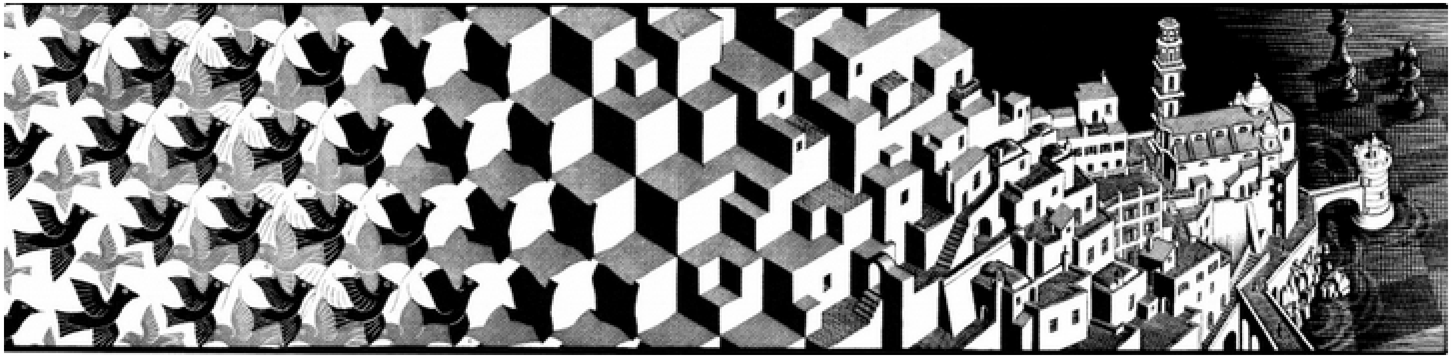
International scientific meeting – Urban Future LABEX
“Urban Natures? describing, practicing, developing”
Université Gustave Eiffel, Champs-sur-Marne 22-23.11.2021

Social-ecological drivers of biodiversity and ecosystem services in cities



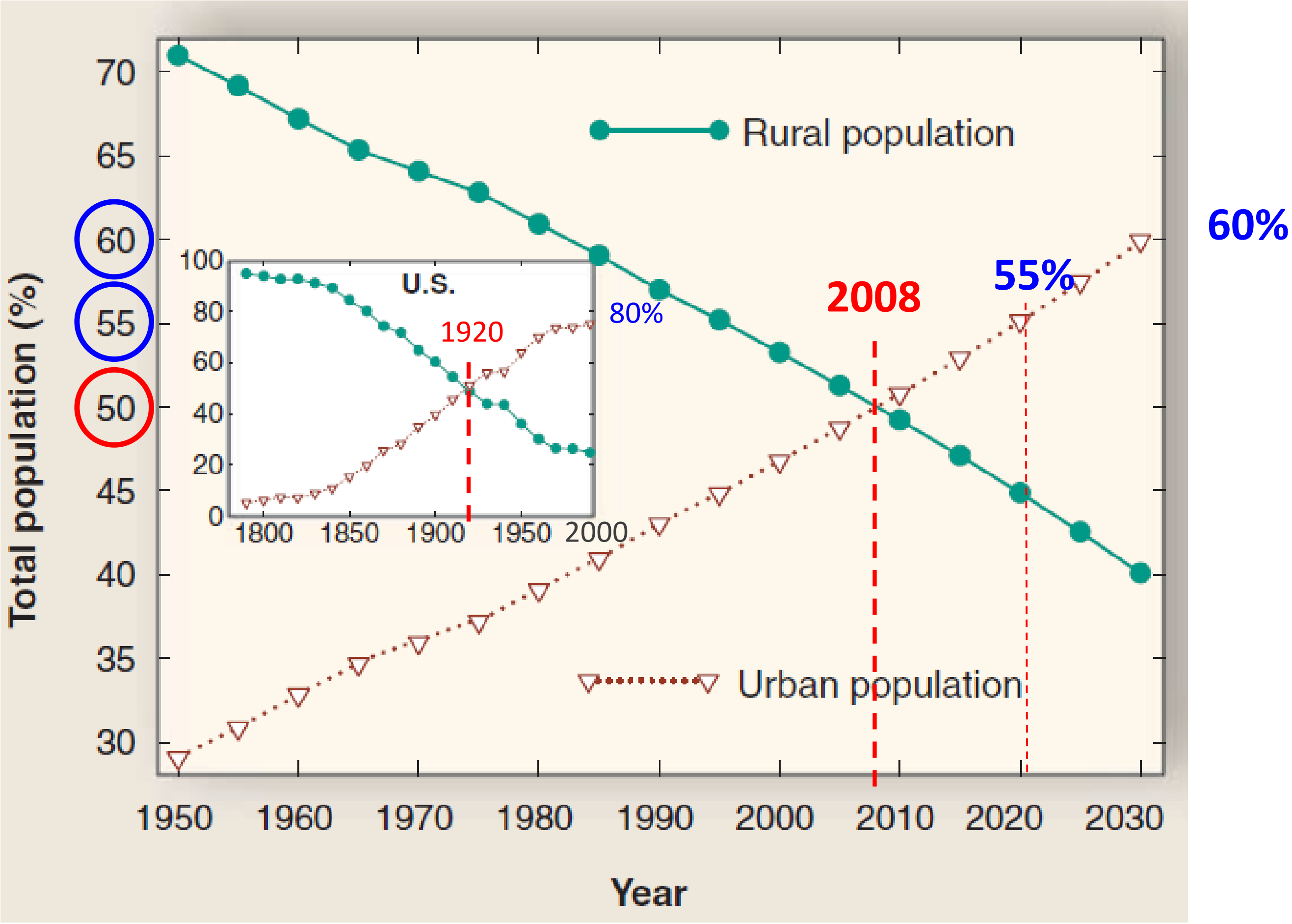
Maurits C. Escher, Methamorphosis, 1939

Marco Moretti

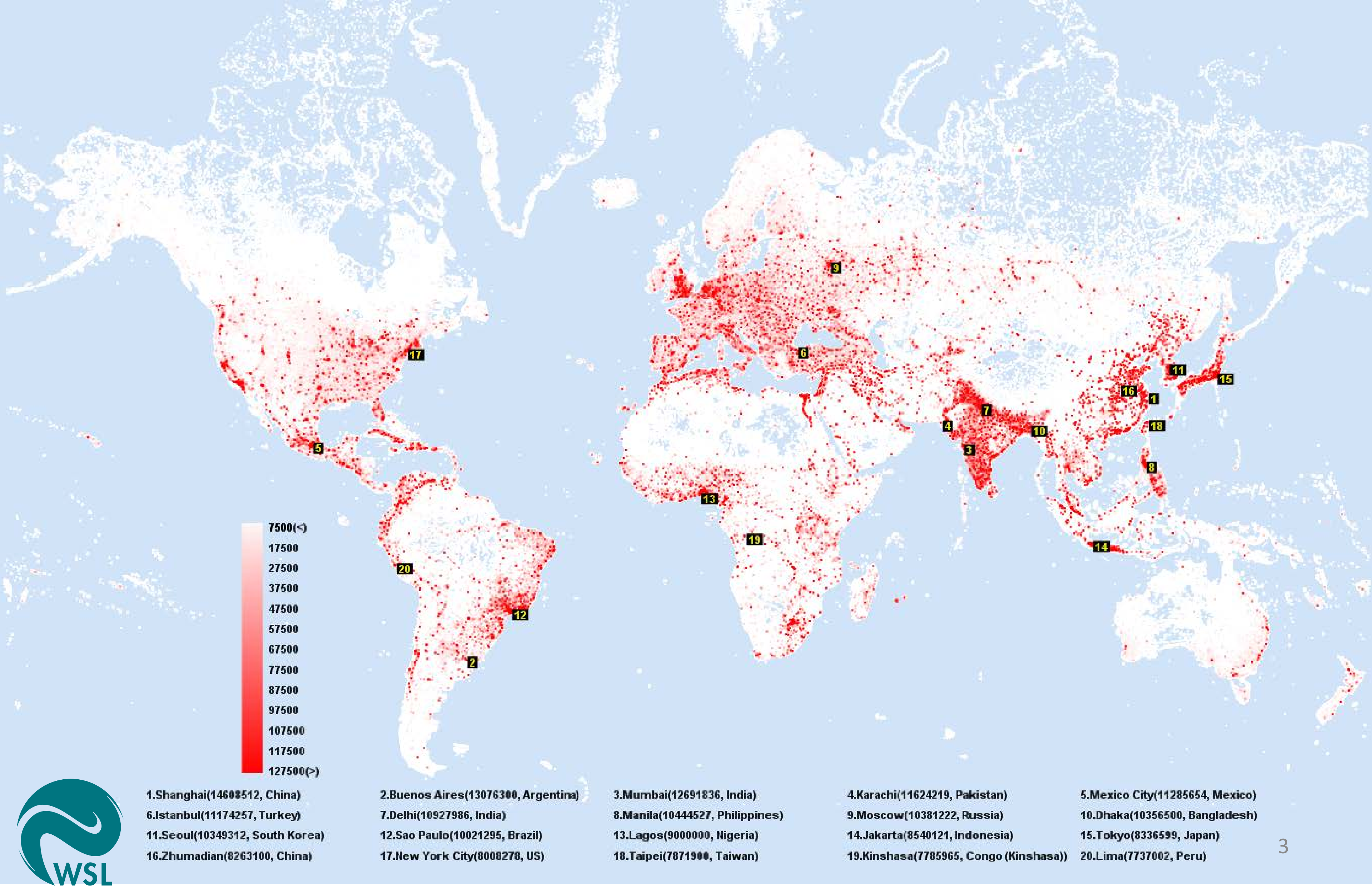
Swiss Federal Research Institute WSL, Birmensdorf (Zurich)
Switzerland

