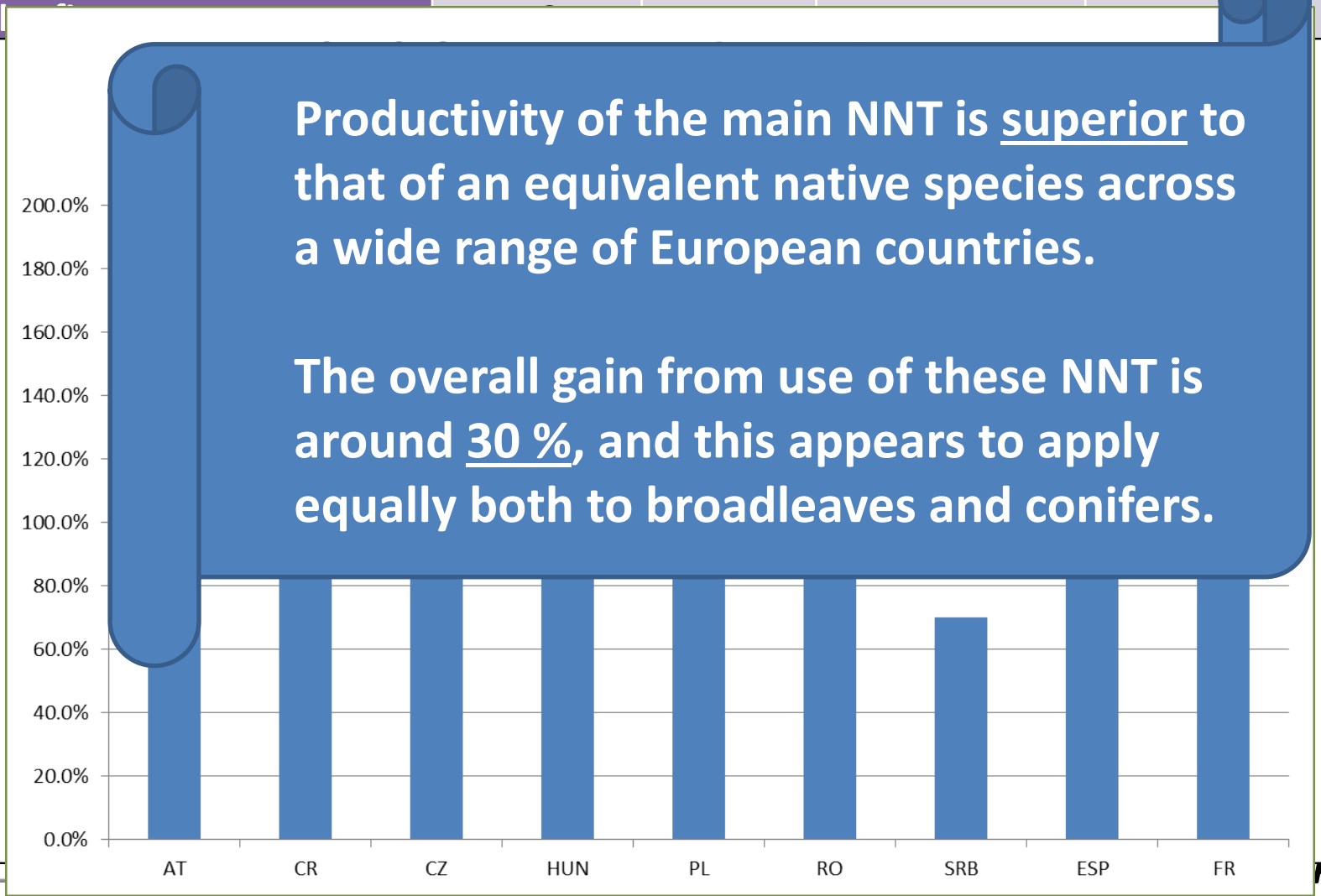
RELATIVE PRODUCTIVITY INCREASE COMPARED TO NATIVE SPECIES – REPORTED BY COUNTRIES

(NNEXT WG3 RESULTS)

Species contrasted	Increase	Equal	Decrease	Average (%)
Dougl				
Red				
Sitk				
Blac				
Gra				
Lod				

Productivity of the main NNT is superior to that of an equivalent native species across a wide range of European countries.

The overall gain from use of these NNT is around 30 %, and this appears to apply equally both to broadleaves and conifers.



prep.)

WHERE DOES THE ROAD LEAD?

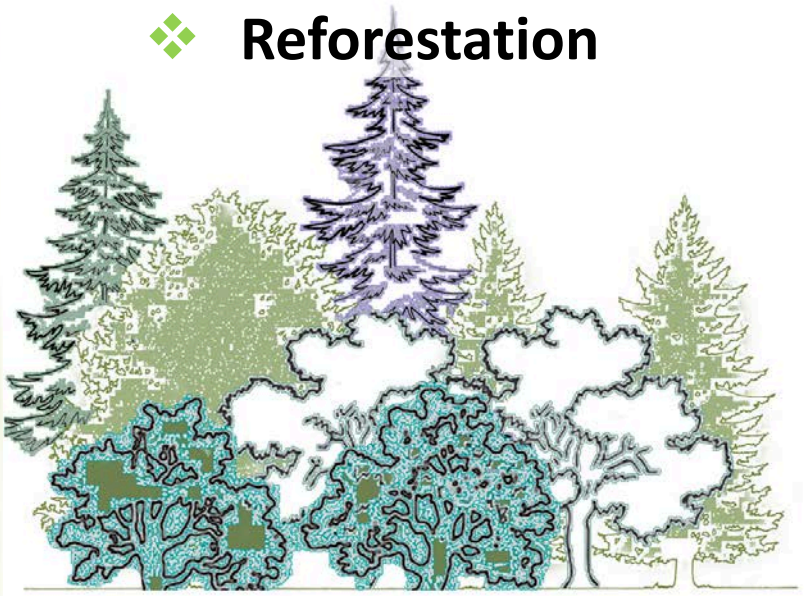
DRIVERS FOR +/– FUTURE INTEREST IN NNT

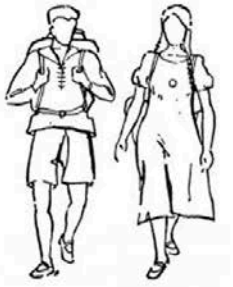
+

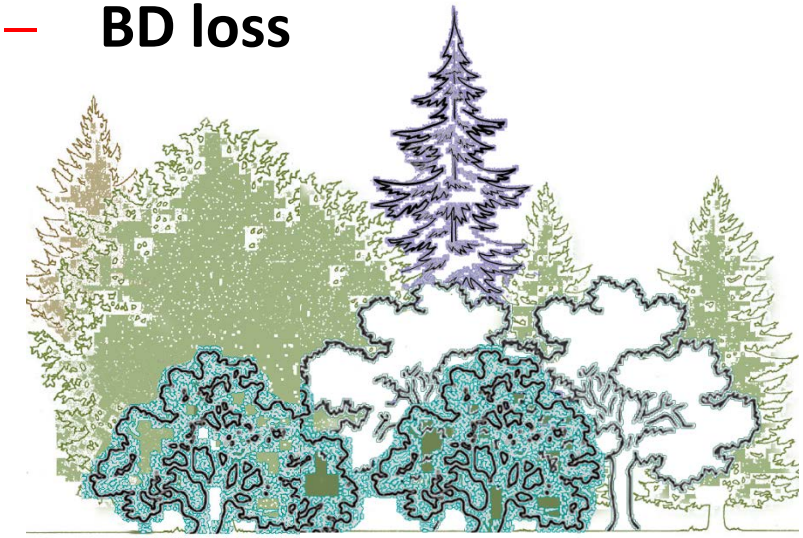
- Alternative products and services
- Further loss of natives
- CC-adaptation
- CC-mitigation:
  - Higher productivity
  - Reforestation

