



Urban trees and invasive species – a biosecurity perspective

09/10/2023, Freiburg



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Protection de la forêt suisse
Protezione della foresta svizzera

Who is that guy?

- Benno Augustinus
- Grew up in Rheinland-Pfalz
- BSc, MSc at Wageningen University, NL
- PhD at CABI in Switzerland: Weed biocontrol, demographic modelling
- Since 2020: WSL, Waldschutz Schweiz

- Free time:
 - Falling off bikes
 - Brewing beer
 - Pickling



What are alien invasive species ?

An alien invasive species is a species that:

1. non-native (or alien) to the ecosystem under consideration and,
2. whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

at least according to the Americans:



National Invasive Species Information Center
U.S. DEPARTMENT OF AGRICULTURE



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Example of invasive plants in forests: Chinese windmill palm

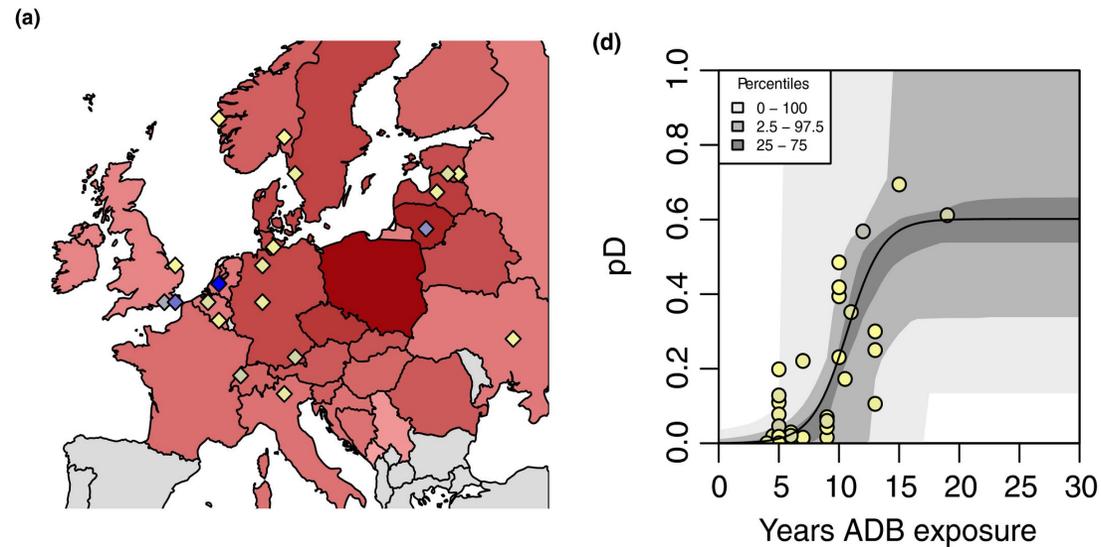
- *Trachycarpus fortunei*
- Popular ornamental
- Turned into an invasive species in Southern Switzerland and Austria
- With climate change: likely to become invasive North of the Alps
- Outcompetes native flora
- Increases risks of forest fires





Example of invasive forest pathogen: Ash dieback

- Ash dieback, caused by the fungus *Hymenoscyphus fraxineus*
- *H. fraxineus*: SE-Asian origin
- In Europe since ~20 years
- Estimated mortality European ash around 60%:



Coker et al. 2019, Plants, People, Planet



Example of invasive forest pest Emerald Ash borer

- *Agrilus planipennis*
- Native to North-Eastern Asia
- Feeds on Ash species
- Invasive in southern and Central US
 - Prediction of 98.8% mortality of ash trees
 - Issue for urban forestry in N-America
- Since 2003: Found in Moscow region
- Spreading West
- Not a matter of if, but when it will arrive in Western Europe



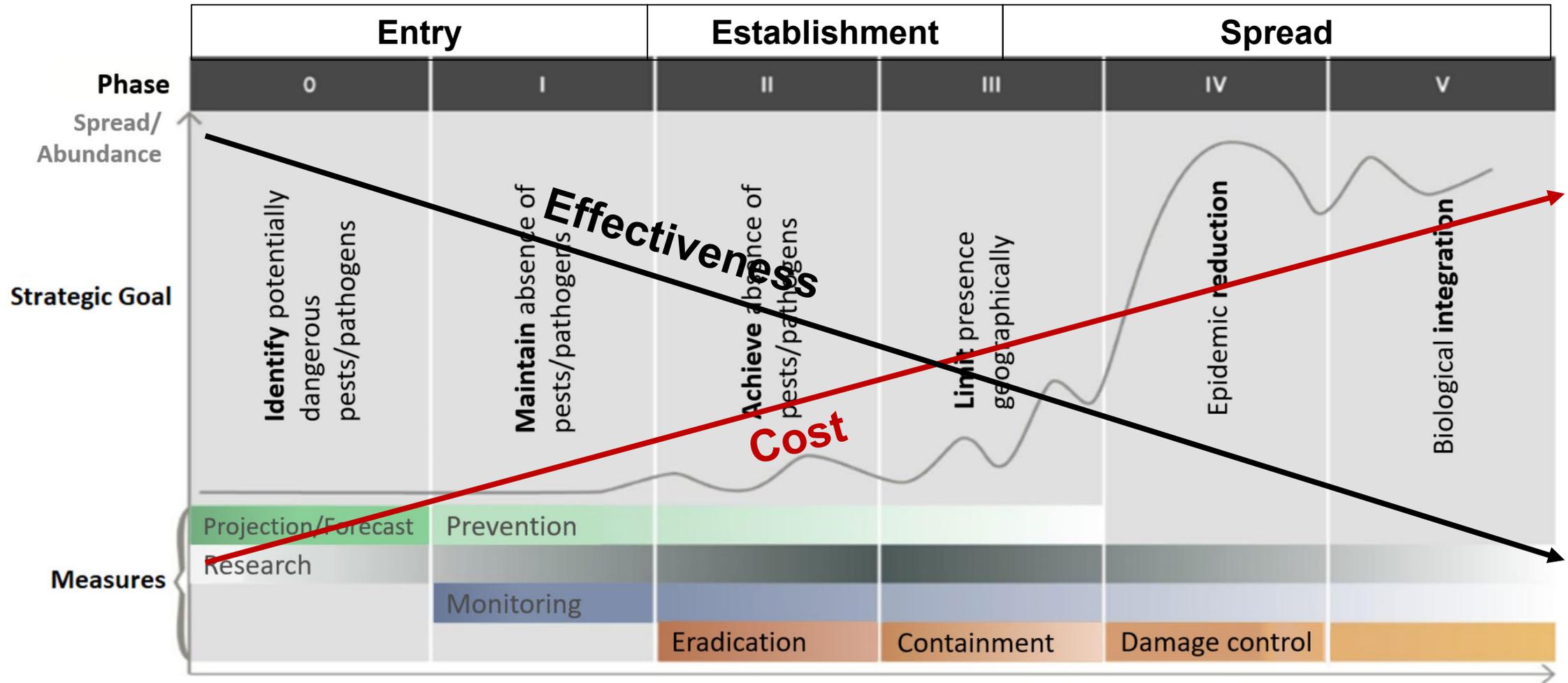
Examples of invasive forest pest Asian Longhorn Beetle



- *Anoplophora glabripennis*
- Imported from Asia, often via packaging wood
- Highly polyphagous, broadleaf trees.
- Preferred hosts: Maple (*Acer*), Birch (*Betula*), Horse chestnut (*Aesculus*)...
- Several outbreaks in Europe, most are under eradication



Invasion framework



Invasive plants

- Ornamental horticulture: Primary pathway for alien invasive plants*
- Conflict of interest (invasive but ornamental e.g.)
- Some alien invasive plants are still for sale

The screenshot shows a Google Shopping search for "water hyacinth for sale". The search results are filtered to show two items:

- Wasser-Hyazinthe Eichhornia crassipes**: Priced at CHF 17.45, available from pflanzendirekt.ch.
- Pontec, Garden ponds, PondoHyacinth**: Priced at CHF 13.80, available from galaxus.ch with a 5-star rating.

Filters on the left include "Show only" (Available nearby, On sale), "Price" (Up to CHF 35, CHF 35 - CHF 90, Over CHF 90), and "Color" (Black, Pink).



Alexander Jung/Shutterstock

*Hulme et al., 2017, Journal of Applied Ecology



Invasive insects track historical plant introductions*



- Places with higher amount of non-native plants receive more invasive insects
- Especially historical records (~1910s) of earliest introductions of plants explain introductions of invasive insects
- Non-native plants in urban forests...



*Bonnamour et al., 2023, PNAS



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Urban trees and invasions

- Urban trees: first location of introductions of invasive forest pests
- (Long-distance) trade goes to urban/peri-urban environments first
- Important for forest biosecurity
- Background for the interest in urban trees: 'Gebietsüberwachung'
- Set out to collect urban tree inventories for Switzerland



Biol Invasions (2017) 19:3515–3526
DOI 10.1007/s10530-017-1595-x



URBAN INVASIONS

Urban trees: bridge-heads for forest pest invasions and sentinels for early detection

Trudy Paap · Treena I. Burgess · Michael J. Wingfield

Urban trees facilitate the establishment of non-native forest insects

Manuela Branco¹, Pedro Nunes¹, Alain Roques²,
Maria Rosário Fernandes¹, Christophe Orazio³, Hervé Jactel⁴