Urbanization: a big challenge

- **Urban areas are expanding at an unprecedented speed**
- **Gradual growth in the proportion of people inhabiting cities** (UN. 2014. World urbanization prospects)
- Transitions from the countryside to cities



- Currently, urban areas cover only **5% of Earth's surface**, **BUT…**
- **50% of the world's population** lives in cities **(70% by 2050)** (UN. 2014. World urbanization prospects)
- **80% in Europe**



Urbanization: a big challenge

SCIENCE'S COMPASS • REVIEW

REVIEW: BIODIVERSITY

Global Biodiversity Scenarios for the Year 2100

Osvaldo E. Sala,[1*] F. Stuart Chapin III,[2] Juan J. Armesto,[4] Eric Berlow,[5] Janine Bloomfield,[6] Rodolfo Dirzo,[7] Elisabeth Huber-Sanwald,[8] Laura F. Huenneke,[9] Robert B. Jackson,[10] Ann Kinzig,[11] Rik Leemans,[12] David M. Lodge,[13] Harold A. Mooney,[14] Martin Oesterheld,[1] N. LeRoy Poff,[15] Martin T. Sykes,[17] Brian H. Walker,[18] Marilyn Walker,[3] Diana H. Wall[16]

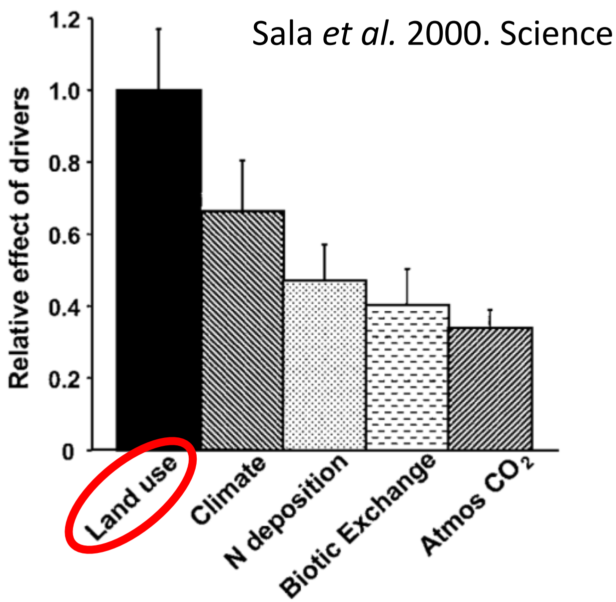
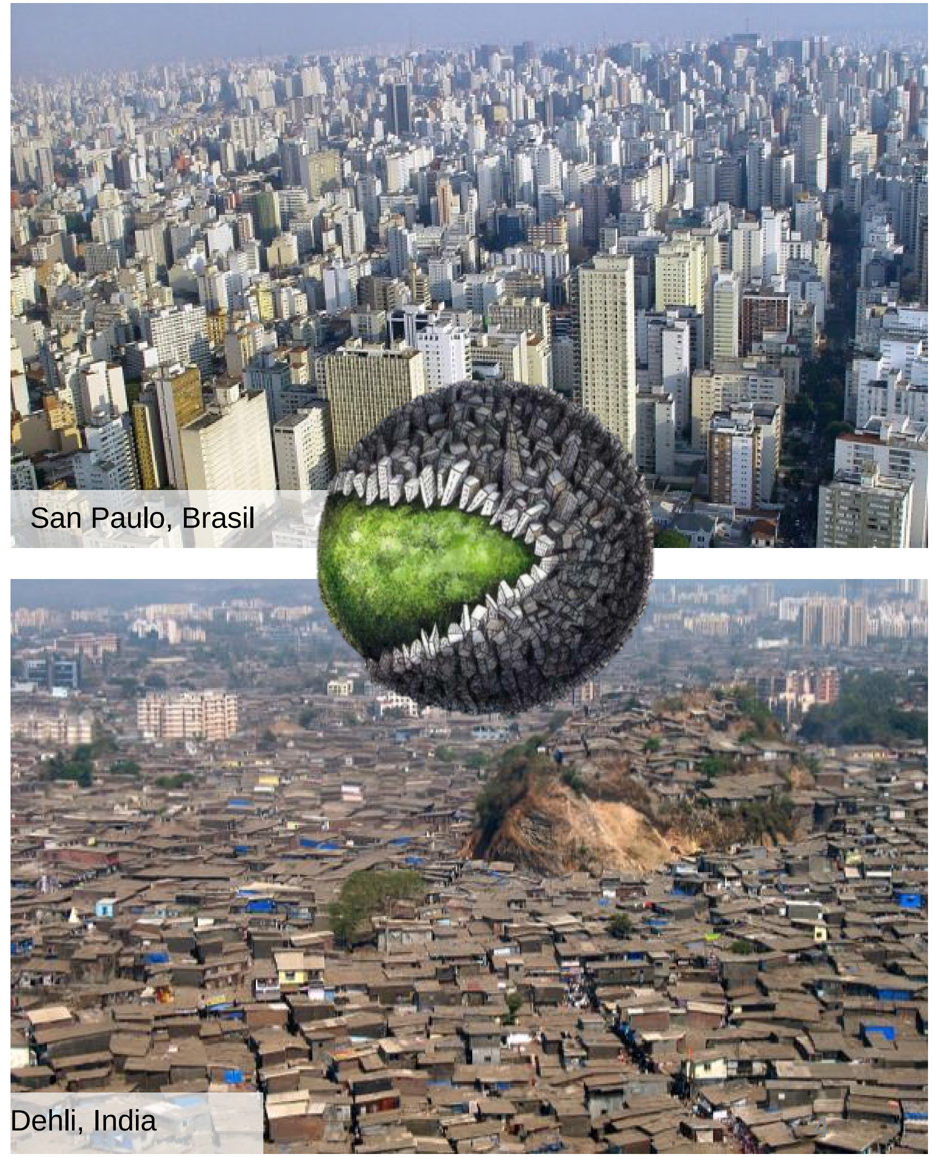


Fig. 1. Relative effect of major drivers of changes on biodiversity. Expected biodiversity change for each biome for the year 2100 was calculated as the product of the expected change in drivers times the impact of each driver on biodiversity for each biome. Values are averages of the estimates for each biome and they are ... relative to the maximum change, which ... from change in land use. Thin bars are ... errors and represent variability among biomes.



Panama City, Panama. 1930s vs Present day. *(Image Source: SkyscraperCity & MagnificTravel)*

Urbanization: effects

Major effects

- Deep changes in space and time
- Habitat loss and fragmentation
- Strong environmental filtering
- Biotic homogenization
- Heat island
- …

But…

- Cities are the habitat where we (humans) live, work, socialize and reproduce
- Most of the knowledge are form the N-hemisphere
- We have an increasing responsibility toward nature conservation in cities

Urban biodiversity conservation

Cities are also associated to:

- Hotspot of biodiversity (Seto et al. 2012, PNAS)
- Endemic species (Ives et al. 2016, Global Ecology and Biogeography)
- To some taxonomic groups are favoured, e.g. bees (Hall et al. 2017, Conservation Biology)

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2015)

RESEARCH PAPER

Cities are hotspots for threatened species

Christopher D. Ives[1*†‡] Pia E. Lentini[2†], Caragh G. Threlfall[3], Karen [...] Danielle F. Shanahan[5], Georgia E. Garrard[1], Sarah A. Bekessy[1], Richard A. Fuller[5], Laura Mumaw[1], Laura Rayner[4], Ross Rowe[4,6,7], Leonie E. Valentine[8] and Dave Kendal[9]

Conservation Biology

Essay

The city as a refuge for insect pollinators

Damon M. Hall,[1*] Gerardo R. Camilo,[2] Rebecca K. Tonietto,[1] Jeff Ollerton,[3] Karin Ahrné,[4] Mike Arduser,[5] John S. Ascher,[6] Katherine C. R. Baldock,[7] Robert Fowler,[8] Gordon Frankie,[9] Dave Goulson,[8] Bengt Gunnarsson,[10] Mick E. Hanley,[11] Janet I. Jackson,[3] Gail Langellotto,[12] David Lowenstein,[12] Emily S. Minor,[13] Stacy M. Philpott,[14] Simon G. Potts,[15] Muzafar H. Sirohi,[3] Edward M. Spevak,[16] Graham N. Stone,[17] and Caragh G. Threlfall[18]

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

25. April 2012

Strategy Biodiversity Switzerland

[...] *Cities also need to play their part in conserving global biodiversity, <u>as urban growth is increasingly concentrated in biodiversity hotspots</u>.*
That in addition to the various ecosystem services for urban populations.