–

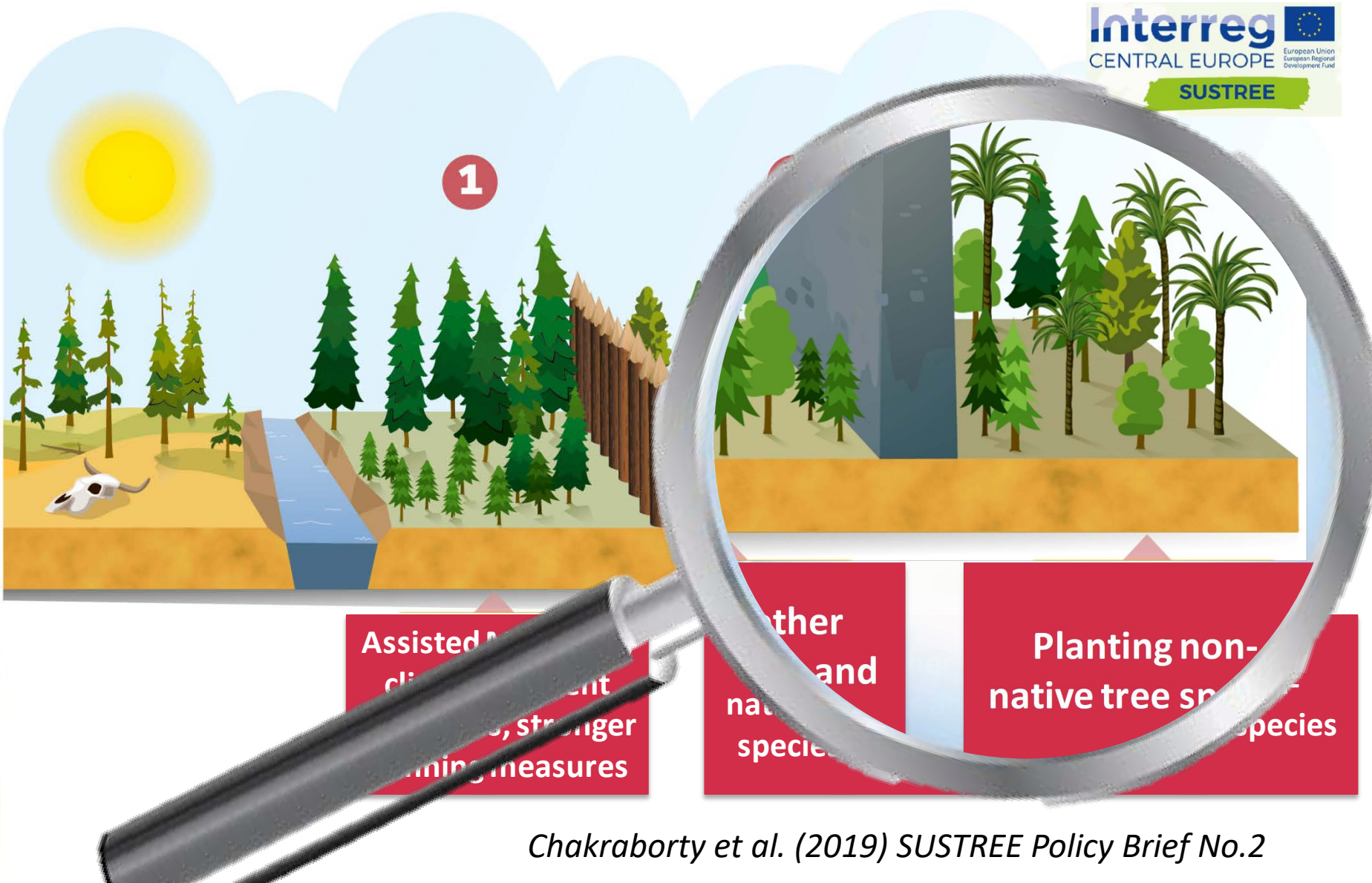
- Problems with FRM
  - Provenance question
  - Seed availablity
- New pests
- Market limitations
- Restrictions / Bans
  - Neg. impact on ES
  - BD loss







CC-ADAPTATION: THREE LINES TO DEFEND FOREST ECOSYSTEM SERVICES AGAINST CC



Chakraborty et al. (2019) SUSTREE Policy Brief No.2

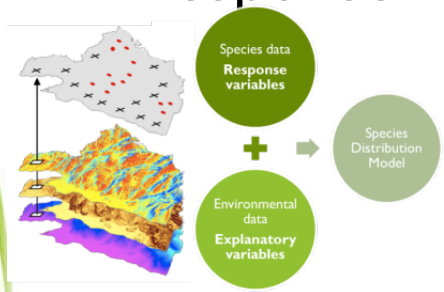
FURTURE POTENTIAL DISTRIBUTION OF NNT

(NNEXT WG4.4)

Method: Ensemble modelling (statistical modells - BIOMOD):

Using **environmental data** (climatic and ecosystem functional data; → explanatory variables)

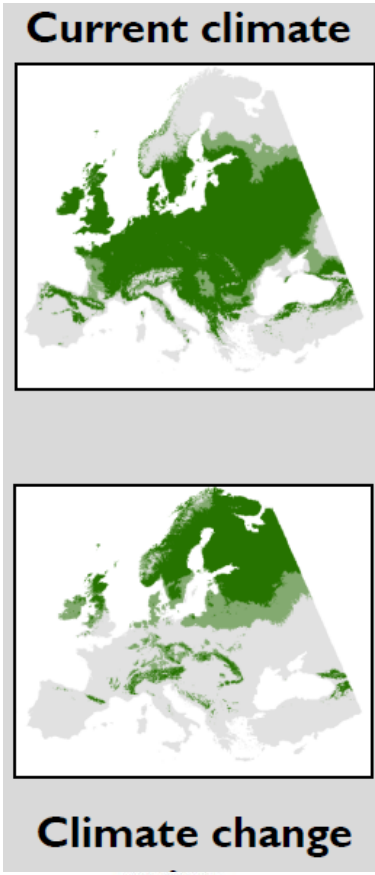
+ **Occurrence data** (native range, introduced range; → response variable)

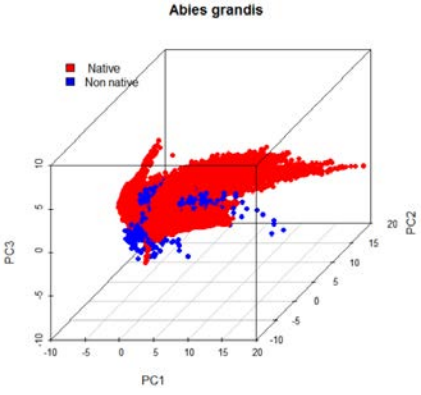


→ **Potential distribution range**

- Will the current planting space also be suitable in the future?
- Which environmental factors are limiting the distribution?
- Support for surveillance of potentially invasive species.