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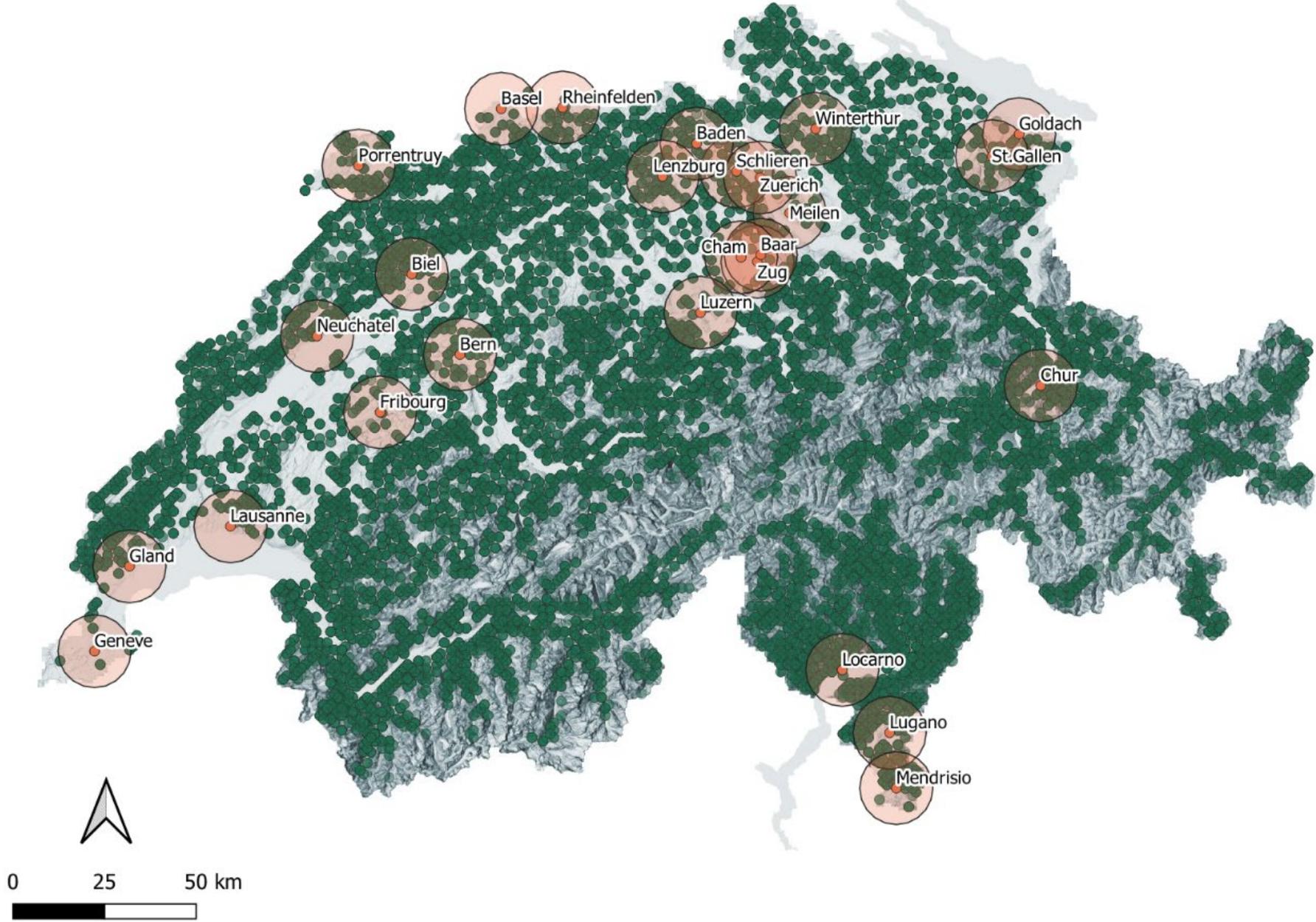


Urban tree inventory for Switzerland

- 26 datasets
 - Combined
 - Formats
 - 4 languages...
 - Determined genus and species with GBIF backbone
- n = 458'977 trees
- 131 genera
- >1500 species



Urban tree inventories from Switzerland



Urban trees in Switzerland – species composition

- No spatial autocorrelation

```
Mantel statistic based on Pearson's product-moment correlation
```

```
Call:
mantel(xdis = distance_matrix, ydis = genus_matrix)
```

```
Mantel statistic r: 0.01931
Significance: 0.134
```

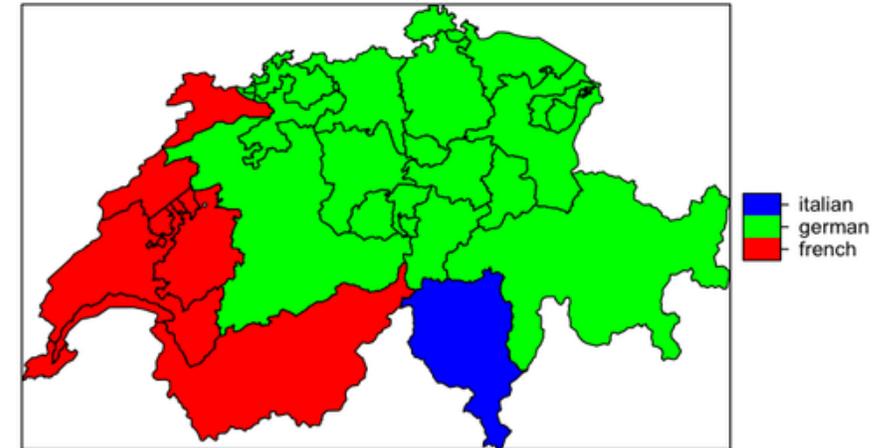
```
Upper quantiles of permutations (null model):
```

```
90% 95% 97.5% 99%
0.0223 0.0291 0.0354 0.0456
```

```
Permutation: free
```

```
Number of permutations: 999
```

Swiss Language Regions



- Region (language) explains the difference! (Adonis)

	De	De/Fr	Fr	It
De	x			
De/Fr	0.125	x		
Fr	0.001	0.037	x	
It	0.001	0.306	0.001	x

Urban vs forest trees in Switzerland

- >1500 tree species in Switzerland – do we need to be impressed?

Porträt des Schweizer Waldes in Zahlen

31 % der Fläche der Schweiz ist mit Wald bedeckt

3,5 % des Waldes sind Waldreservate

3 Urwälder gibt es in der Schweiz

120 verschiedene Waldtypen

70 % sind Nadelbäume (vor allem Fichte, Weisstanne)

20 % sind Laubbäume (vor allem Buche)

53 Baumarten kommen in den Wäldern vor

Bis zu 30'000 Arten von Lebewesen bevölkern den Wald
(Tiere, Pflanzen, Pilze und Kleinlebewesen), das sind 40 %
aller in der Schweiz vorkommenden Arten.



Bundesministerium
für Ernährung
und Landwirtschaft

In der Bundeswaldinventur wurde
Baumarten nehmen ca. 90 % des
Baumarten Gemeine Fichte, Geme
desweiteren die Baumarten Geme



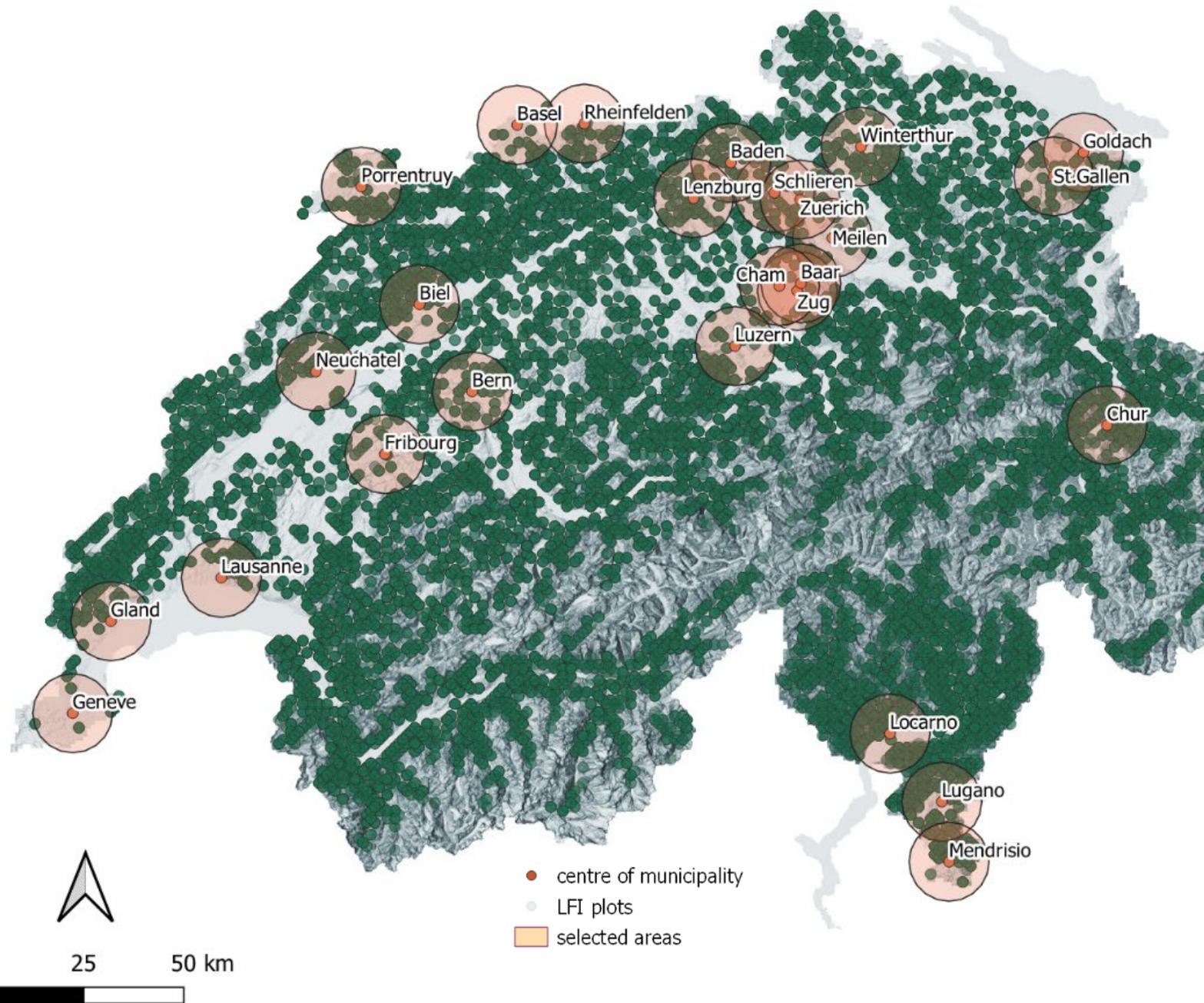
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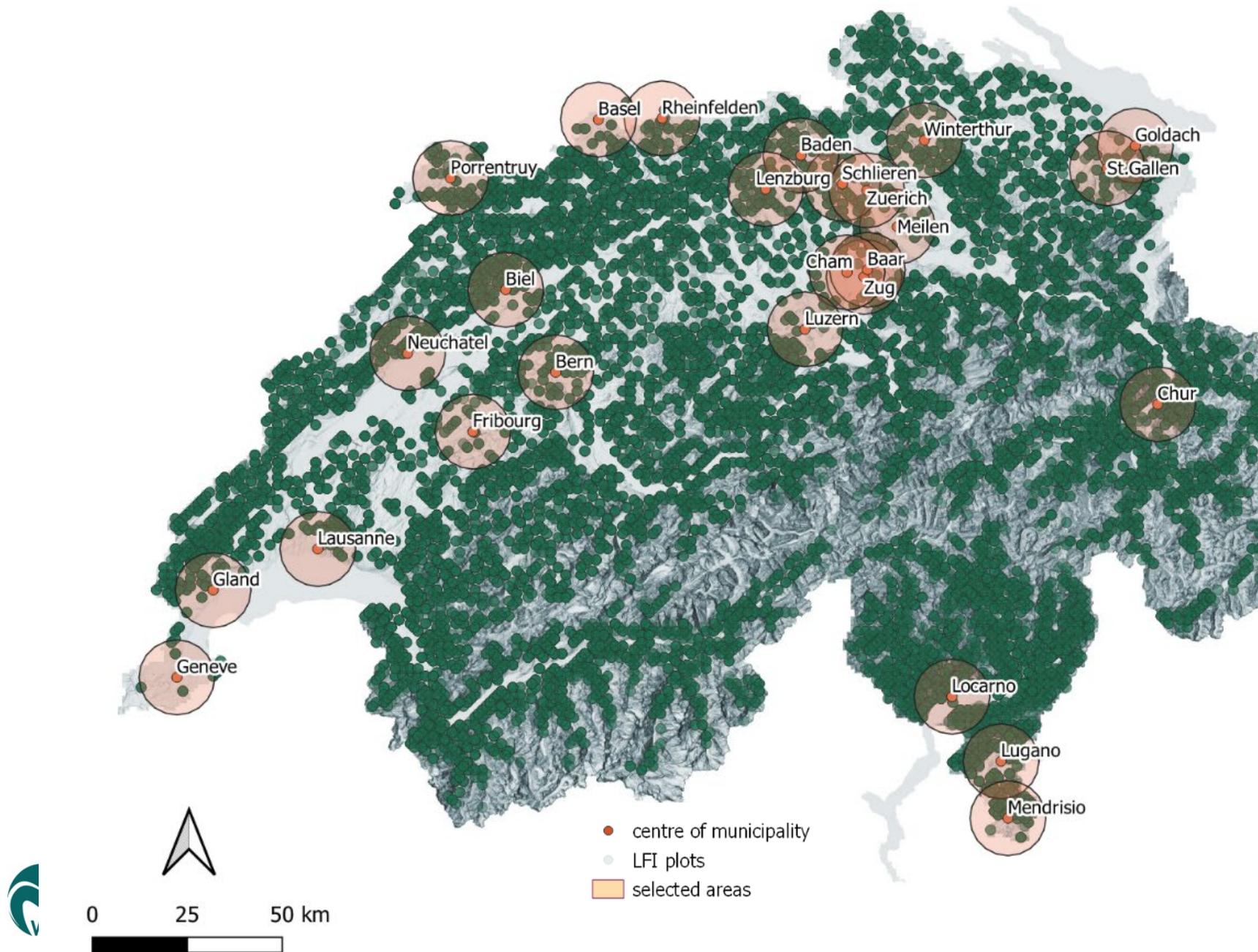
Urban vs. Forest trees in Switzerland:

How do the urban tree inventories compare to the Swiss National Forest inventory (NFI)?



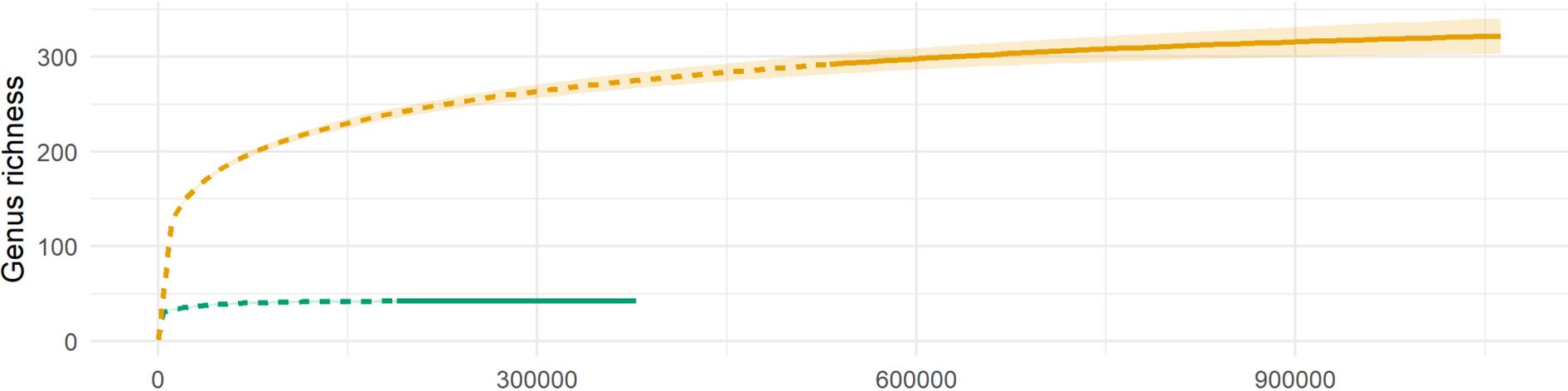
Locations of urban and forest tree inventories

- How different is urban tree composition (species and genera) compared to the tree composition of surrounding forests?
- What are implications for urban and surrounding forest health?

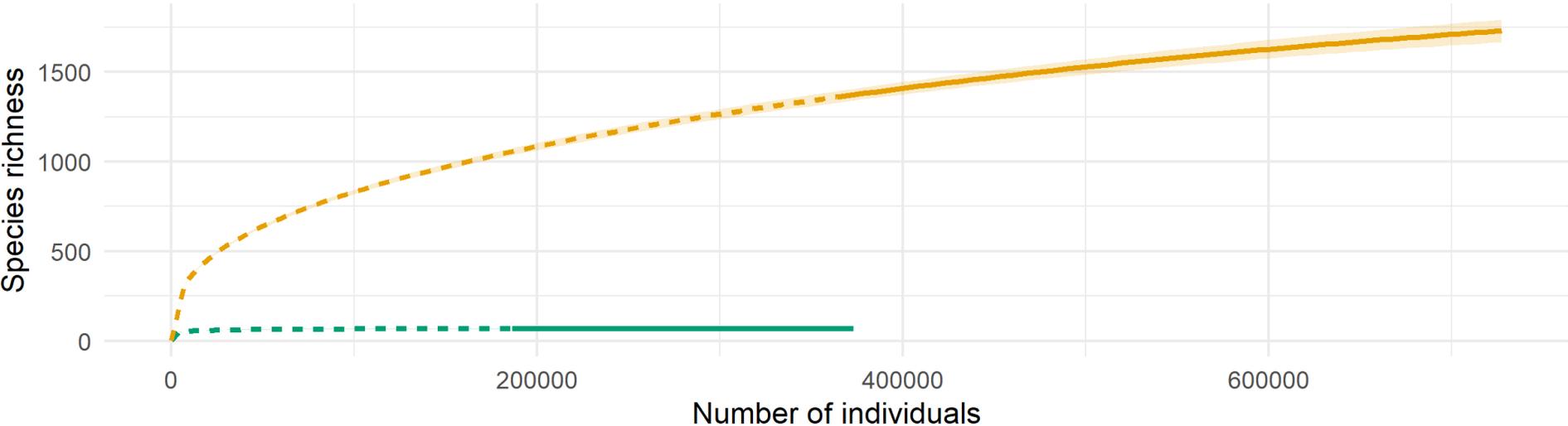


Genus and species richness

A - Rarefaction of genus richness



B - Rarefaction of species richness

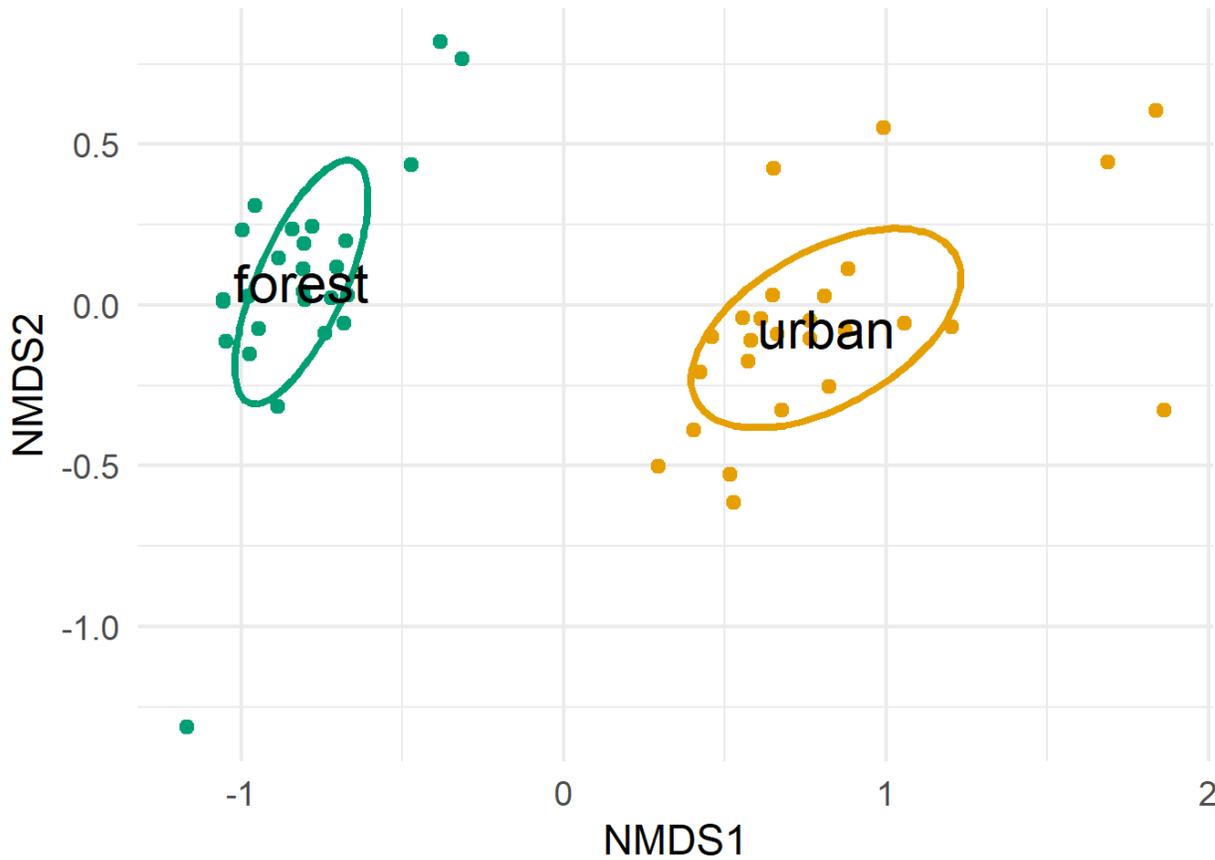


- NFI
- urban
- extrapolated
- interpolated
- observed

Urban tree composition is described by different genera and species than surrounding forests