Goals of the talk

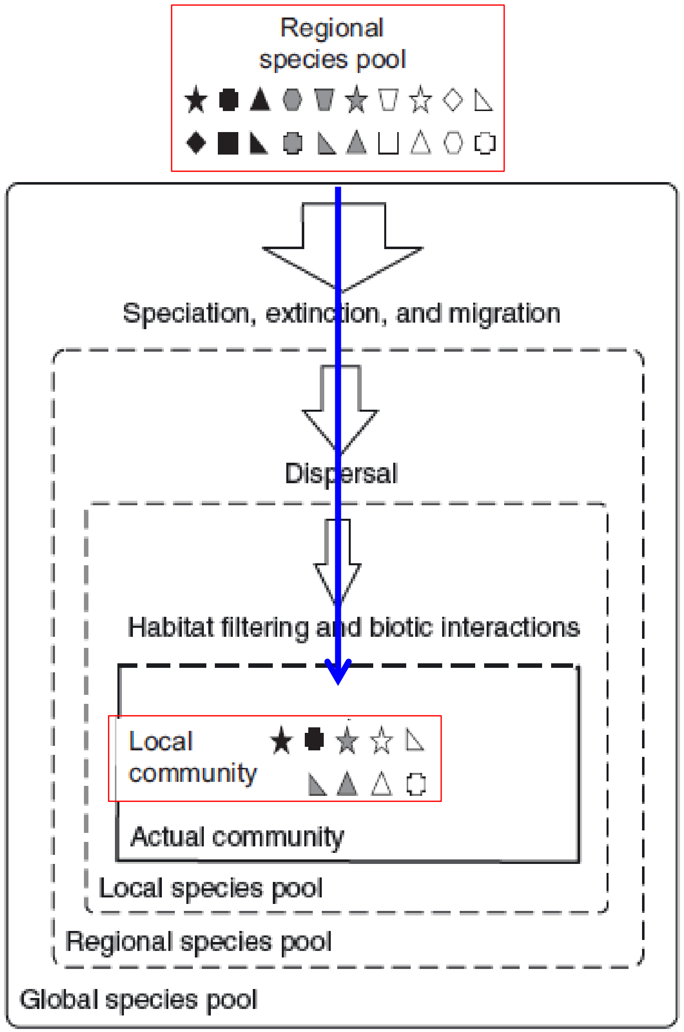
Try to understand some of the mechanisms that drive biodiversity and species assemblages in cities and possible effects on ecosysem functions.

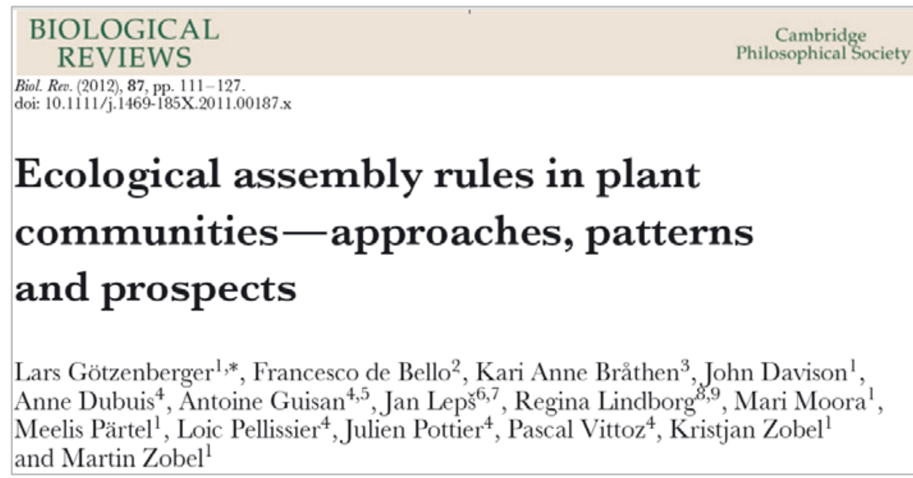
I'll try to answer the following questions:

- Which biodiversity?
- For whom?
- For what?
- How?

I'm going to start with few **theories/concepts -> examples -> perspectives**

Species assembly rules




BIOLOGICAL REVIEWS
Cambridge Philosophical Society
Biol. Rev. (2012), **87**, pp. 111–127.
doi: 10.1111/j.1469-185X.2011.00187.x

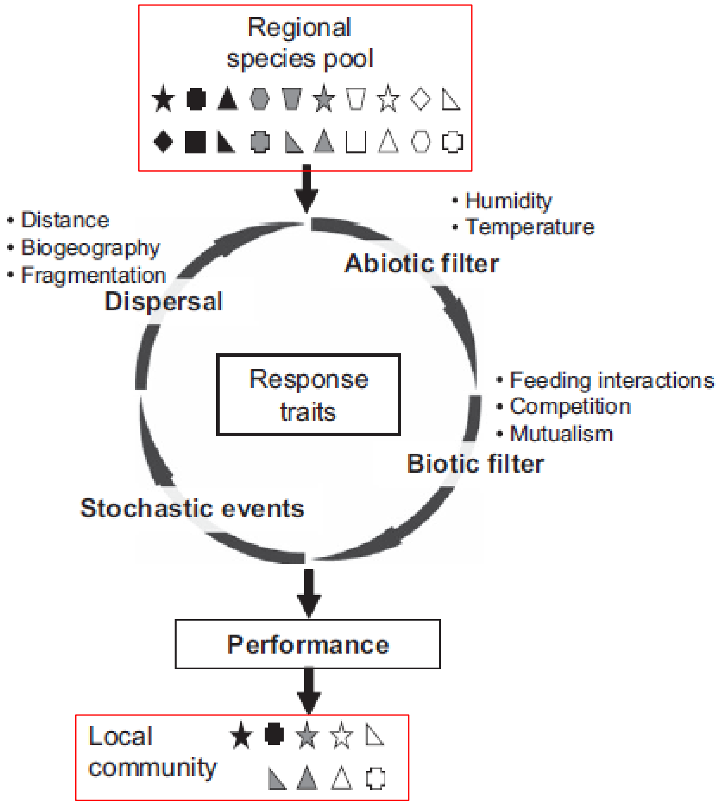
Ecological assembly rules in plant communities—approaches, patterns and prospects

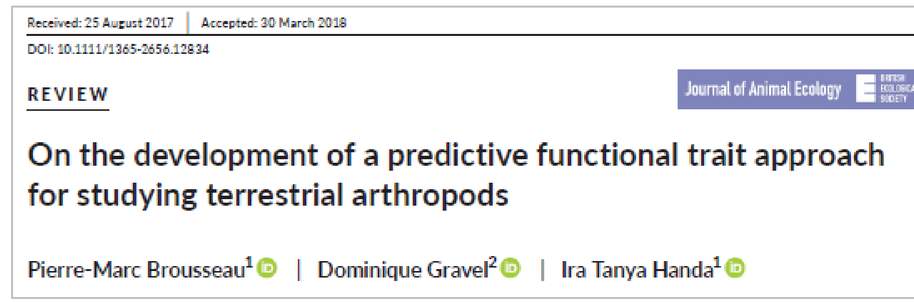
Lars Götzenberger[1,*], Francesco de Bello[2], Kari Anne Bråthen[3], John Davison[1], Anne Dubuis[4], Antoine Guisan[4,5], Jan Lepš[6,7], Regina Lindborg[8,9], Mari Moora[1], Meelis Pärtel[1], Loic Pellissier[4], Julien Pottier[4], Pascal Vittoz[4], Kristjan Zobel[1] and Martin Zobel[1]

Götzenberger et al. 2012 *Biol Rev* **87**, 111

How do species assemble in cities?