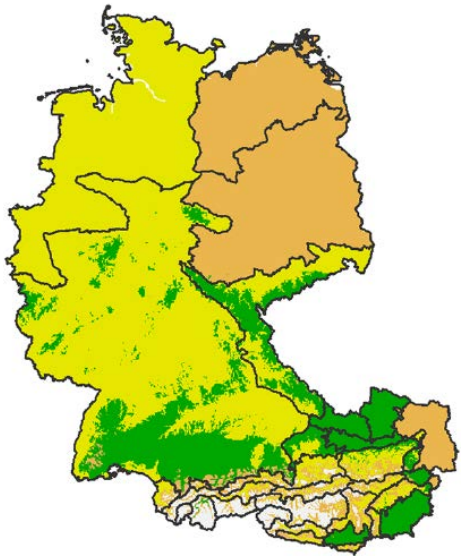
Vicente et al. (in prep.)

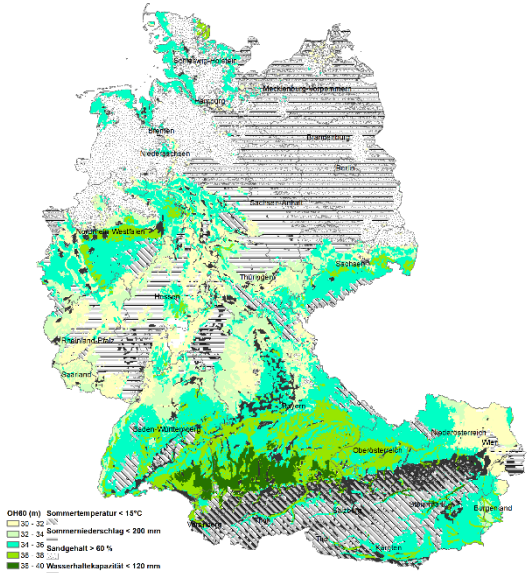




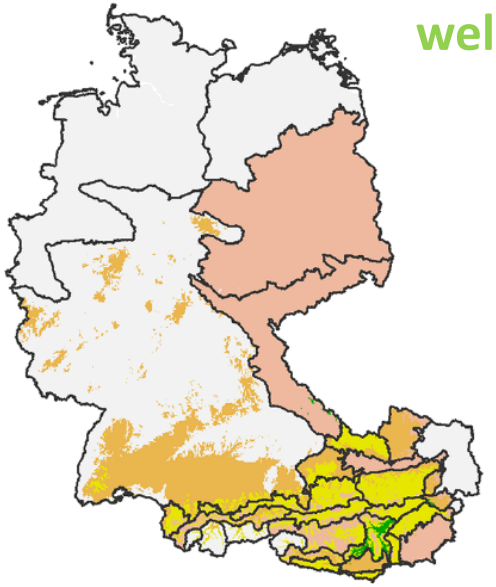
CC-MITIGATION: GROWTH PERFORMANCE UNDER CC

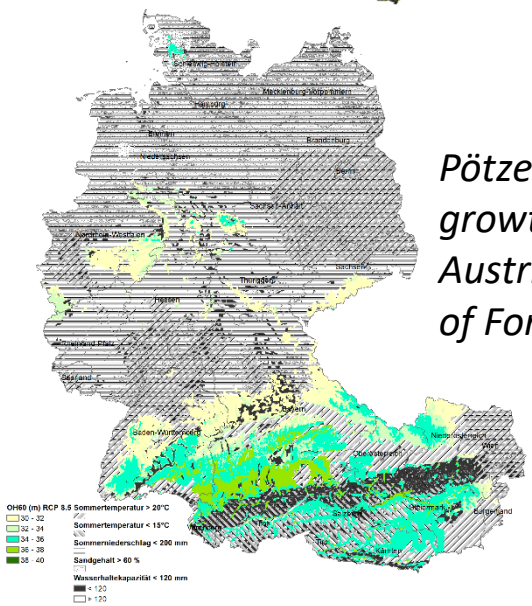
Current climate





RCP 8.5, 2070





Example **Douglas-fir (a rel. widely distributed and well studied species)**

Chakraborty et al. 2016 Adapting Douglas-fir forestry in Central Europe: evaluation, application, and uncertainty analysis of a genetically based model. European Journal of Forest Research

Considers:

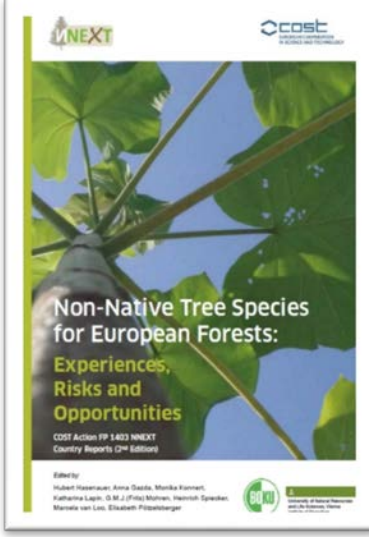
- growth data from **long term research trials (provenances)**
- climate data, CC

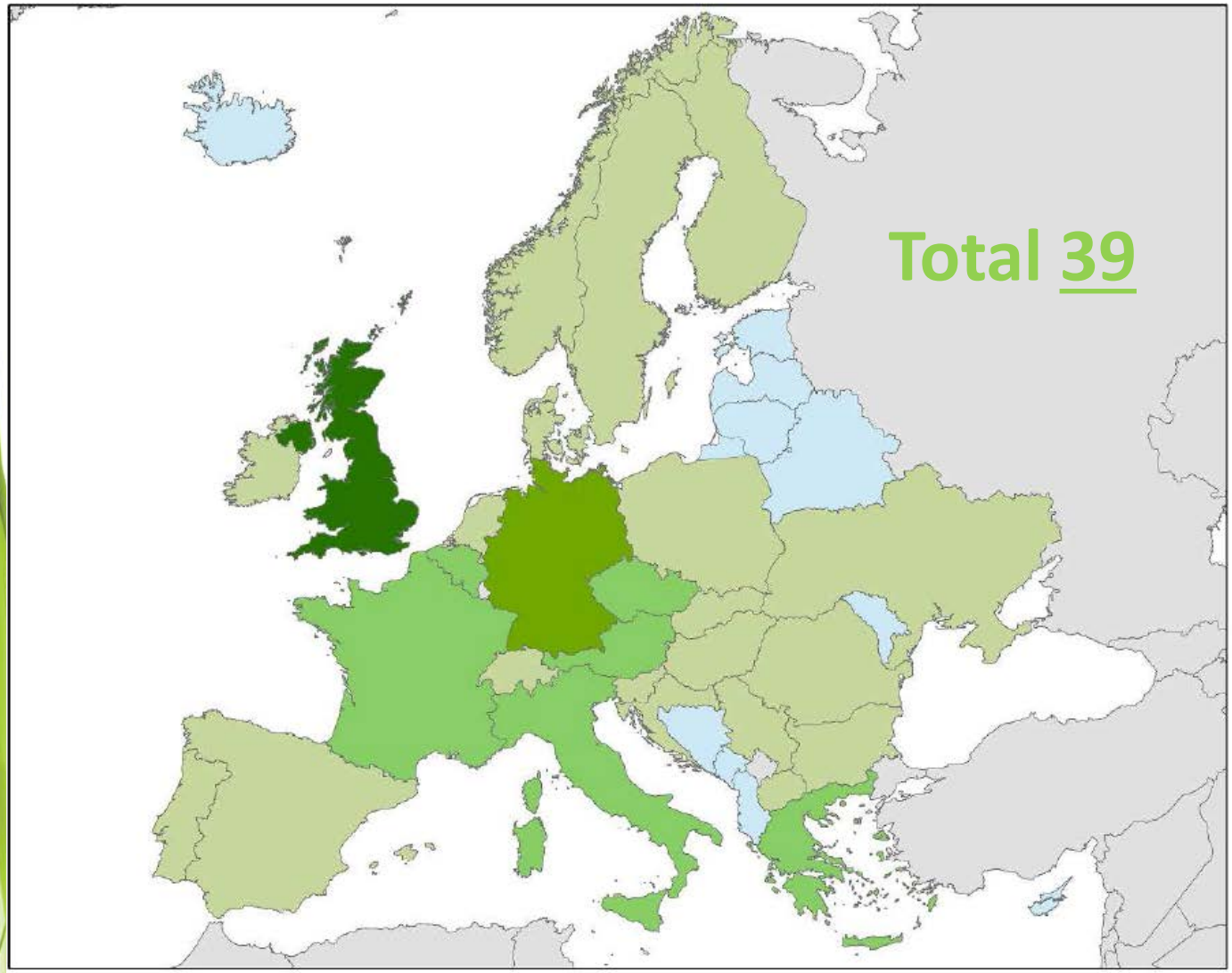
Pötzelsberger et al. 2019 Mapping the growth potential of Douglas-fir in Austria and Germany. Austrian Journal of Forest Research