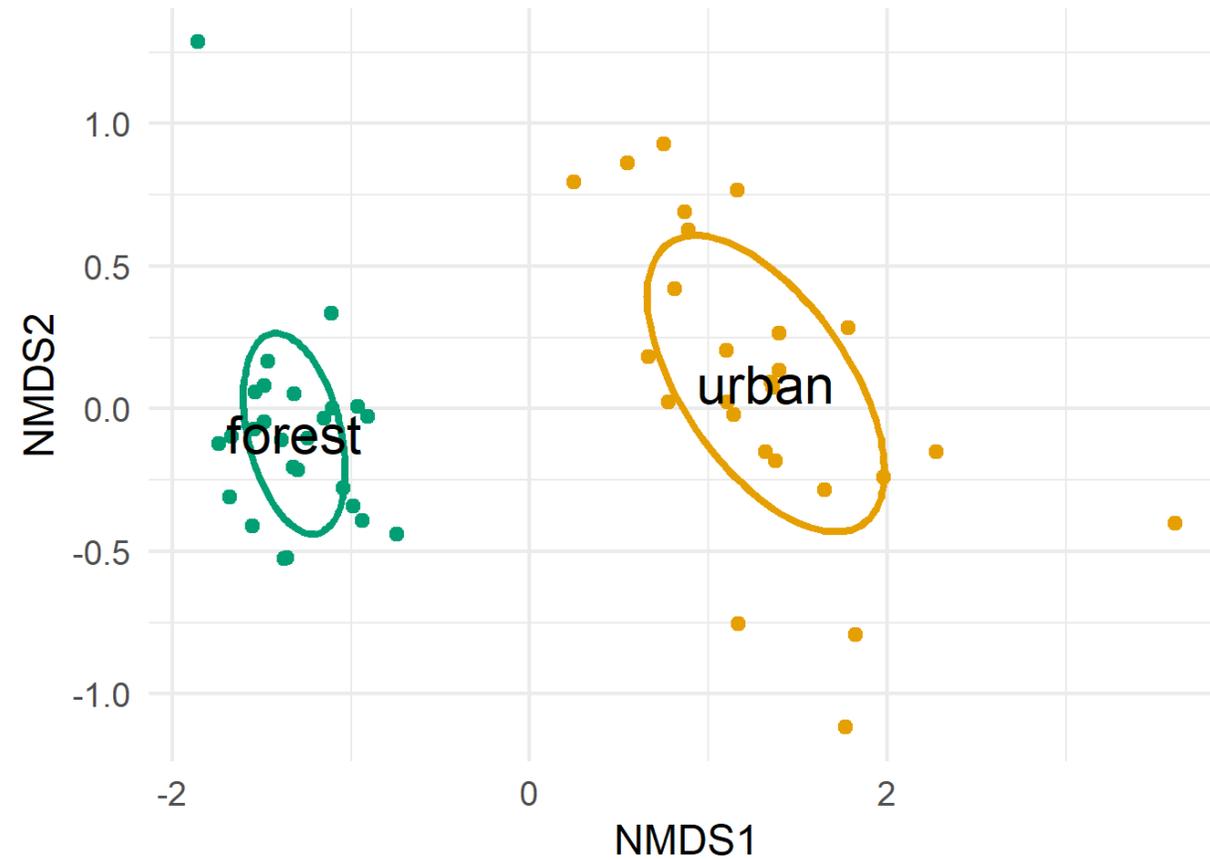
A

Result of NMDS (sd) - genus level



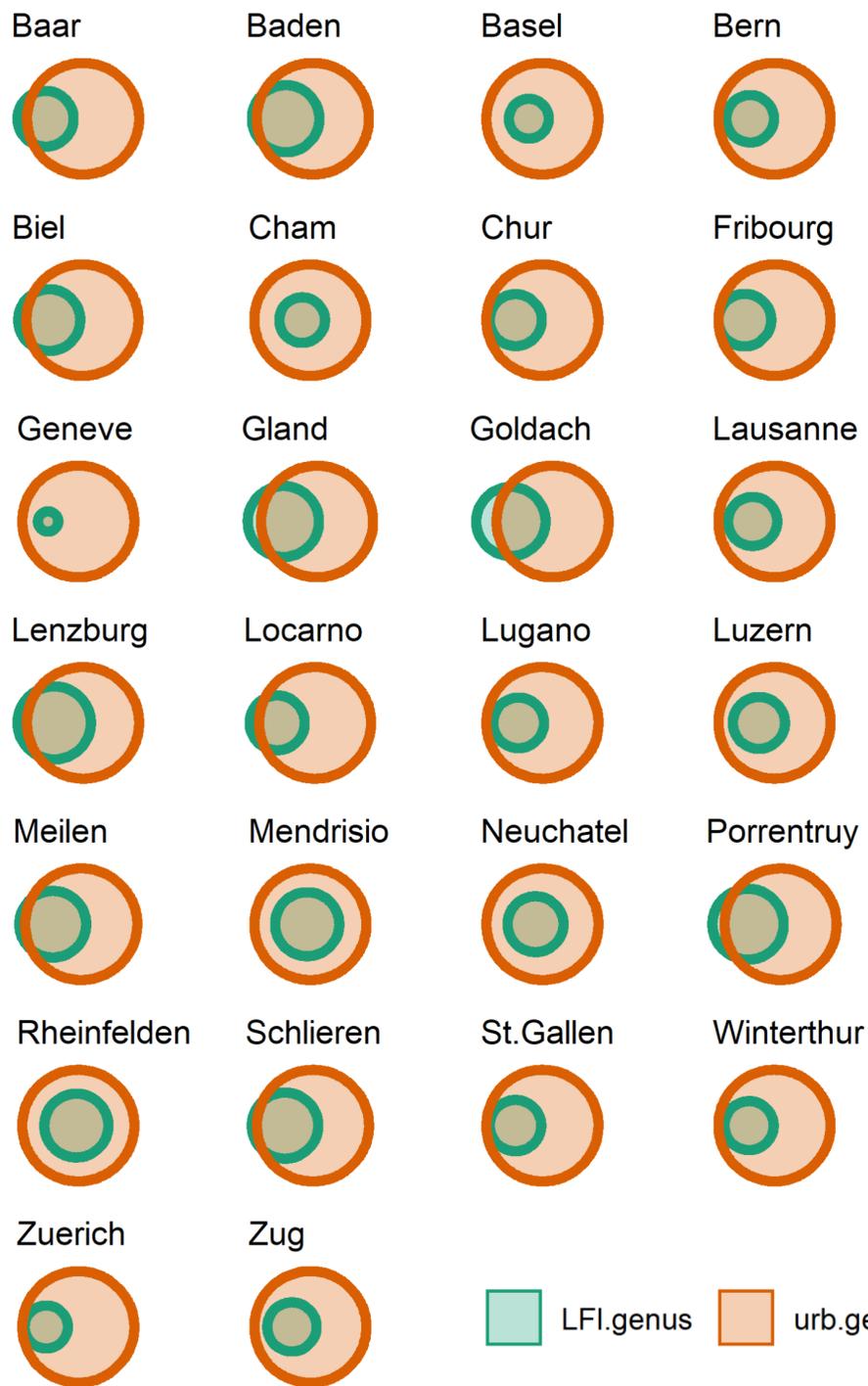
B

Result of NMDS (sd) - species level



Genera

Genera in forest: subsets of genera in urban tree datasets



>1% of tree species

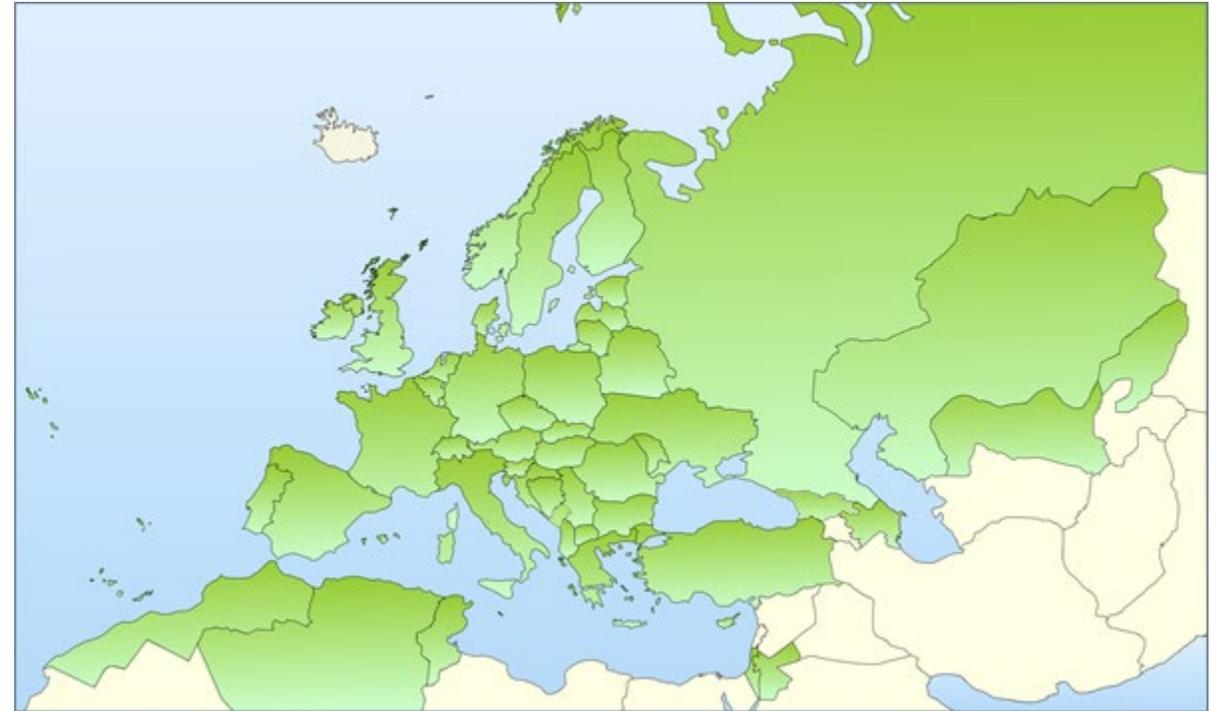
Forest trees		
species	percentage	native in CH
<i>Picea abies</i>	25.3%	yes
<i>Fagus sylvatica</i>	23.2%	yes
<i>Abies alba</i>	10.7%	yes
<i>Castanea sativa</i>	7.5%	yes
<i>Fraxinus excelsior</i>	6.6%	yes
<i>Acer pseudoplatanus</i>	5.3%	yes
<i>Quercus petraea</i>	2.5%	yes
<i>Pinus sylvestris</i>	2.1%	yes
<i>Betula pendula</i>	1.9%	yes
<i>Ostrya carpinifolia</i>	1.7%	yes
<i>Larix decidua</i>	1.6%	yes
<i>Tilia cordata</i>	1.2%	yes