Species assembly rules





Received: 25 August 2017 | Accepted: 30 March 2018
DOI: 10.1111/1365-2656.12834
Journal of Animal Ecology

REVIEW

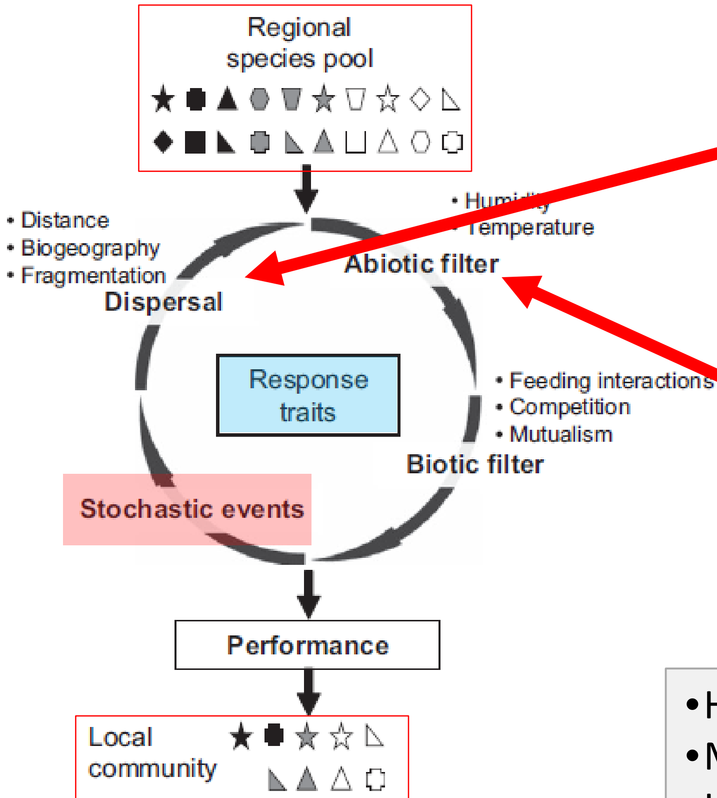
On the development of a predictive functional trait approach for studying terrestrial arthropods

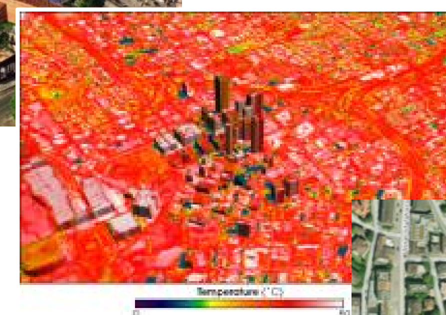
Pierre-Marc Brousseau[1] | Dominique Gravel[2] | Ira Tanya Handa[1]

Brousseau *et al.* 2017 *J Anim Ecol* **87**, 1209

How do species assemble in cities?

Species assembly rules





- Historical legacy
- Microclimate
- Habitat loss
- Fragmentation

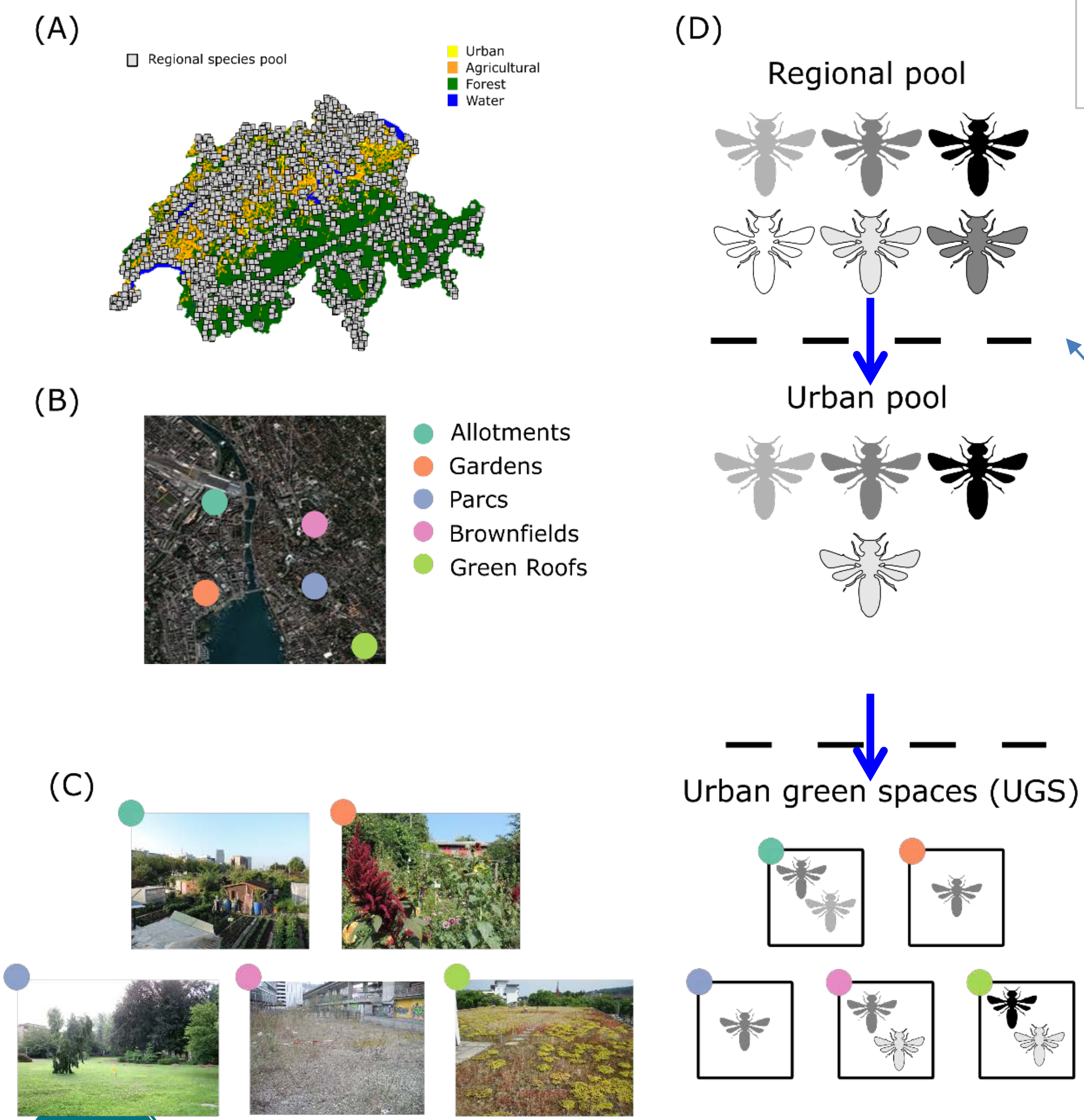
adapted from Aronson *et al.* 2016. *Ecology*, **97**, 29523

How do species assemble in cities?

Received: 28 March 2019 | Revised: 14 October 2019 | Accepted: 22 October 2019
DOI: 10.1111/jbi.13772
RESEARCH PAPER
Journal of Biogeography WILEY

The origin of urban communities: From the regional species pool to community assemblages in city

Bertrand Fournier[1] | David Frey[2] | Marco Moretti[3]

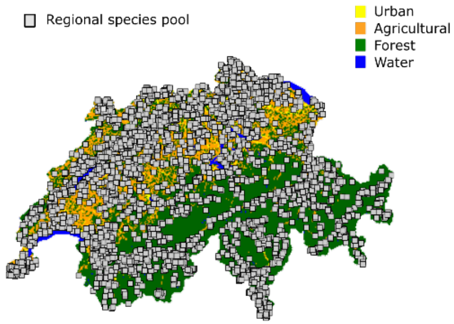


- Body size
- Mobility
- Phenology
- Feeding prefernences
- Reproduction
- Abiotic tolerance

Fournier *et al.* 2020 *J Biog* **47**, 615

How do species assemble in cities?

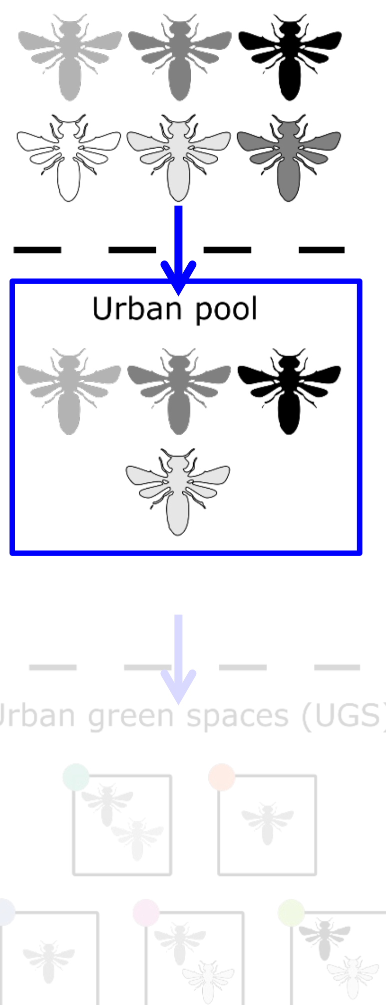
(A)



(B)

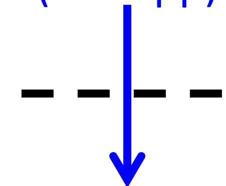
(C)