Considers:

- **inventory data**
- climate data, CC
- soil data

REPORTED NUMBER OF NNT PER COUNTRY GROWN IN PROVENANCE TRIALS





Mostly, less NNT in trials than NNT grown in the forest!

Brus et al. (2019) Extent, Distribution and Origin of Non-native Forest Tree Species in Europe. **Scandinavian Journal of Forest Research (accepted)**

PROVENANCE QUESTION

(NNEXT WG2 RESULTS)

…crucial for the success of a NNT

- **Wrong provenance → high risk, low revenues**

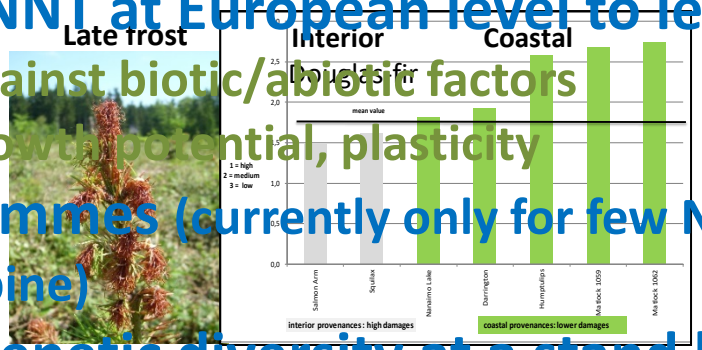
For the first plantations the origin was often unknown!

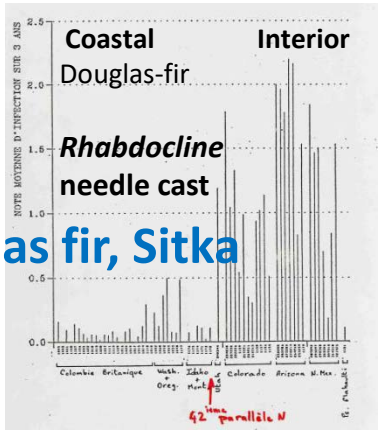
Example DF in DE: Difference in revenue for poor vs. good provenance: 26,000 €/ha (Kleinschmit 2002)

Needs:

→ **New, coordinated provenance trials including European land races for many more NNT at European level to learn about…**

- **tolerance against biotic/abiotic factors**
- **adaptive/growth potential, plasticity**





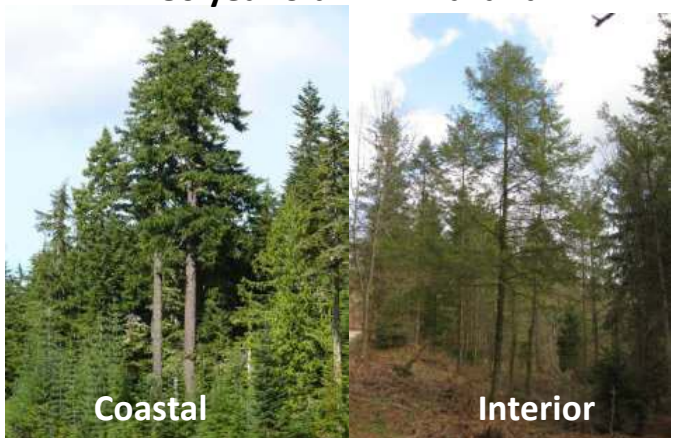
→ **Breeding programmes (currently only for few NNT e.g. Douglas fir, Sitka spruce, lodgepole pine)**

→ **Assessment of genetic diversity at a stand level**

12 year old DF in FR (low elevation)

J.-C. BASTIEN

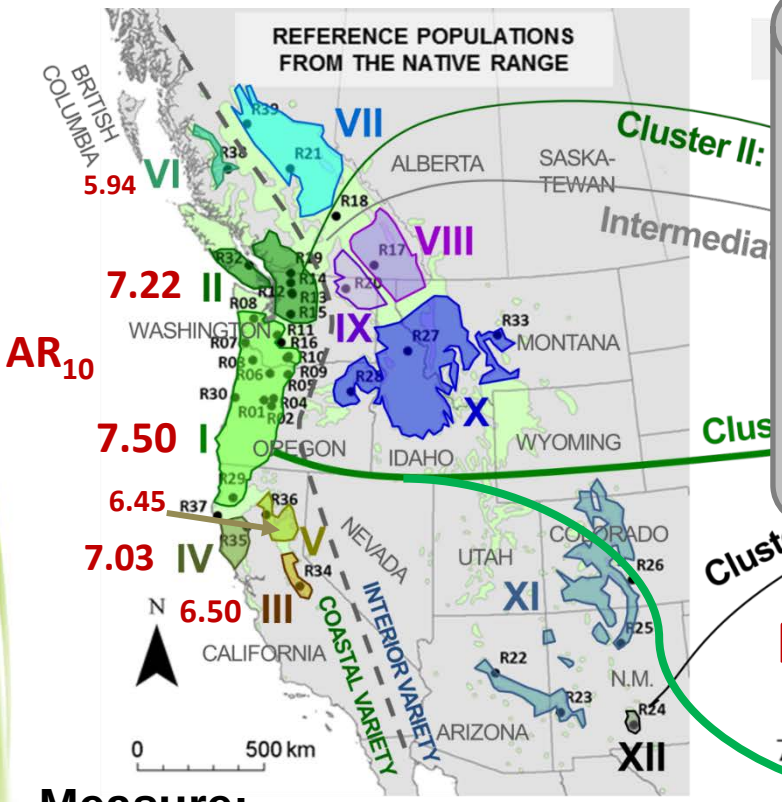
80 year old DF in Bavaria



GENETIC DIVERSITY

Example **Douglas-fir**

Origin and genetic diversity of Central European stands



AR_{10}

→Small reproducing population may cause a bottleneck (drift) after introduction.

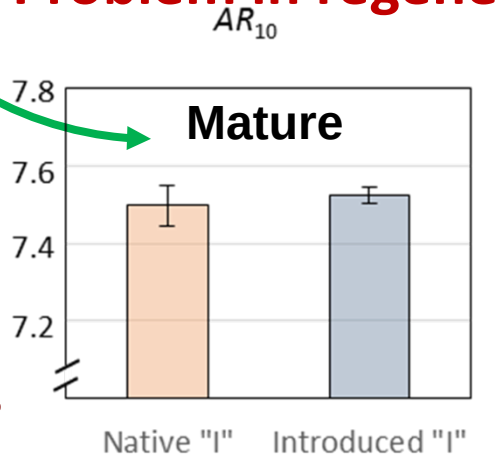
→In small / isolated stands: forestry should not rely on natural regeneration (at least complementary planting is recommended).