Urban trees

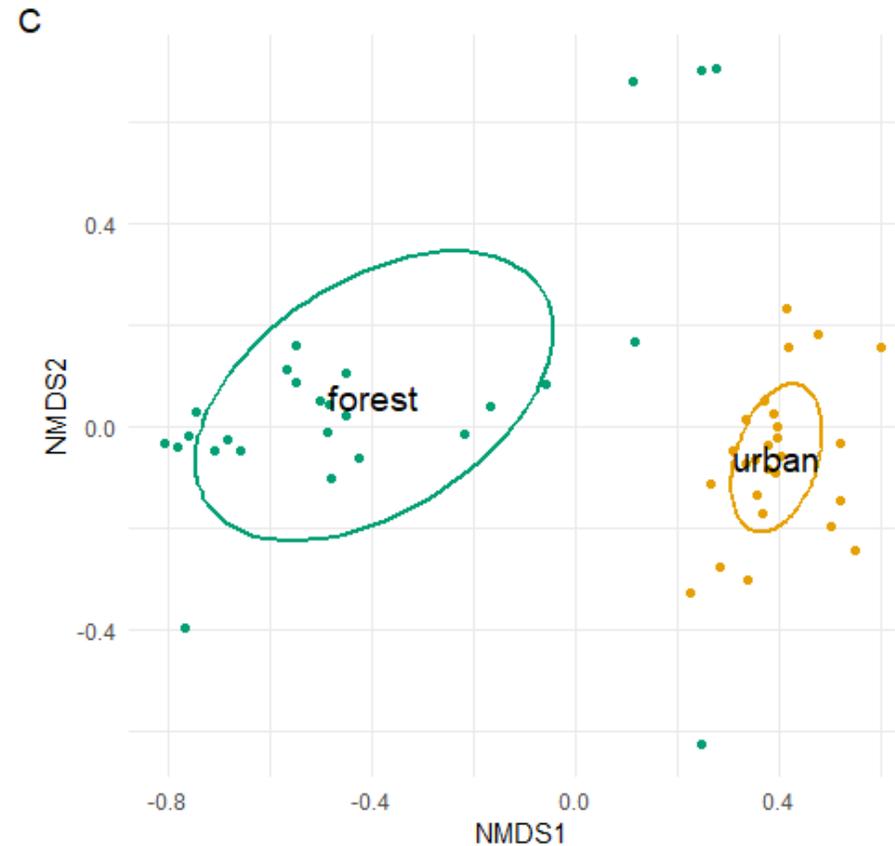
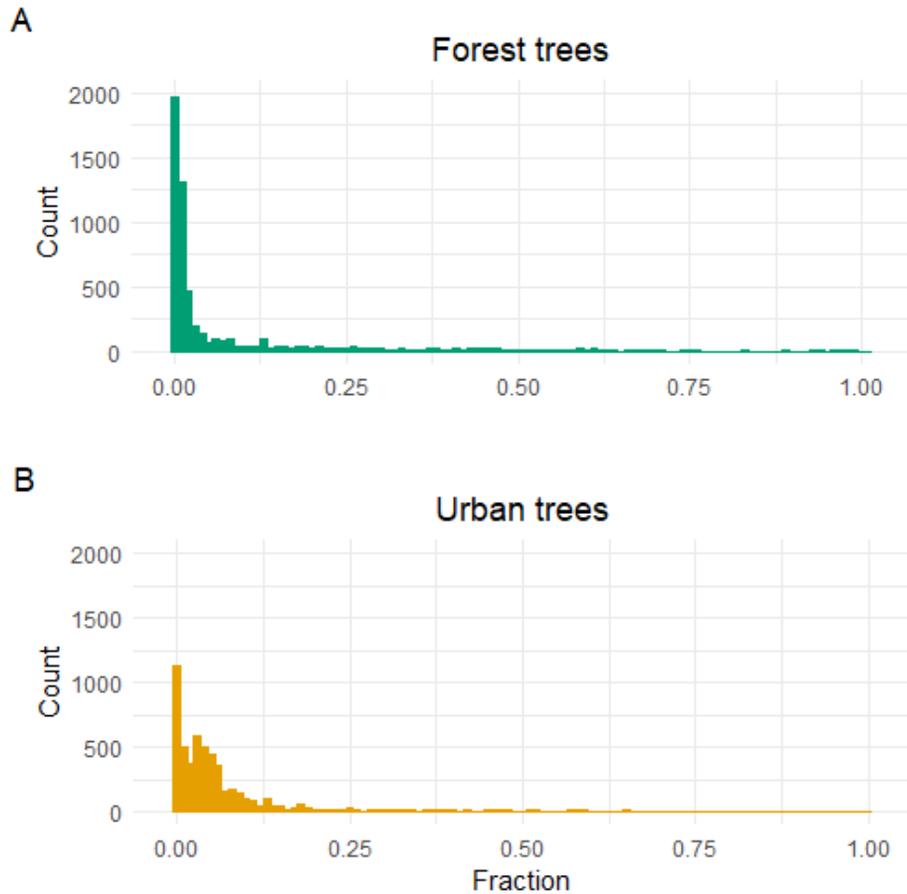
species	percentage	native in CH
<i>Carpinus betulus</i>	6.3%	yes
<i>Acer platanoides</i>	6.1%	yes
<i>Quercus robur</i>	5.0%	yes
<i>Acer campestre</i>	4.2%	yes
<i>Aesculus hippocastanum</i>	4.0%	no
<i>Acer pseudoplatanus</i>	3.4%	yes
<i>Fraxinus excelsior</i>	3.4%	yes
<i>Platanus hispanica</i>	3.2%	no
<i>Betula pendula</i>	3.1%	yes
<i>Pinus sylvestris</i>	2.8%	yes
<i>Pinus nigra</i>	2.7%	yes
<i>Malus domestica</i>	2.7%	yes
<i>Taxus baccata</i>	2.7%	yes
<i>Tilia cordata</i>	2.5%	yes
<i>Prunus avium</i>	2.4%	yes
<i>Fagus sylvatica</i>	2.1%	yes
<i>Tilia ×europaea</i>	1.9%	yes
<i>Tilia platyphyllos</i>	1.8%	yes
<i>Robinia pseudoacacia</i>	1.7%	no
<i>Populus nigra</i>	1.6%	yes
<i>Tilia ×euchlora</i>	1.5%	yes
<i>Juglans regia</i>	1.5%	yes
<i>Prunus domestica</i>	1.4%	yes
<i>Picea abies</i>	1.4%	yes
<i>Pyrus communis</i>	1.1%	yes
<i>Platanus ×acerifolia</i>	1.1%	no

What is more suitable for invasive species: forests or cities?

- EPPO (European Plant Protection Organization) A1-list
 - 208 pests (not only forest)
 - Not present in the EPPO region yet
- Compared fraction of host trees in Swiss cities with fraction of host trees in surrounding forests



What is more suitable for invasive species: forests or cities?



- More urban than forest host trees ($p < 0.00$)
 - But – mean is 8.3% vs. 7.4%
- Forest trees are hosts for different pests in cities than in surrounding forests
- ->, the peri-urban environment gives more choice of host trees for invasive forest pests
- -> that's where we should sample!

Urban vs. Forest trees in Switzerland

What did we learn

- Urban trees show an extraordinary high species richness
- Urban trees are particularly suitable stepping stones for forest pests and pathogens
 - Trade goes to urban/peri-urban environments
 - Pests arriving at (peri-)urban environment are likely to encounter hosts
 - Forest trees (genus levels) are subsets of urban trees (aiding establishment and then further spread)
- → Need and opportunity for surveillance
- But: How about private trees?



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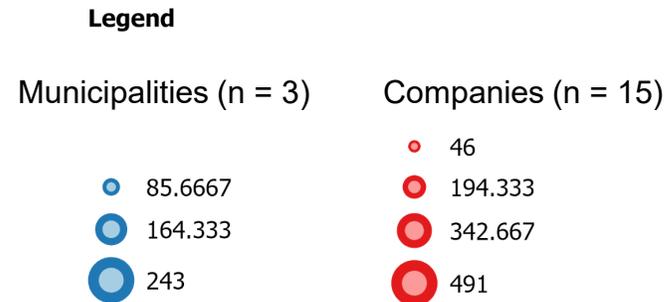
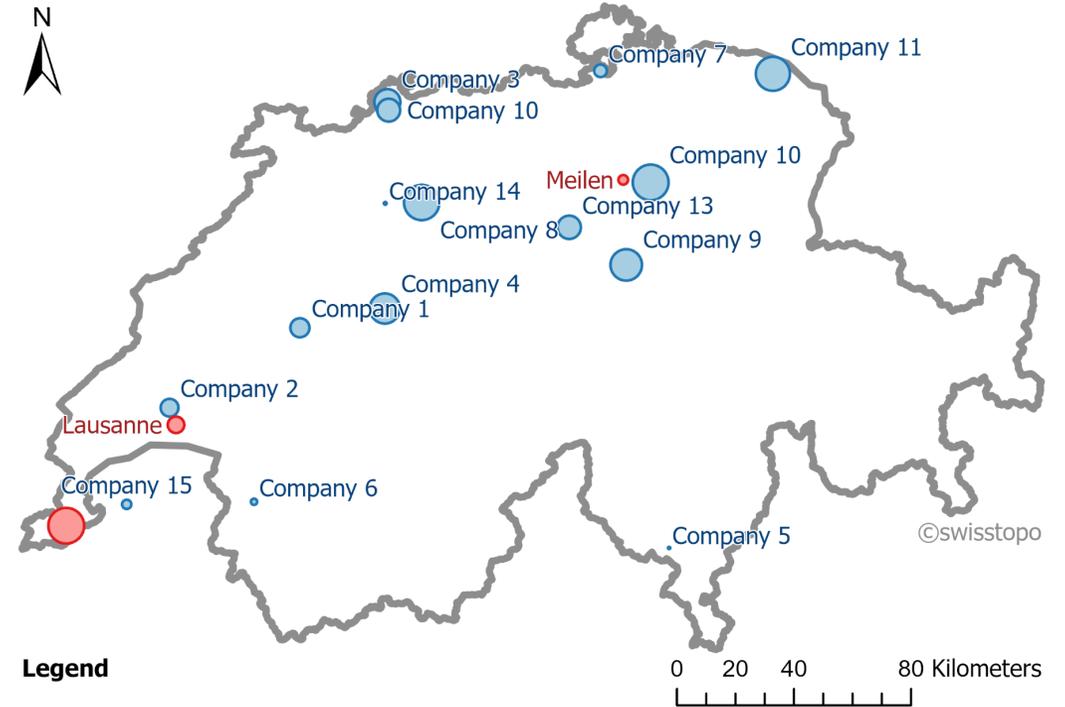
Private vs. Public trees in Switzerland

- Urban tree inventories generally only contain urban trees in city care
- Private trees could be completely different!
- MSc thesis Sarina Christen:
 - Comparison species composition of
 - Public urban trees
 - Private urban trees
 - Trees for sale



MSc thesis,
Sarina Christen (ETH)