(D)



Regional species pool

(535 spp)

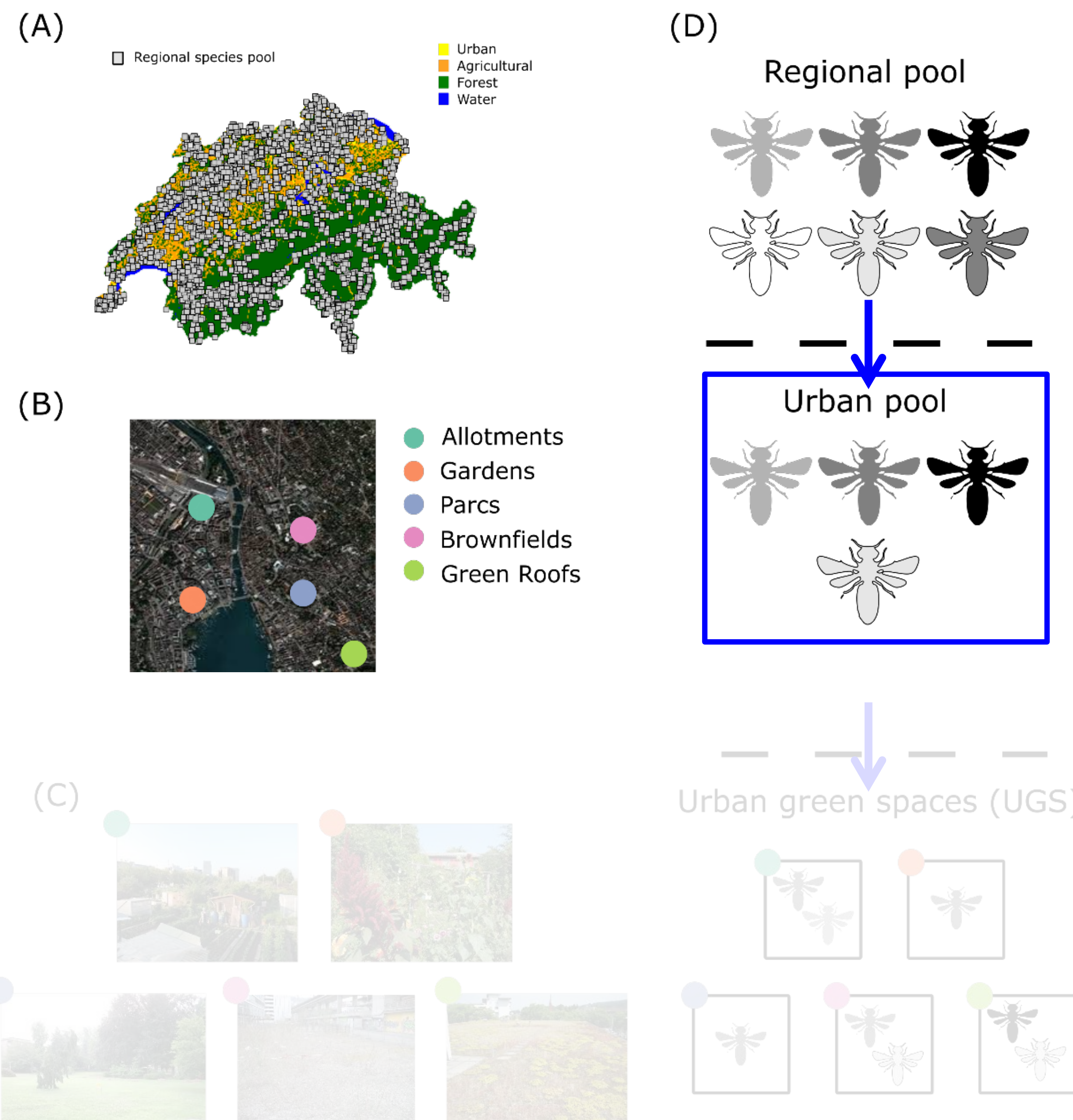


(164 spp; 31%)

Bees	
Trait	
ACTIVITY TIME	**Earlier↑**
	Longer↑
BODY SIZE	Larger↑
FEEDING PREFERENCES	**Generalist↑**
TONGUE LENGTH	**Shorter↑**
NESTING MODE	**Renter↑**
	Mason↓
	Parasite↓
VOLTINISM	**Polymorph↑**
SOCIAL STATUS	**Social↑**
	Polymorph↑
NICHE BREATH	**Larger↑**
FUNCTIONAL DIVERSITY	*n.s.*

Fournier *et al.* 2020 *J Biog* **47**, 615

How do species assemble in cities?



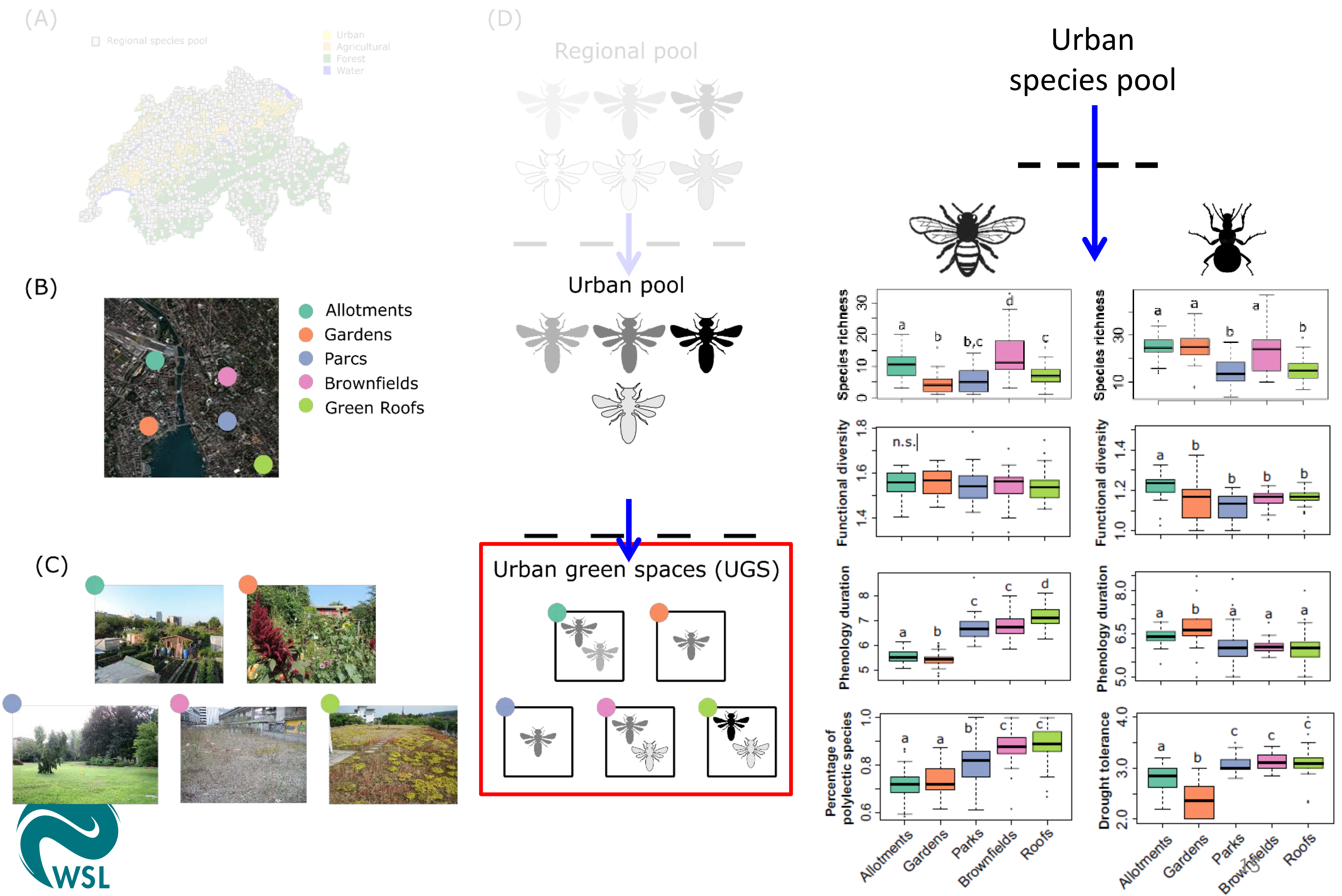
Regional species pool
(447 spp)

(86 spp; 19%)