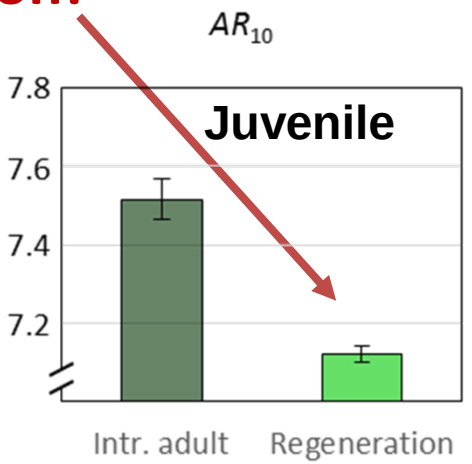
→Seed stands: a large population size and a high number of harvested trees are important!

Hinsteiner, W. et al. 2018. The geographic origin of old Douglas-fir stands growing in Central Europe. Eur. J. For. Res. 137, 447-461

Neophytou, C. et al. 2019. Genetic diversity in introduced Douglas-fir and its natural regeneration in Central Europe. Forestry (in press);

Problem in regeneration!





Measure:

AR_{10} = standardised allelic richness

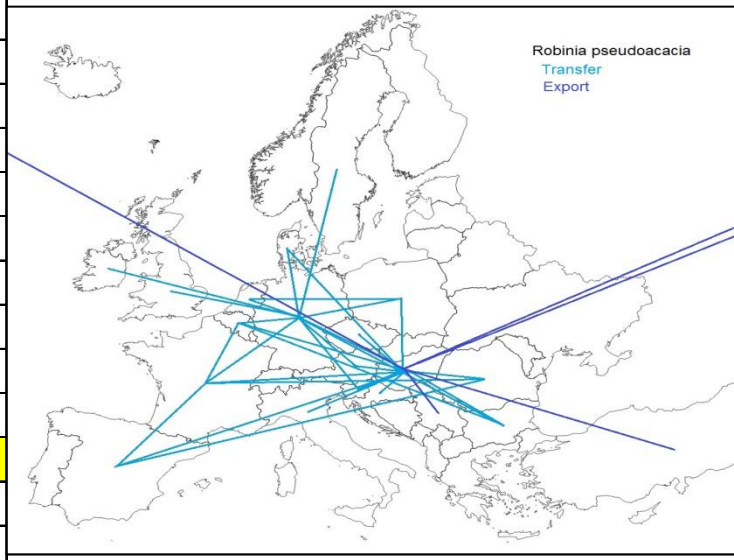
Genetic diversity in autochthonous populations not evenly distributed.

SEED SOURCES FOR MAIN NNT IN EU

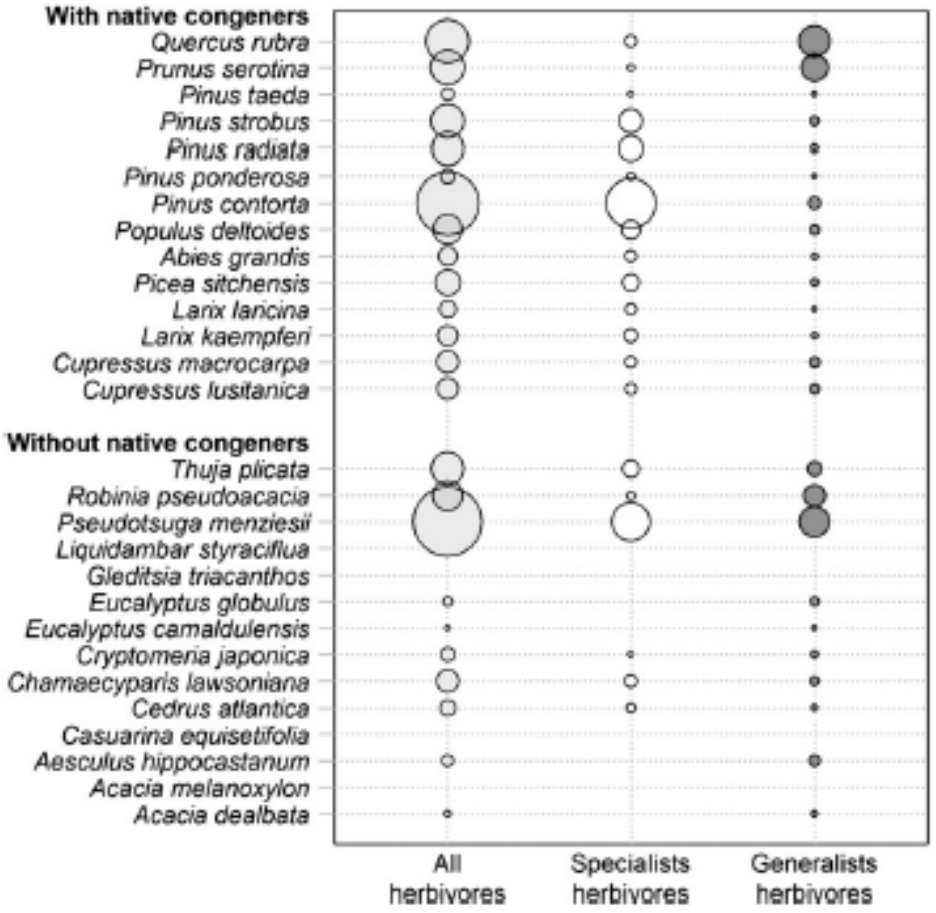
(NNEXT WG2 RESULTS)

- Only for few NNT a (small) part of seeds is imported from countries of origin.
- FRM mainly produced in seed stands and seed orchards in Europe (under same legal regulations that hold for native species – Directive 1999/105/EC*).
- For some NNT (e.g. black locust, red oak) only FRM from European land races or clones is currently used.

	Seed stands			Seed orchards	
Species	**source identified**	**selected**	**tested**	**qualified**	**tested**
Abies grandis *	3	158	-	3	-
Cedrus atlantica *	7	40	3	7	-
Cedrus libani *	1	1	-	4	-
Juglans nigra	2	25	-	25	-
Larix hybr. *	1	10	-	18	14
Larix kaempferi *	3	341	-	10	4
Picea sitchensis *	3	29	-	2	13
Pinus contorta*	6	9	-	3	10
Pinus strobus	-	10	-	-	-
Pseudotsuga menziesii *	279	2507	19	74	4
Quercus rubra*	274	757	-	5	-
Robinia pseudaccacia *	70	203	-	51	-