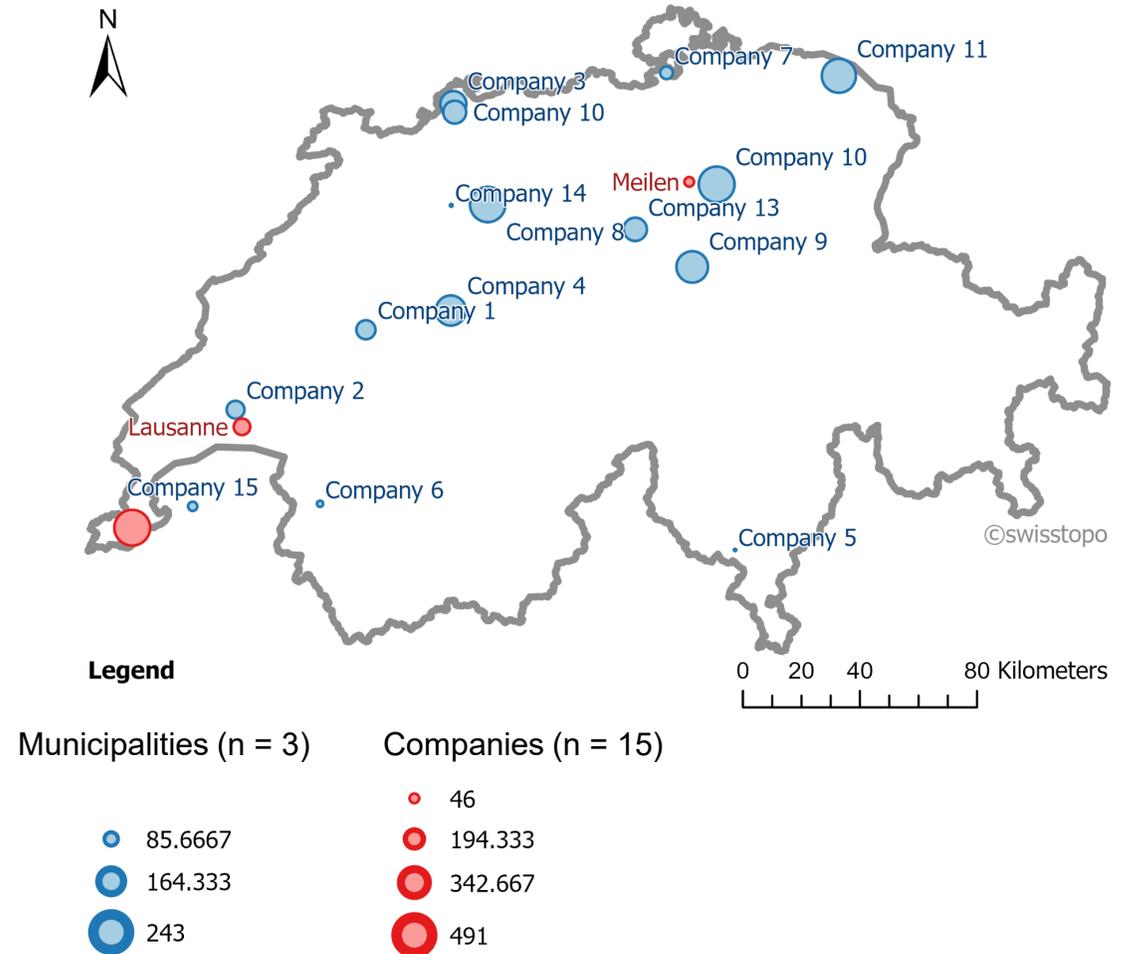
Spatial distribution of companies and municipalities



Private vs. Public trees in Switzerland

- Webscraping of catalogue data of 15 companies (tree nurseries) in and around Switzerland
- For three cities (Geneva, Lausanne, Meilen): Data on private trees
- Comparison of private, public, and commercially available trees

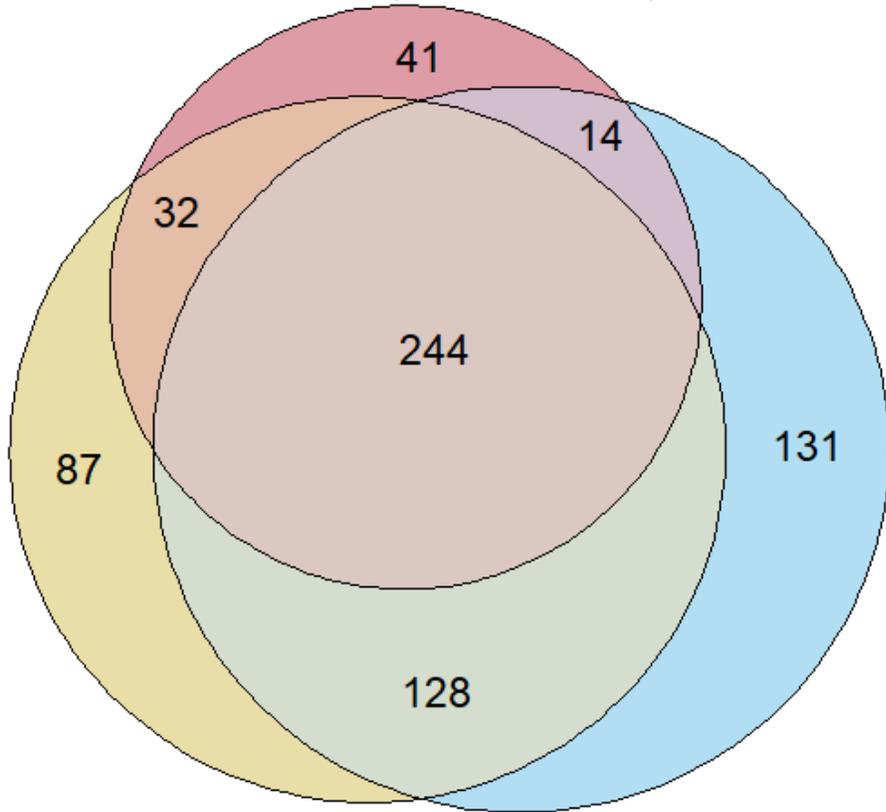
Spatial distribution of companies and municipalities



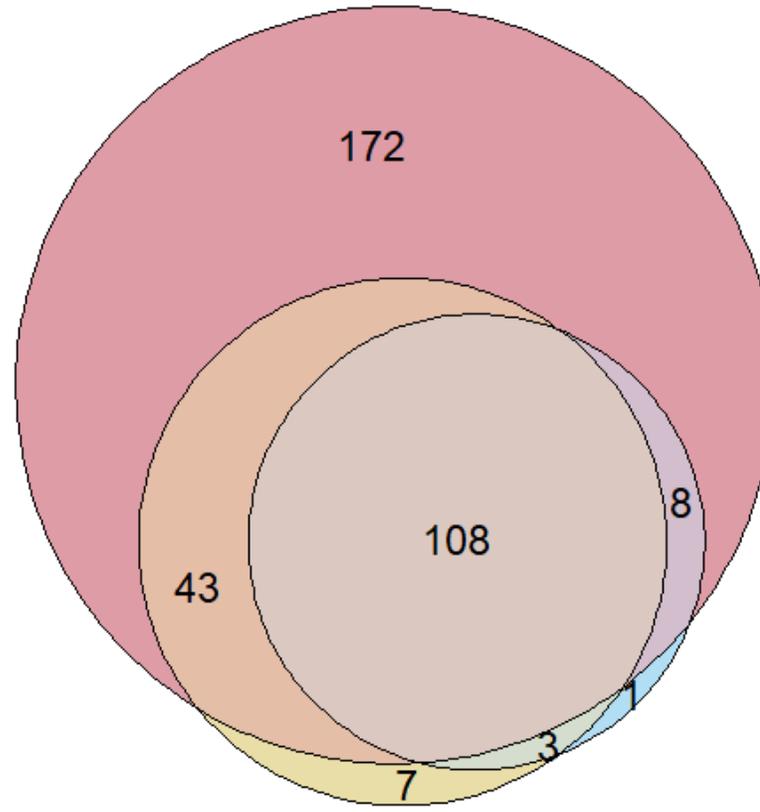
Private vs. Public trees in Switzerland

Overlap species presence

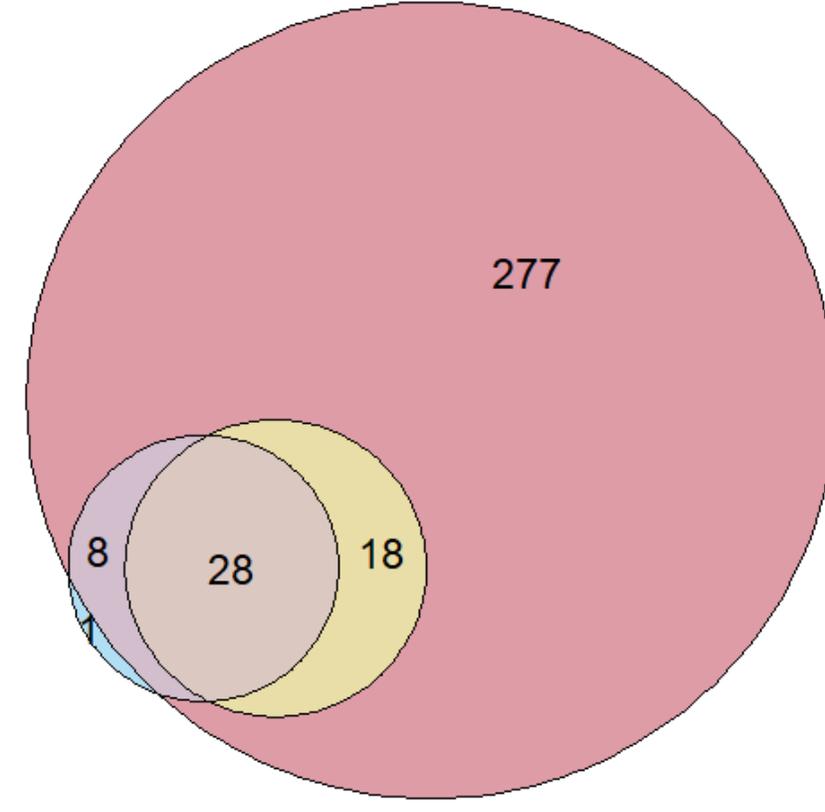
Geneva (n ~ 112'000)



Lausanne (n ~ 20'000)



Meilen (n ~ 1200)



● public urban
● private urban
● Catalogue

Larger datasets – more overlap with catalogue

Majority of public and private tree species overlap

Private vs. Public trees in Switzerland

Species composition

- On genus level:
no statistically significant difference between Public and Private trees
- Species level: most common species in both datasets
 - Top 10 species Geneva e.g.:
- Surprising (?) similarity