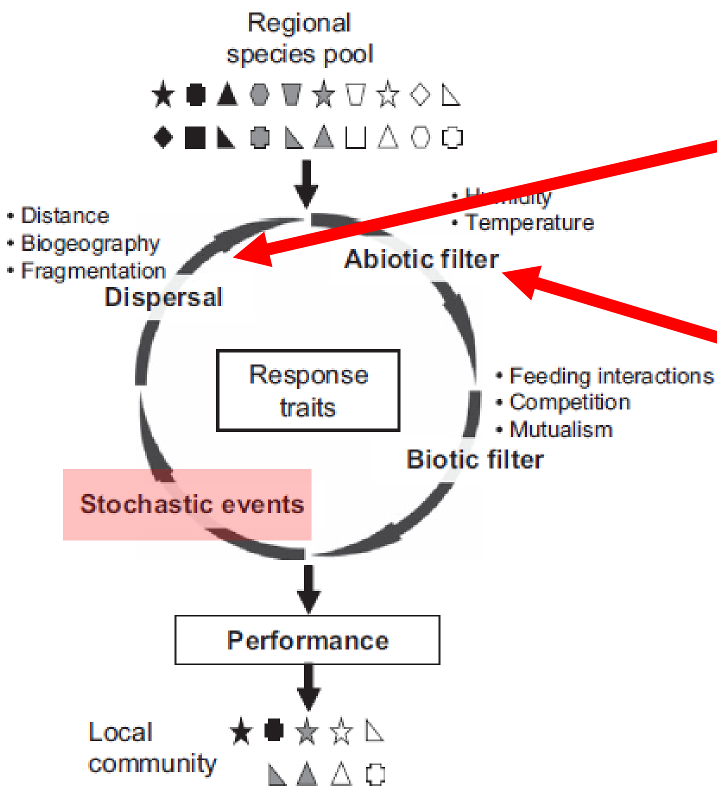
Carabid beetles	
Trait	
ACTIVITY TIME	*n.s.*
BODY SIZE	*n.s.*
FEEDING PREFERENCES	**Omnivore↑**
OVER-WINTERING	Imago↑
MOBILITY	Macropter↑
ABIOTIC TOLERANCE	Xerophil↑
NICHE BREATH	**Larger↑**
FUNCTIONAL DIVERSITY	**Lower↓**

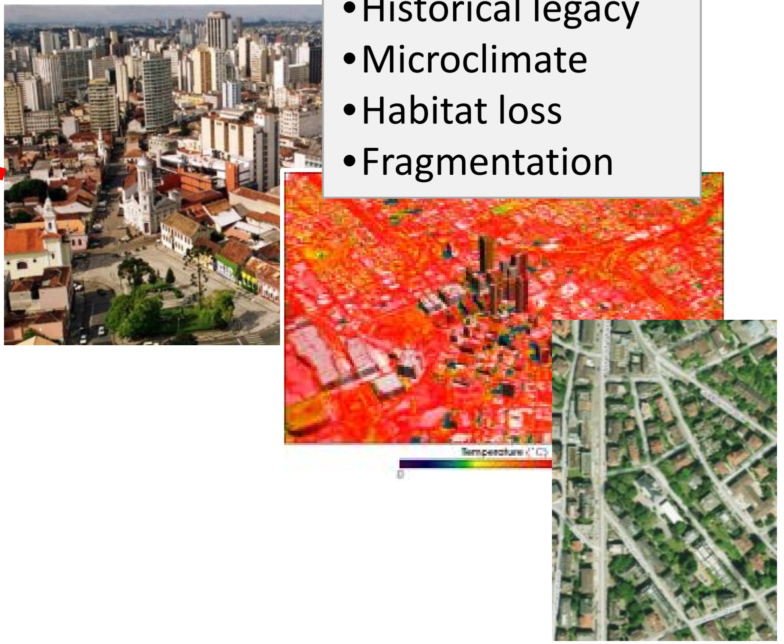
Fournier *et al.* 2020 *J Biog* **47**, 615

How do species assemble in cities?



Species assembly rules



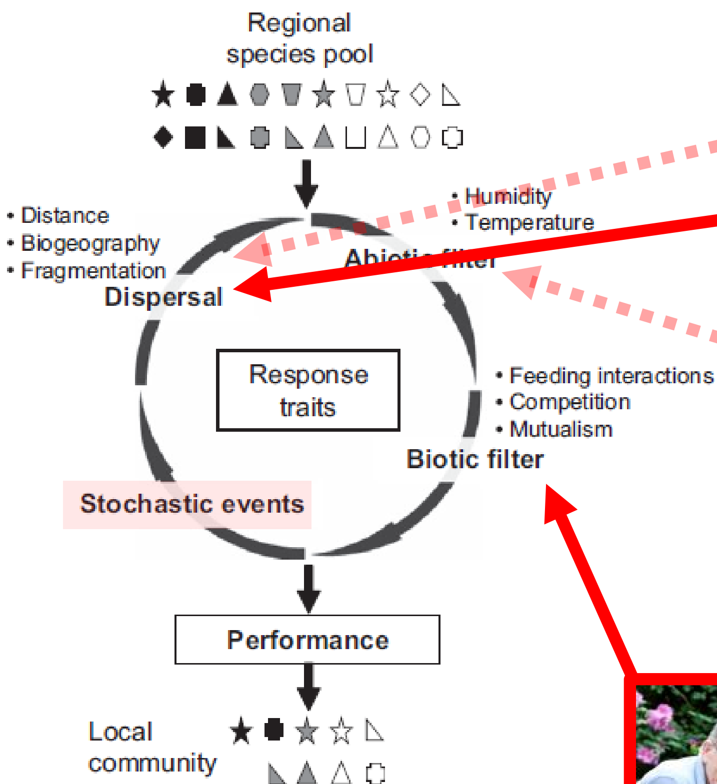


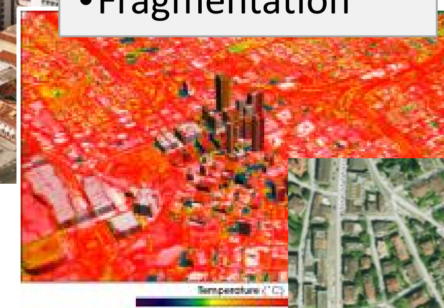
- Historical legacy
- Microclimate
- Habitat loss
- Fragmentation

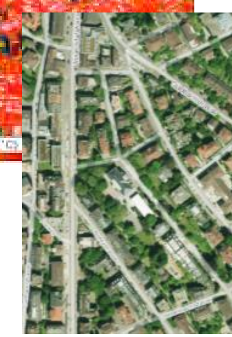
adapted from: Aronson *et al.* 2016. *Ecology*, **97**, 29523

How do species assemble in cities?

Species assembly rules







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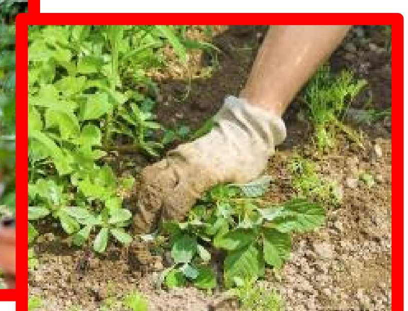
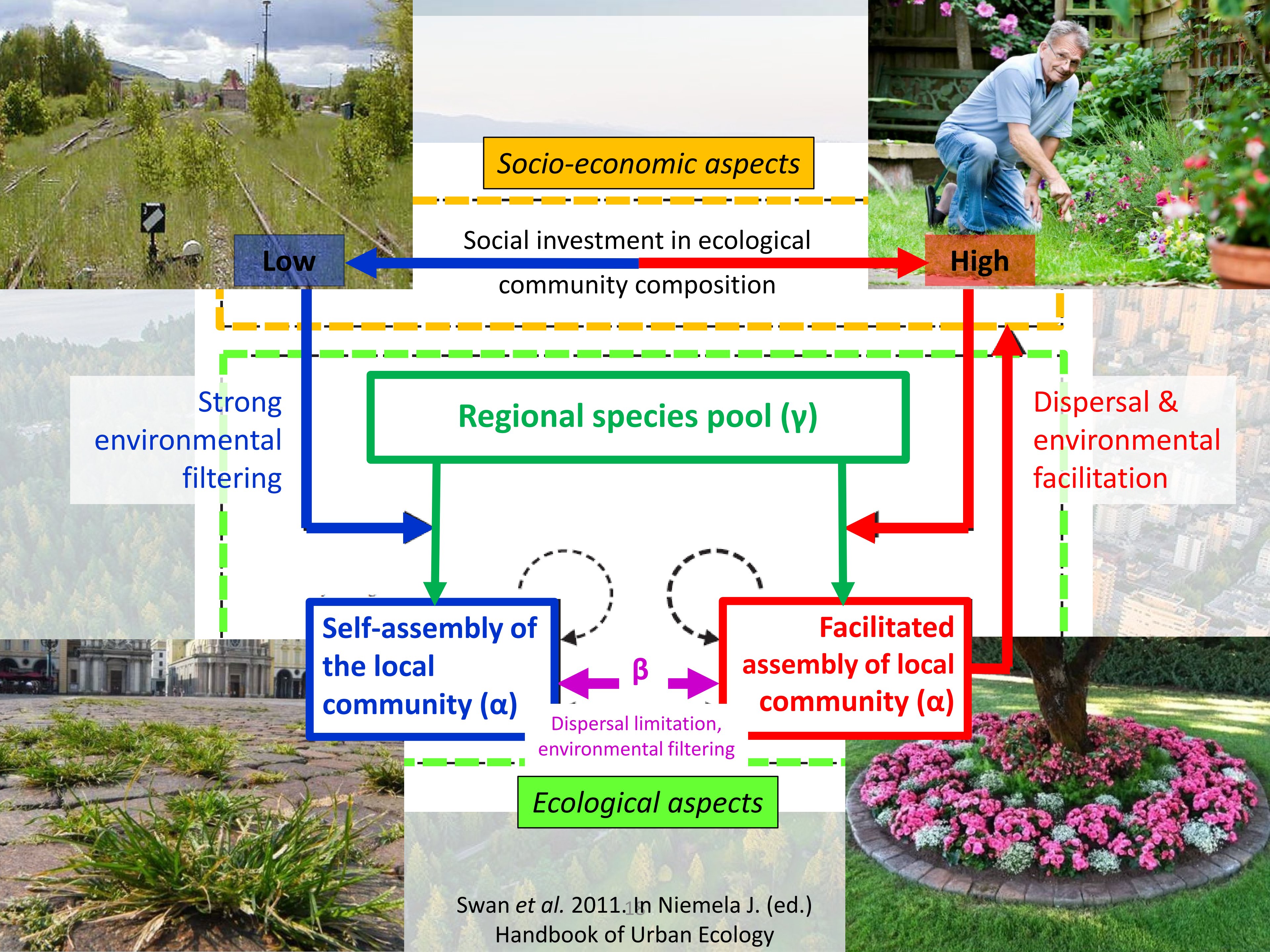