RISK FOR NNT e.g. FROM NATIVE HERBIVORES

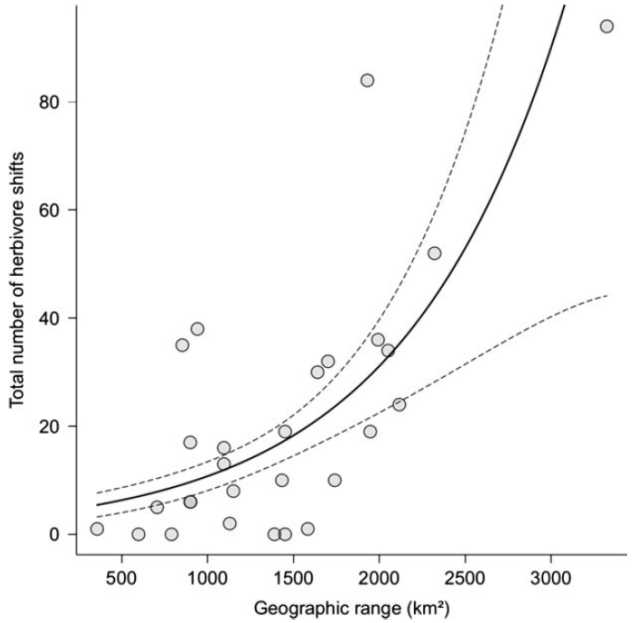


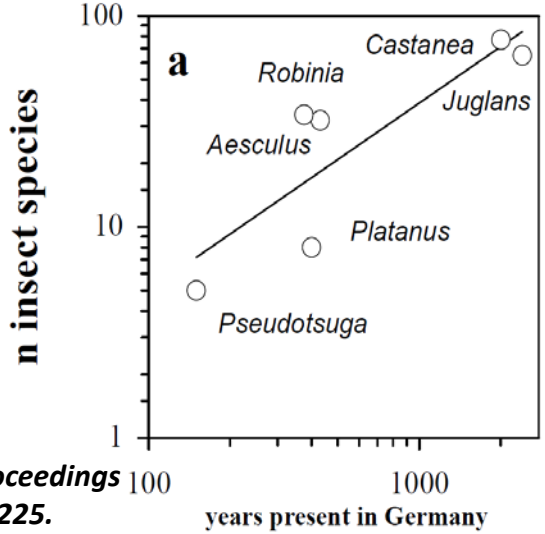
Relative number of native insect herbivores recruited by NNT in Europe (Dot diameter proportional to number of insect species recruited)

Journal of Applied Ecology 2015, **52**, 69–77 doi: 10.1111/1365-2664.12362

Host range expansion of native insects to exotic trees increases with area of introduction and the presence of congeneric native trees

Manuela Branco[1]*, Eckehard G. Brockerhoff[2,3], Bastien Castagneyrol[4,5,6], Christophe Orazio[7] and Hervé Jactel[4,5]





Frenzel e al. (2000) Proceedings IAVS Symposium: 223-225.


Biodiversity?


Biodiversity

BIOMASS (t C/ha) PER PLOT PER SPECIES (NFI DATA)

(SPECIES WITH COUNTS OF PURE STANDS >10)

(NNEXT WG 1)

	All plots				Pure stands (BM of NNT >80% of total BM)				
Species	mean BM	median BM	max BM	Counts	mean BM	median BM	max BM	Counts	Share pure
Robinia pseudoacacia	27.1	15.3	431.7	4060	28.8	16.65	431.7	3654	90%
Pseudotsuga menziesii	38.95	25.2	261.65	2903	41.55	28.7	261.65	2562	88%
Quercus rubra	27.5	12.2	634.1	1749	28.25	12.3	634.1	1529	87%
Picea sitchensis	42.3	26.2	368.2	1369	46.6	32	368.2	1150	84%
Larix kaempferi	40.65	27.15	327.45	1304	45.65	34.6	327.45	989	76%
Pinus contorta	20	13.55	136.25	975	21.5	15.45	136.25	813	83%
Prunus serotina	3.3	1.05	79.4	896	3.35	1.2	79.4	661	74%
Ulmus pumila	4.8	1.95	90.1	687	5.55	2.1	90.1	450	66%
Pinus strobus	20.6	11.8	208.6	390	22.1	12.45	208.6	333	85%
Populus x canescens	23.2	9.85	208.4	342	30.95	15.25	208.4	206	60%
Acer negundo	9.15	2	148.95	259	12.7	3	148.95	133	51%
Juglans nigra	9.5	2.85	259.3	222	20	5.25	259.3	75	34%
Fraxinus pennsylvanica	7.65	1.8	62.35	177	9.2	2.4	62.35	106	60%
Abies grandis	33.25	13.4	492.15	130	38.25	15.1	492.15	84	65%
Picea pungens	6.15	2.55	35.35	114	6.2	2.65	35.35	105	92%
Ailanthus altissima	5.65	1	118.2	112	9.85	1	118.2	42	38%
Pinus banksiana	7.35	3.1	66.6	62	7.35	2.9	66.6	55	89%
Tsuga heterophylla	51.8	11.3	388.1	32	92.1	54.7	225.8	12	38%
Gleditsia spp.	10.6	2.3	74.75	28	9.05	1.15	74.75	12	43%
Abies procera	31.8	13.25	166.55	19	39.15	10	166.55	12	63%
Cupressus sempervirens	13.45	6.2	62.55	19	13.45	6.2	62.55	19	100%

AT, BG, CH, CR, CZ, DE, FI, HU, IE, IS, NL, NO, PL, RS, SE, SK (ENFIN)
+ BE (Wallonia), ES, FR, IT, ME, SI (NFI)

IMPACT OF NNT ON BIODIVERSITY AND THE SOIL

(NNEXT WG 4.1)

…IMPORTANT ASPECT OF INVASIVENES
→ RELEVANT FOR NATURE CONSERVATION LEGISLATION !

Close-to-nature forests **Mixed forests** **NNT plantations**

Biodiversity
Soil fertility

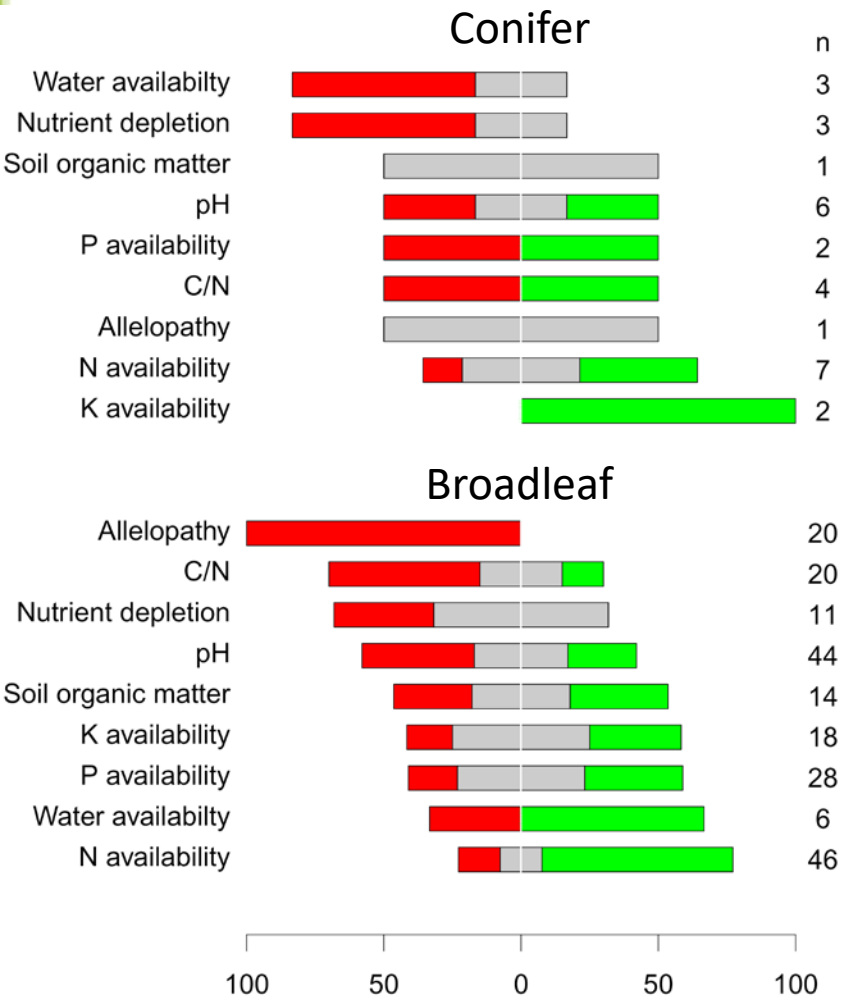
Wohlgemuth et al. (in prep.)