Private urban trees species frequencies Geneva		Public urban tree species frequencies Geneva	
Species name	Percentage	Species name	Percentage
<i>Quercus robur</i>	9.27	<i>Quercus robur</i>	9.81
<i>Carpinus betulus</i>	7.85	<i>Carpinus betulus</i>	9.05
<i>Fraxinus excelsior</i>	4.85	<i>Acer campestre</i>	6.03
<i>Prunus avium</i>	4.75	<i>Acer platanoides</i>	5.05
<i>Malus domestica</i>	4.66	<i>Fraxinus excelsior</i>	4.73
<i>Acer platanoides</i>	4.56	<i>Acer pseudoplatanus</i>	4.07
<i>Taxus baccata</i>	3.83	<i>Taxus baccata</i>	3.53
<i>Acer pseudoplatanus</i>	3.81	<i>Malus domestica</i>	3.45
<i>Juglans regia</i>	3.64	<i>Pinus sylvestris</i>	3.39
<i>Acer campestre</i>	3.38	<i>Prunus avium</i>	3.02

Species on the 'Release ordinance list' of Switzerland (September 2024)

- *Acacia dealbata* (Silver wattle , Falsche Mimose)
- *Broussonetia papyrifera* (Paper mulberry, Papiermaulbeerbaum)
- *Paulownia tomentosa* (Fox glove tree, Blauglockenbaum)
- *Prunus laurocerasus* (Cherry Laurel, Kirschlorbeer)
- *Prunus serotina* (Black cherry, Herbst-Traubenkirsche)
- *Trachycarpus fortunei* (Chinese windmill palm, Chinesische Hanfpalme)

Banned from putting on the market

- *Ailanthus altissima* (Tree of heaven, Götterbaum)
- *Rhus typhina* (Staghorn sumac, Essigbaum)

Banned from handling in environment

- All species represented in the datasets
- 11/15 companies sold at least one of the species
- *Ailanthus altissima* is present in all datasets



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Baum der Götter - *Ailanthus altissima* - 30 frische Samen - extrem schnell wachsender
★★★★★ 25 Bewertungen



- 25% UVP: 3,99 €
2,99 €
pro 30 Stück inkl. MwSt. (0,10 €/Stück)
Versandkosten nur 1,10 €

In den Warenkorb

Sofort lieferbar Auf Lager 52 verkauft

Zahlung **PayPal**, **Sofort**, Kreditkarte, Lastschrift, Ratenzahlung, Vorkasse per Überweisung, Barzahlung bei Abholung, Sofortüberweisung

Zustellung Mo, 9. Okt. bis Mi, 11. Okt.

Verkäufer **Nicks Asianshop**
★★★★★ 100% positiv

10% Rabatt ab 20,00 € Bestellwert.

Private urban trees in Switzerland

What did we learn

- There is not a lot of data on private urban trees !
- Catalogue data can help us getting an idea of the big picture of tree species presence in public and private datasets
- Surprisingly (?), similar overall species composition in private and public tree datasets
- You, too, can buy invasive trees!





What trees are planted in European cities?

- Set out to collect a European urban tree inventory
 - Within COST action
 - Personal contacts
 - Ossola et al., (2020): Global urban tree inventory
 - Opentrees.org
- Combined datasets
 - Check for species names using GBIF backbone (rgbif)



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DOI: 10.1111/geb.13169

DATA PAPER

Global Ecology
and Biogeography

A Journal of
Macronutrient

WILEY

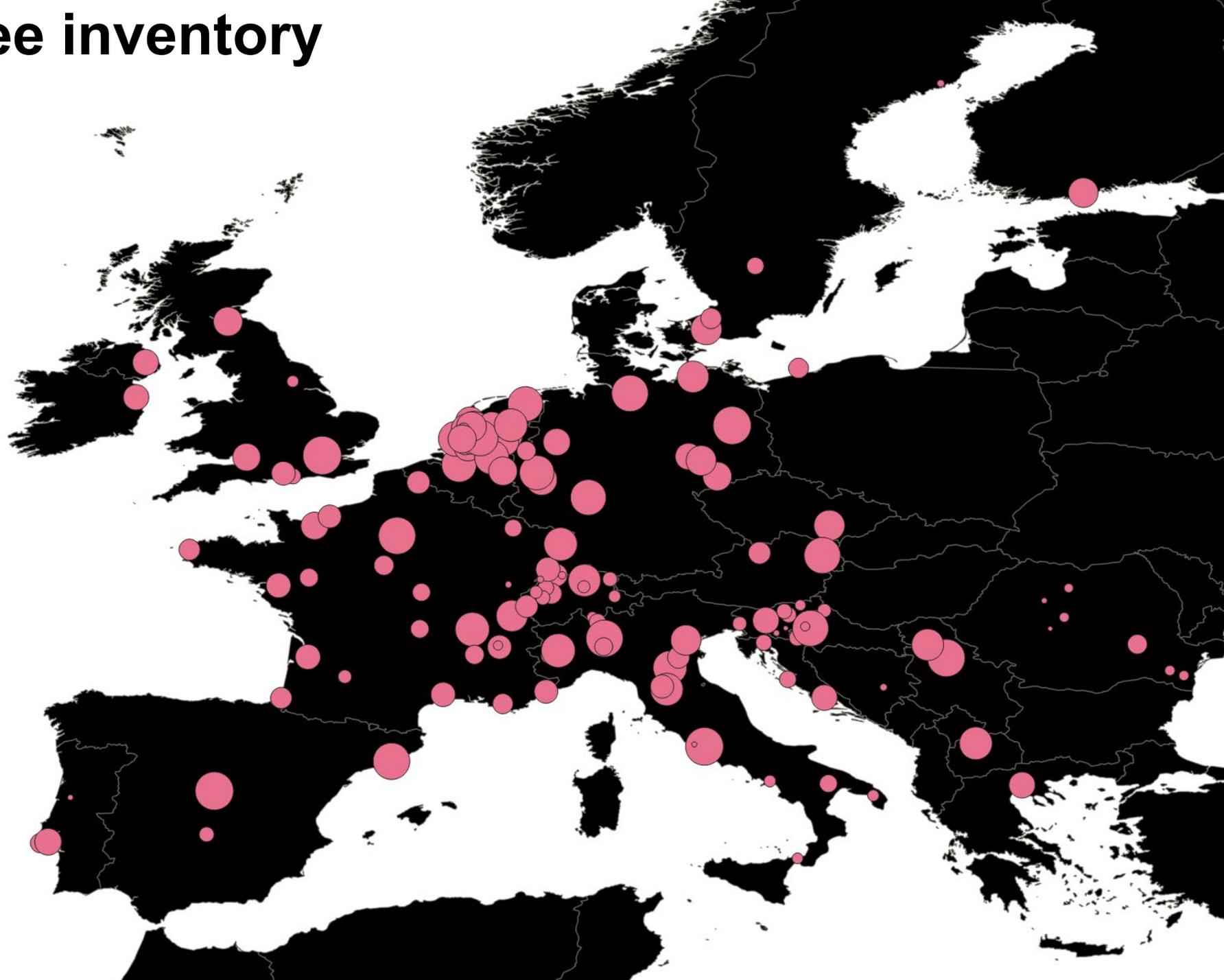
The Global Urban Tree Inventory: A database of the diverse tree flora that inhabits the world's cities

Alessandro Ossola | Malin J. Hoepfner | Hugh M. Burley | Rachael V. Gallagher |
Linda J. Beaumont | Michelle R. Leishman



European urban tree inventory

- 27 countries
- 178 inventories
- ~200 → 700'000 trees per inventory
- ~9.6 mio trees in total
- >2'700 species



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Toblerone time

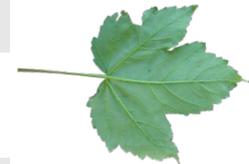
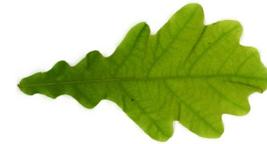
What is the most common tree species –
percentage of all trees by number



Most common trees – percentage of all trees by number



Species	Percent
Acer platanoides	4.9
Quercus robur	4.8
Fraxinus excelsior	4.2
Platanus x hispanica	3.7
Tilia cordata	3.5
Acer pseudoplatanus	3.4
Aesculus hippocastanum	2.7
Tilia x europaea	2.6
Carpinus betulus	2.5
Celtis australis	2.4



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Toblerone time

What is the most common tree species – by presence in inventories



Most common trees – presence in inventories



Species	Percent
Tilia cordata	91.6
Acer platanoides	89.6
Aesculus hippocastanum	89.6
Robinia pseudoacacia	89.6
Acer pseudoplatanus	88.3
Carpinus betulus	87.0
Juglans regia	86.4
Liriodendron tulipifera	86.4
Quercus robur	86.4
Acer negundo	85.7



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Susceptibility of urban trees to invasive forest pests