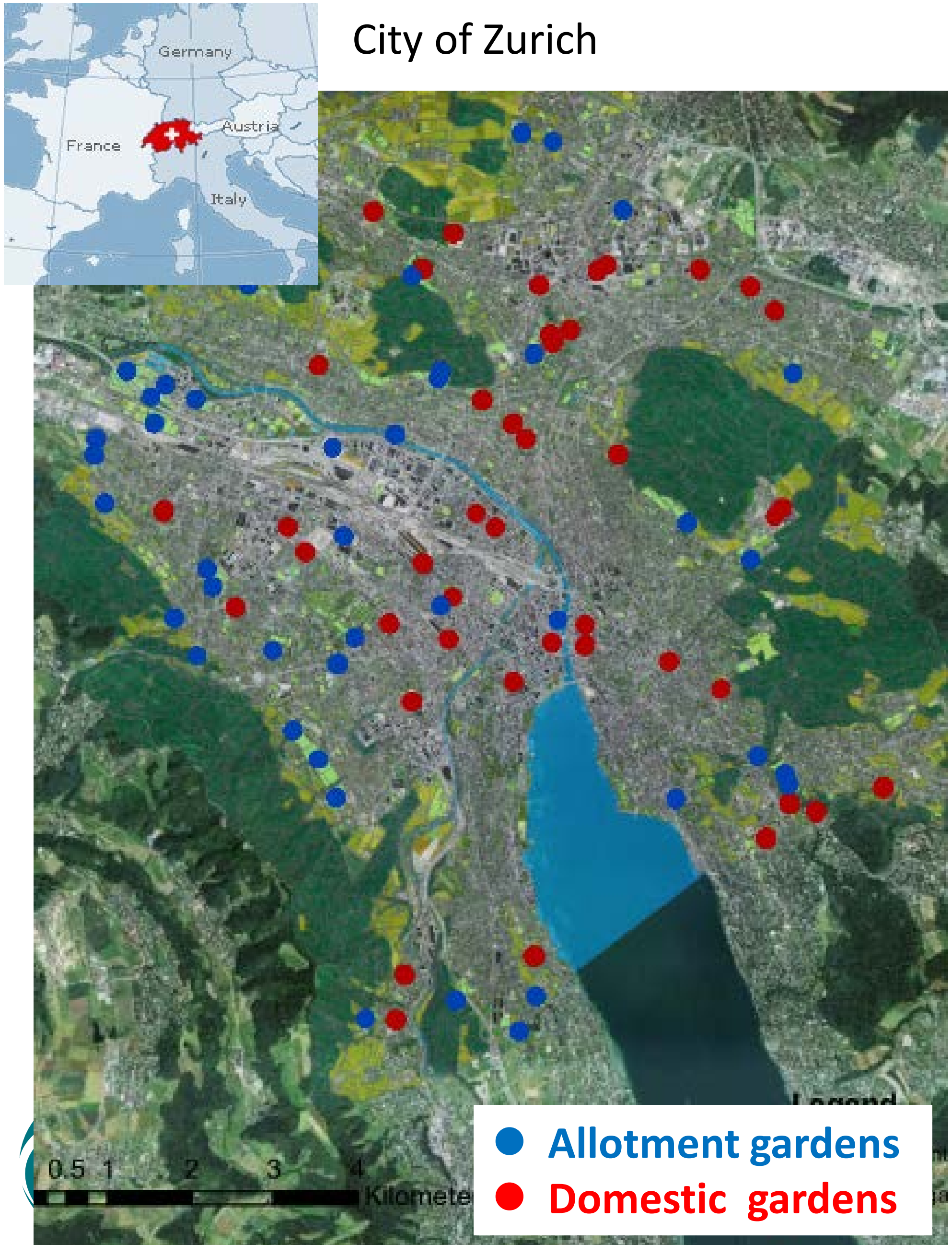
adapted from: Aronson *et al.* 2016. *Ecology*, **97**, 29523


Socio-economic aspects
Social investment in ecological community composition
Low
High
Strong environmental filtering
Regional species pool (γ)
Dispersal & environmental facilitation
Self-assembly of the local community (α)
β
Facilitated assembly of local community (α)
Dispersal limitation, environmental filtering
Ecological aspects
Swan et al. 2011. In Niemela J. (ed.) Handbook of Urban Ecology


www.bettergardens.ch
Pesticide
Policy and regulations?
Social norms, attitudes?
Perceived behavioral control?
What are the factors influencing gardeners' behavior?
Outcomes for gardeners
Outcomes for biodiversity
Outcomes for soil quality
WSL
FiBL
Restoration, well-being, social cohesion etc.
Species richness, pollination, pest-control etc.
Soil quality, physical and chemical properties etc.

Urban gardens as a model system

City of Zurich



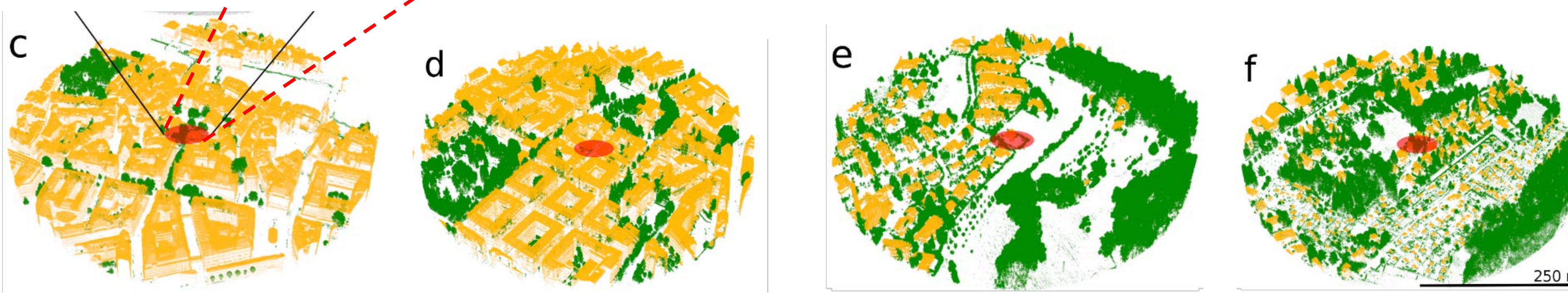
Domestic gardens (N=42)

Allotment gardens (N=43)

Local (garden) scale: high *vs.* low management intensity

Landscape scale: amount impervious area within 250 m radius

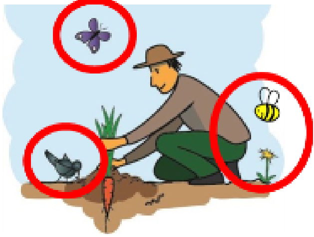
Laser scan data (LiDAR) as measure of the vertical woody structure
(St.Dev. of the laser reflection height)