IMPACT – CONIFEROUS VS. DECIDUOUS NNT

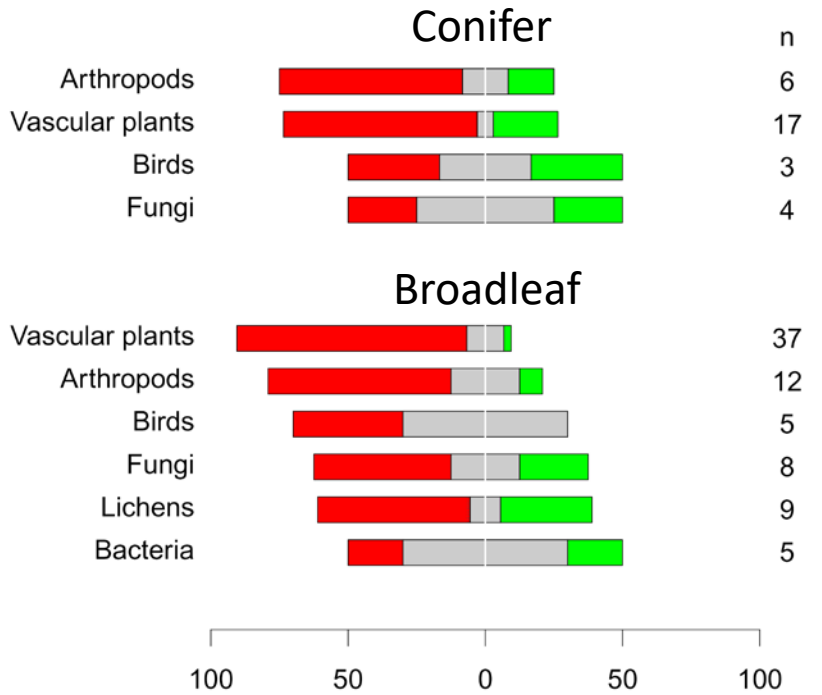
(NNEXT WG 4.1)

Method for –/+ EFFECTS:
Published pairwise comparisons of NNT stands (test) with native stands (control) in Europe

Effects on soils



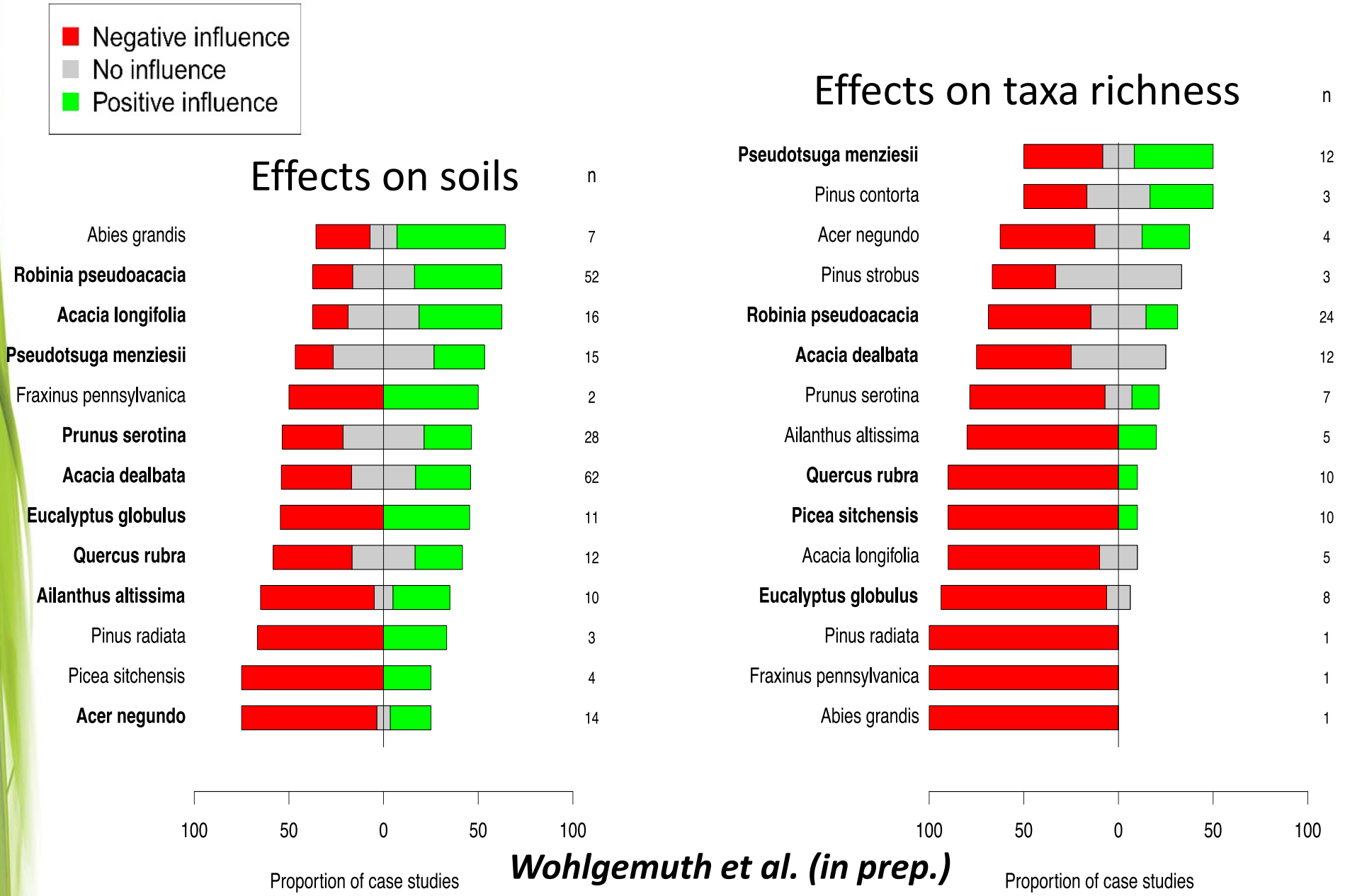
Effects on taxa richness



Negative influence
No influence
Positive influence

Wohlgemuth et al. (in prep.)

IMPACT – SPECIES RANKING



Wohlgemuth et al. (in prep.)