EFSA priority quarantine pests

Species

Siberian silk moth
Dendrolimus sibiricus

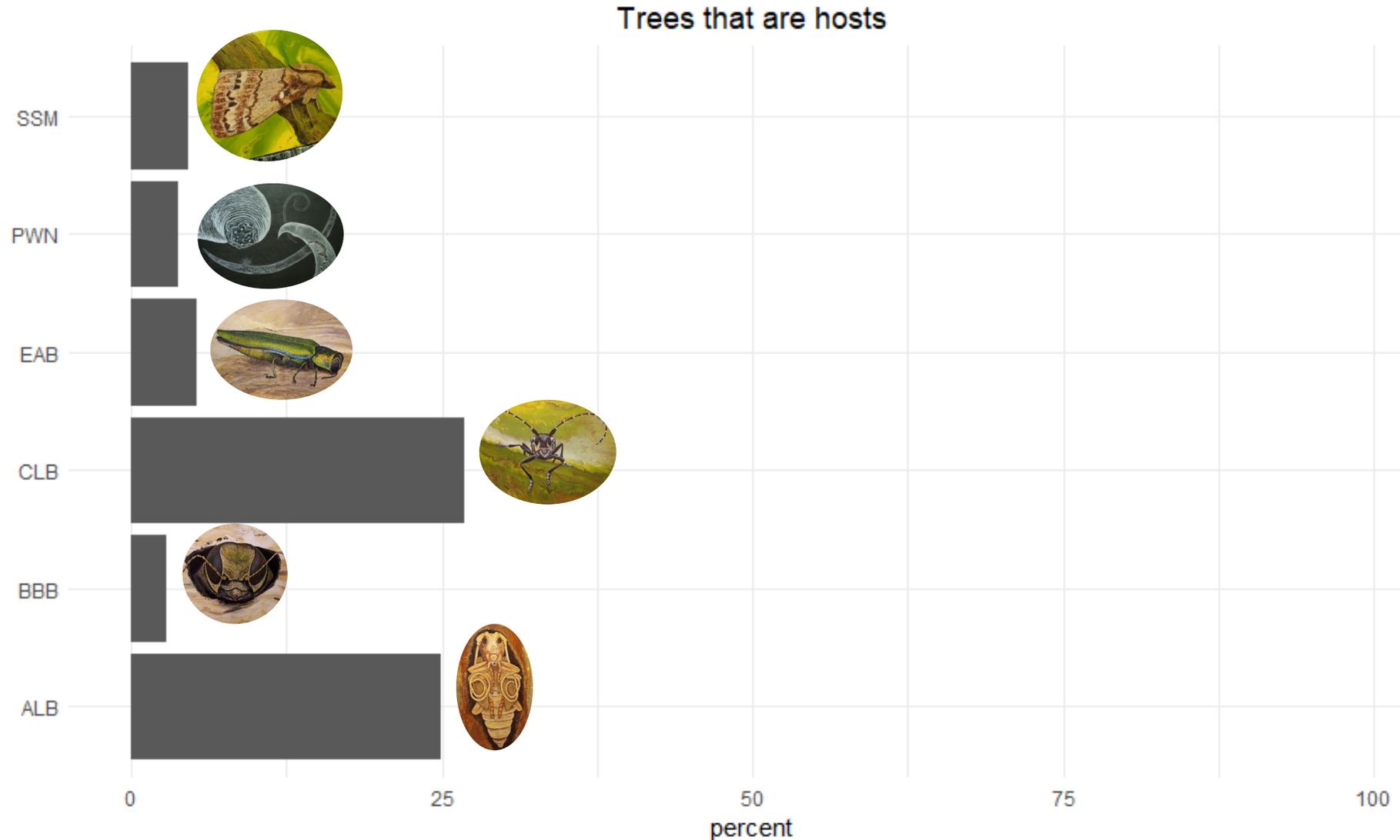
Pinewood nematode
Bursaphelenchus xylophilus

Emerald ash borer
Agrilus planipennis

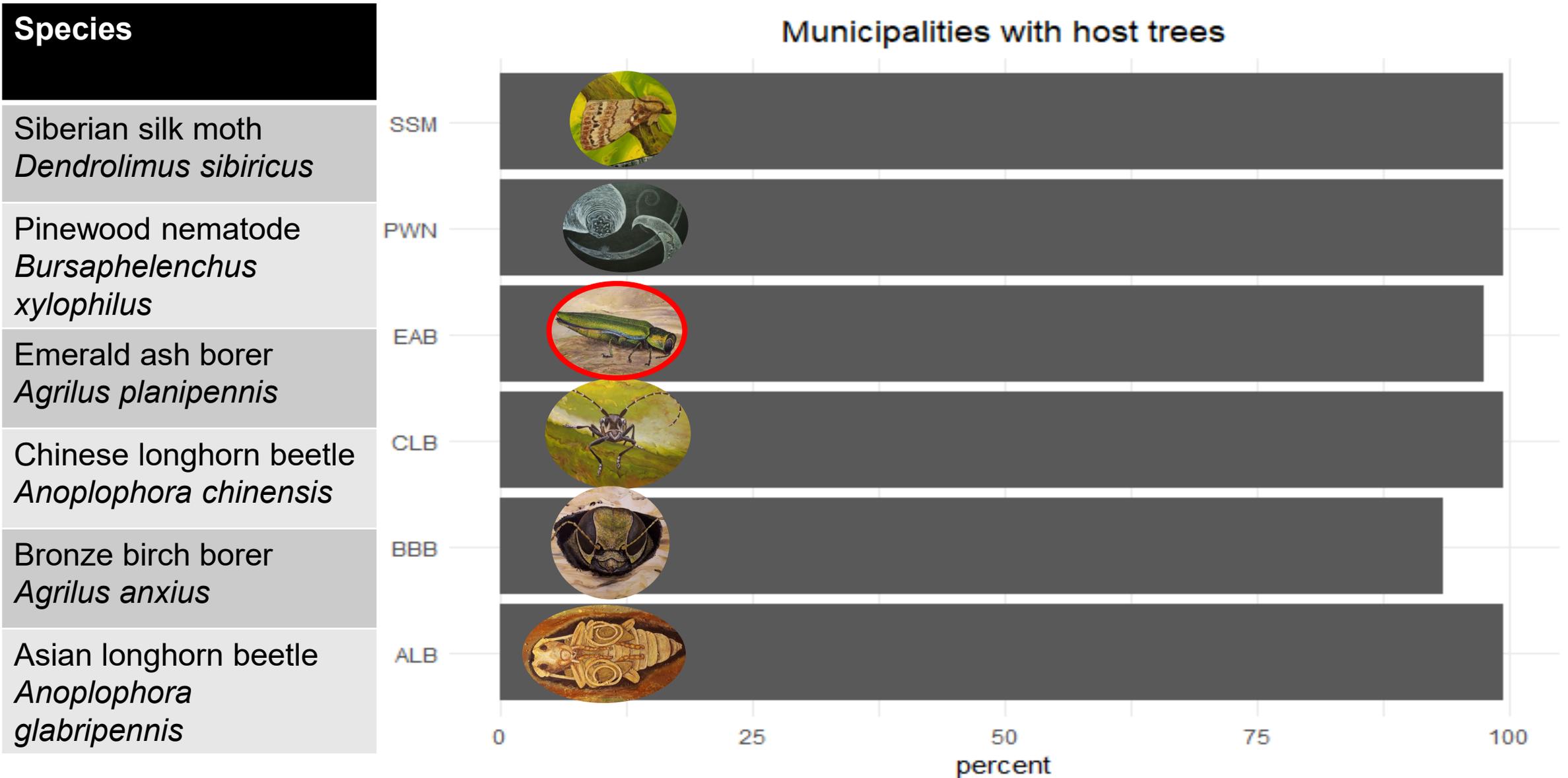
Chinese longhorn beetle
Anoplophora chinensis

Bronze birch borer
Agrilus anxius

Asian longhorn beetle
Anoplophora glabripennis



'Urban trees as stepping stones for invasive forest pests'

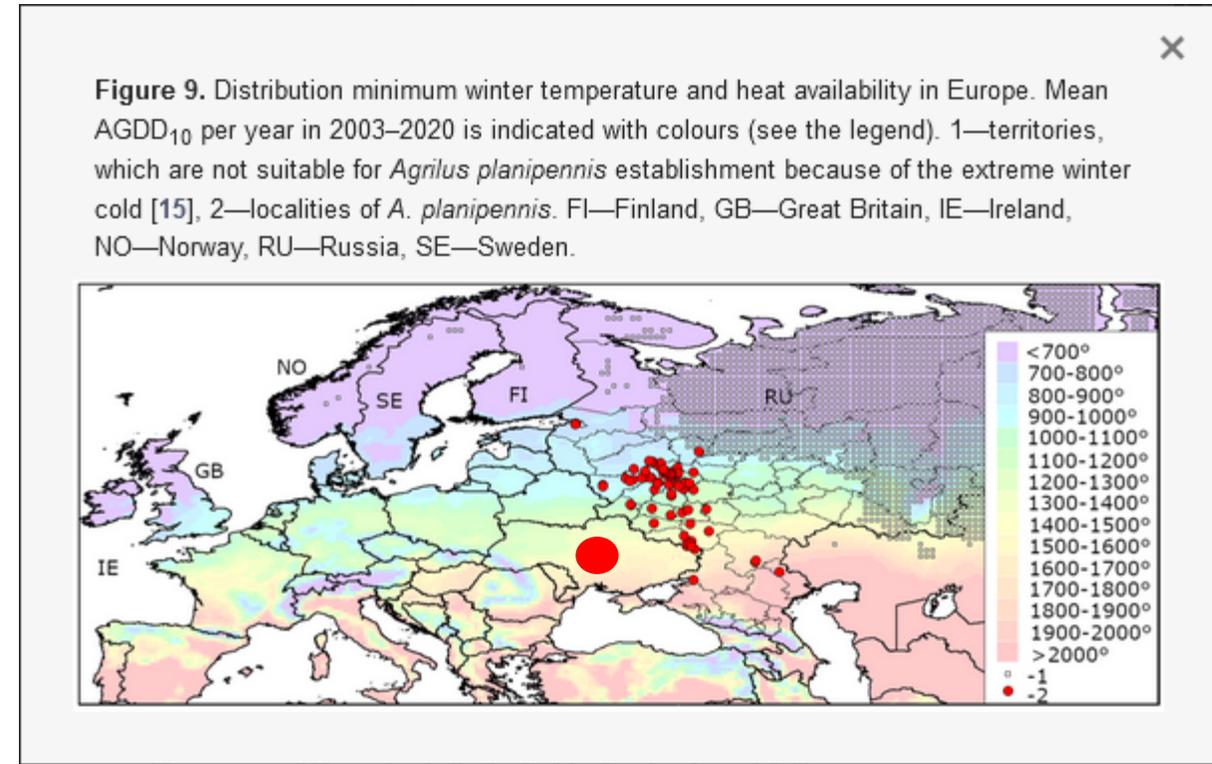


Approaching invasive forest pests in Europe

Example: Emerald Ash Borer



- Emerald Ash Borer in Europe
 - First detected in 2003 near Moscow
 - Spreading
- Concerning, because 5.3% of trees in the EUTI are *Fraxinus* sp.
- 97% of urban tree inventories contain *Fraxinus* sp.



Article

Low Heat Availability Could Limit the Potential Spread of the Emerald Ash Borer to Northern Europe (Prognosis Based on Growing Degree Days per Year)

Marina J. Orlova-Bienkowskaja * and Andrzej O. Bienkowski



- In USA: >90% ash tree mortality due to emerald ash borer predicted*
- *Fraxinus excelsior* less susceptible than American Ash species**
 - But : stressed trees in urban environments
 - *Fraxinus* spp. in Europe are already suffering from Ash dieback
- Reason for concern

*Hudgins et al., 2022, J. of Applied Ecology
**Shaw et al., 2019, Plants People Planet



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Future of Ash in European cities

- For 52 inventories: data on plant year
- ~160'000 trees planted from 2018-2023
- From which 4.7% *Fraxinus* sp.
- ~7638 trees
- Low estimate of planting costs: >15Mio €



European urban tree inventory

What did we learn

- EU priority quarantine pests and pathogens:
 - most will find abundant host trees in European cities.
- Specific situation EAB:
 - Advise against planting more Ash trees in European cities
- Urban trees: stepping stones for invasive forest pests
 - Monitoring opportunities
- Generally:
 - Planning urban tree species: do we consider potentially invasive species enough?
 - Astonishingly high species richness: 'common garden experiment'



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A research institute of the ETH Domain



Waldschutz Schweiz
Protection de la forêt suisse
Protezione della foresta svizzera