SPREAD

…SECOND IMPORTANT ASPECT OF INVASIVENES

Viennese beech forest with spreading *Thuja plicata*

RELEVANT INTERNAT. & EUROP. BODIES, TREATIES, CONVENTIONS, SELF-REGULATORY TOOLS (e.g. SFC)

+ Forest Europe – Ministerial Conference on the Protection of Forests in Europe:

→ 2nd Ministerial Conference in Helsinki 1993: *'**Native species and local provenances** should be **preferred** where appropriate. The use of species, provenances, varieties or ecotypes outside their natural range should be discouraged where their **introduction would endanger important/ valuable indigenous ecosystems, flora and fauna**. Introduced species may be used where they provide **more benefits** than do indigenous ones in terms of wood production and other functions.'*

+ European Union:

- **Directive 92/43/EEC** on the conservation of natural habitats and of wild fauna and flora: Member States shall *'…ensure that the **deliberate introduction into the wild** of any species which is not native to their territory is **regulated** and, if they consider it necessary, **prohibit** such introduction.'*
- **Directive 1999/105/EC** on the marketing of forest reproductive material
- **Regulation (EU) No. 1143/2014** on the prevention and management of the introduction and spread of invasive alien species + Regulation (EU) 2016/1141 on the **List of invasive alien species of Union concern**

+ Council of Europe:

- Bern Convention on the Conservation of European Wildlife and Natural Habitats 1979
- European Strategy on IAS 2003
- Code of Conduct for Invasive Alien Trees 2017

+ A GLOBAL STRATEGY FOR INVASIVE ALIEN TREES / Global Code of Conduct *(in prep.)*

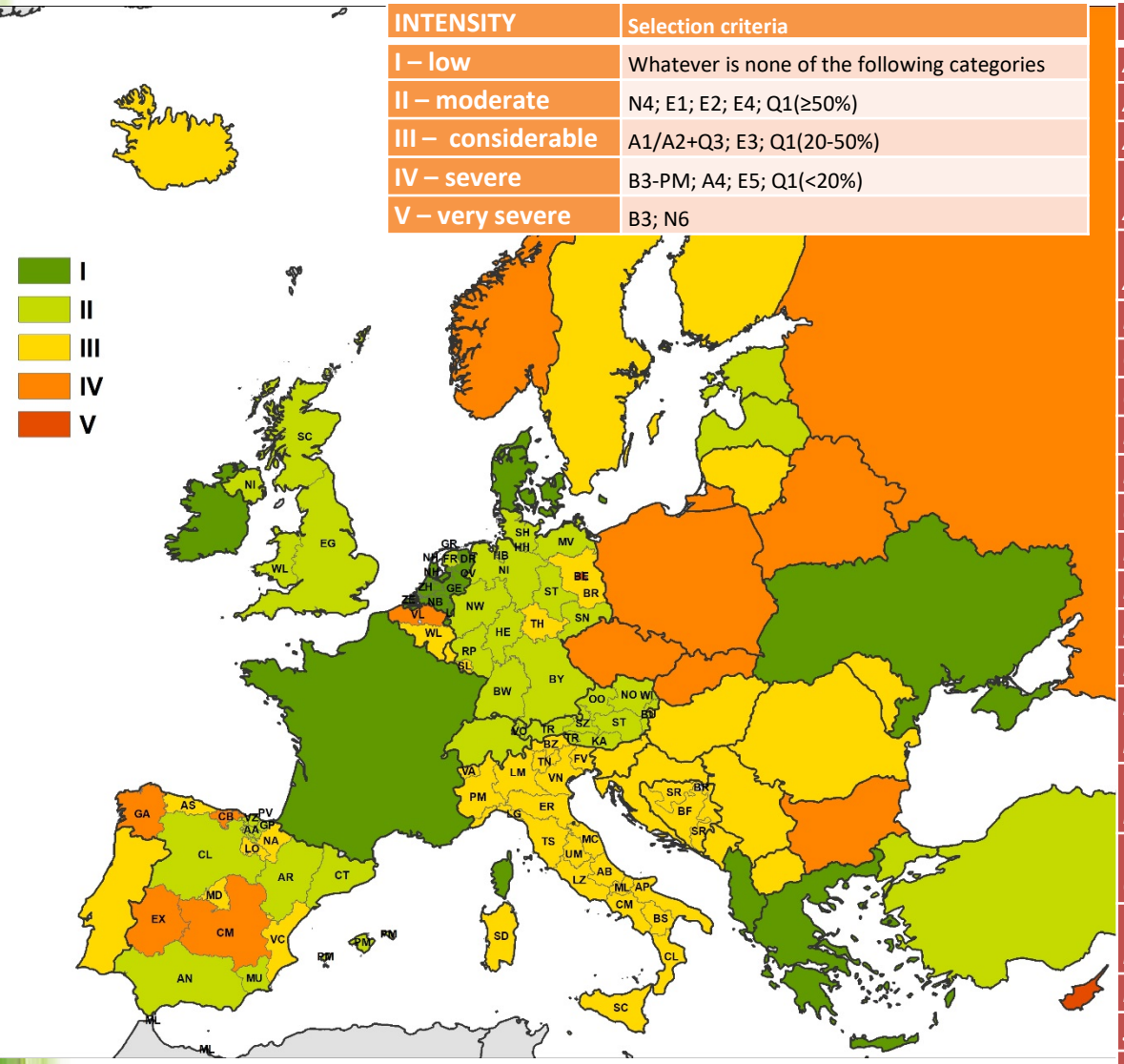
- ❑ *Initiated in 2019 (mainly invasion biologists)*

+ IPBES - Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services:

- *Global assessment of biodiversity and ecosystem services 2019 (Media response!)*
- ***IAS assessment** (May 2019 ~ 2022/23)*

LEGAL RESTRICTIONS ON NNT

INTENSITY	Selection criteria
I – low	Whatever is none of the following categories
II – moderate	N4; E1; E2; E4; Q1(≥50%)
III – considerable	A1/A2+Q3; E3; Q1(20-50%)
IV – severe	B3-PM; A4; E5; Q1(<20%)
V – very severe	B3; N6



Prohibited species	Countries	Regions
Acacia spp.	PT	ES-GA
Acacia dealbata	ES	-
Acacia saligna	!CY	-
Acer negundo	BY, LT, !MK, !ME, PT, SK	IT-LM[2], IT-PM, NL
Ailanthus altissima	!CY, !MK, !ME, PL, PT, SK, ES	!BE-WL, IT-LM[2], IT-PM, IT-TS
Broussonettia papyrifera	!MK, !ME	IT-LM[2], IT-PM
Catalpa ovata	-	IT-PM
Catalpa speciosa	-	IT-PM
Eleagnus angustifolia	!MK	-
Eucalyptus spp.	-	IT-TS
Gleditsia triacanthos	PT	-
Leucaena laucocephala	!CY, PT	-
Parkinsonia aculeata	!CY	-
Paulownia tomentosa	PT	IT-PM
Pittosporum undulatum	PT	-
P. balsamifera, P. x berolinensis	NO[1]	-
Prunus serotina	LT, DK	BE-VL, !BE-WL, IT-LM[2], IT-PM
Quercus rubra	-	BE-VL, IT-LM[2], IT-PM
Robinia pseudoacacia	BY, LT, !MK, !ME, PT	BE-VL, IT-LM[2], IT-PM[3], IT-TS[3]
Rhus typhina	CH	IT-PM
Salix euxina, S. x fragilis	NO[1]	-
Ulmus pumila	-	IT-PM

Pötzelsberger et al. (in review) **Mapping the patchy legislative landscape of non-native tree species in Europe**

CRITERIA FOR A 'GOOD' NON-NATIVE TREE

- Climatic suitability (not exact climate matching!)
- Tolerance of a range of soils/sites → more than a niche
- Low/moderate biotic and abiotic risks
- Provenance information and seed availability
- Same/higher productivity than natives
- Desirable timber properties
- Easy handling in nursery and during establishment
- No major impact on full range of ecosystem services – biodiversity, soils, water balance,….
- Easy to confine/eradicate

TAKE HOME MESSAGES

- Numerous NNT present (~150) but few widely used
- Productivity: on average 30% higher than natives
- More trials needed to derive cross-European provenance recommendations for majority of NNT (CC adaptation!)
- Gentetic diversity: nat. regeneration may be problematic
- Soil: Conditions under NNT partly improve
- Biodiversity: NNT species may affect BD negatively (taxa group differences)
- Legal restrictions limit the use of NNT in many countries (invasivenes is an important issue!)
- NNT are not a simple solution too every problem and must be used responsibly.

Thank you for the attention!

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