Increasing amount of green within 250 m radius

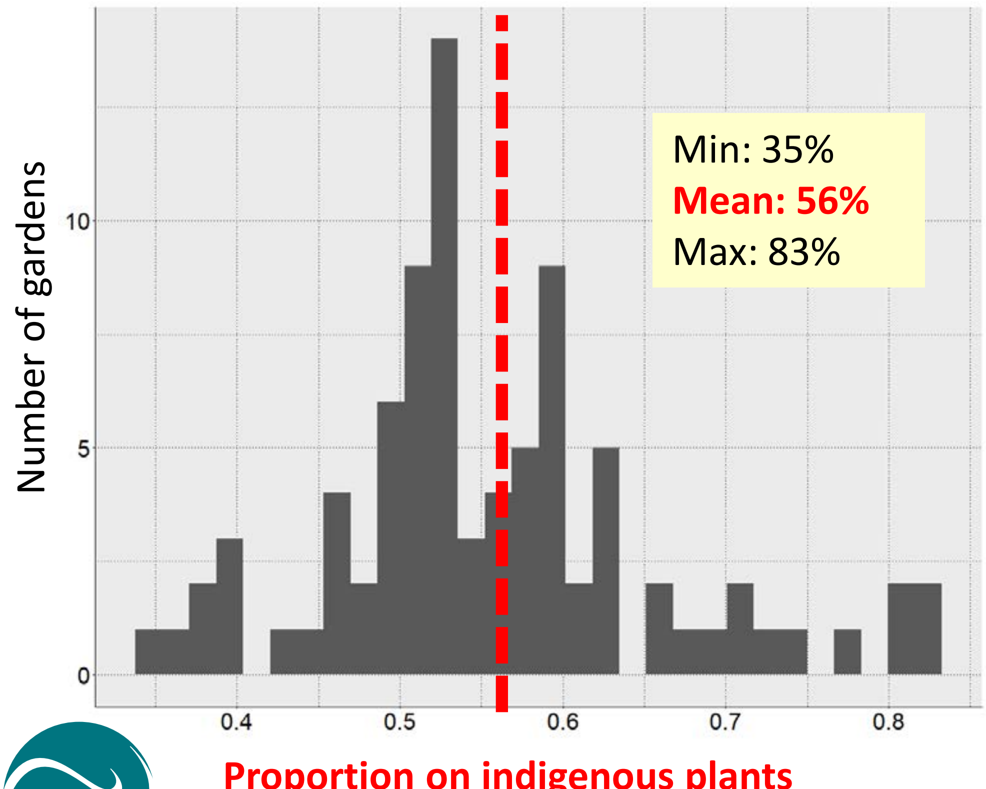
How much biodiversity did we find?

85 gardens (allotments + domestic gardens)



Plants (spontaneous & cultivated)

- ***N* species: ca. 1’100**
- Mean: 119
- Max: 204
- Min: 52



Viola elatior

Melampyrum arvense

Schoenoplectus mucronatus

Herniaria hirsuta

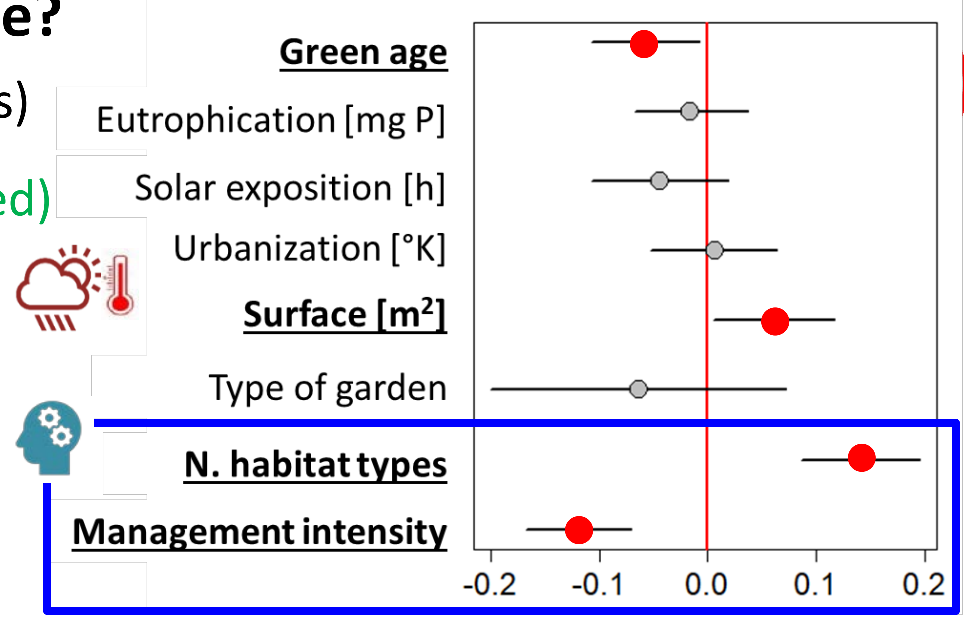
Frey 2019 *PhD thesis*

How much biodiversity is over there?

85 gardens (allotments + domestic gardens)

Plants (spontaneous & cultivated)

- ***N* species: ca. 1’100**
- Mean: 119
- Max: 204
- Min: 52

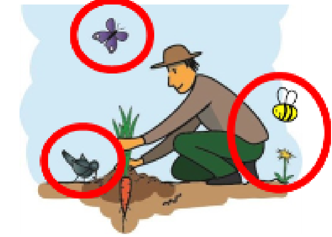


Regression coefficient
± 95% confidence interval

Frey 2019 *PhD thesis*

How much biodiversity is over there?

85 gardens (allotments + domestic gardens)

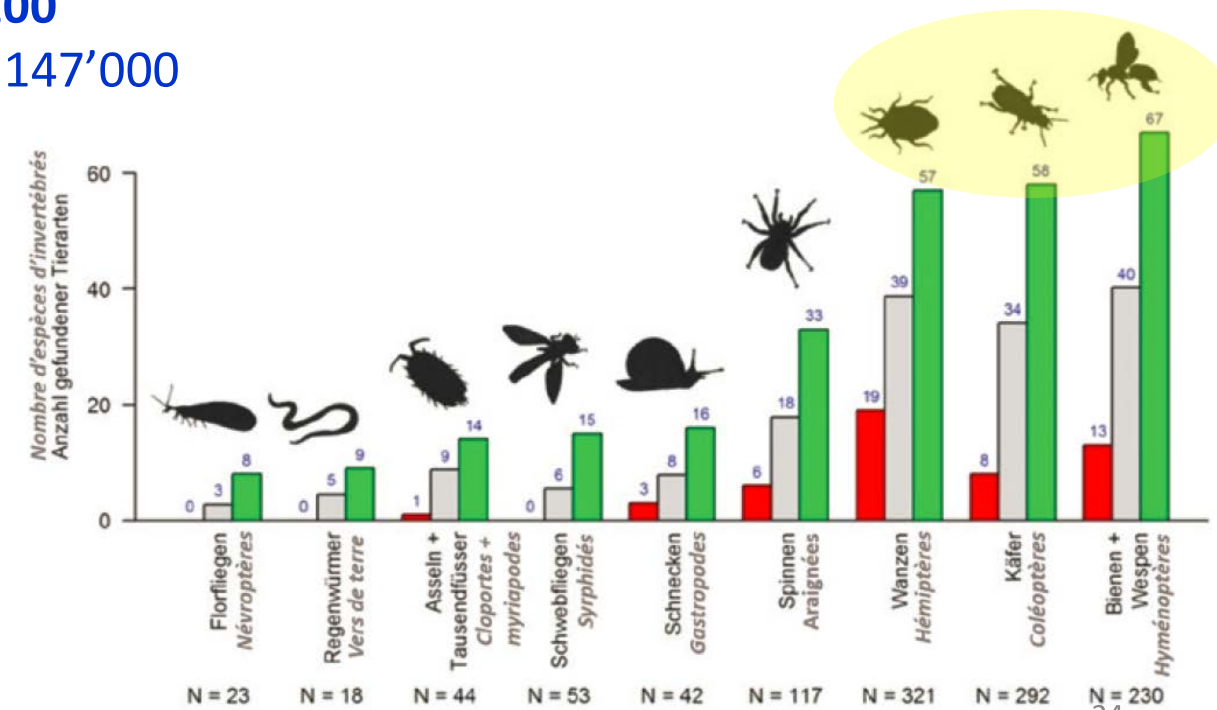


Plants (spontaneous & cultivated)

- ***N* species: ca. 1’100**
- Mean: 119
- Max: 204
- Min: 52

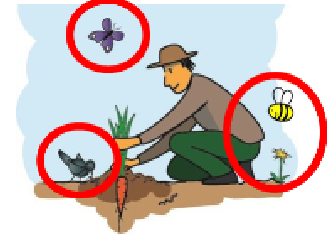
Invertebrates (13 weeks)

- ***N* species: ca. 1’200**
- *N* individuals: ca. 147’000
- Mean: 142
- Max: 201
- Min: 53



Frey 2019 *PhD thesis*

How much biodiversity is over there?



85 gardens (allotments + domestic gardens)

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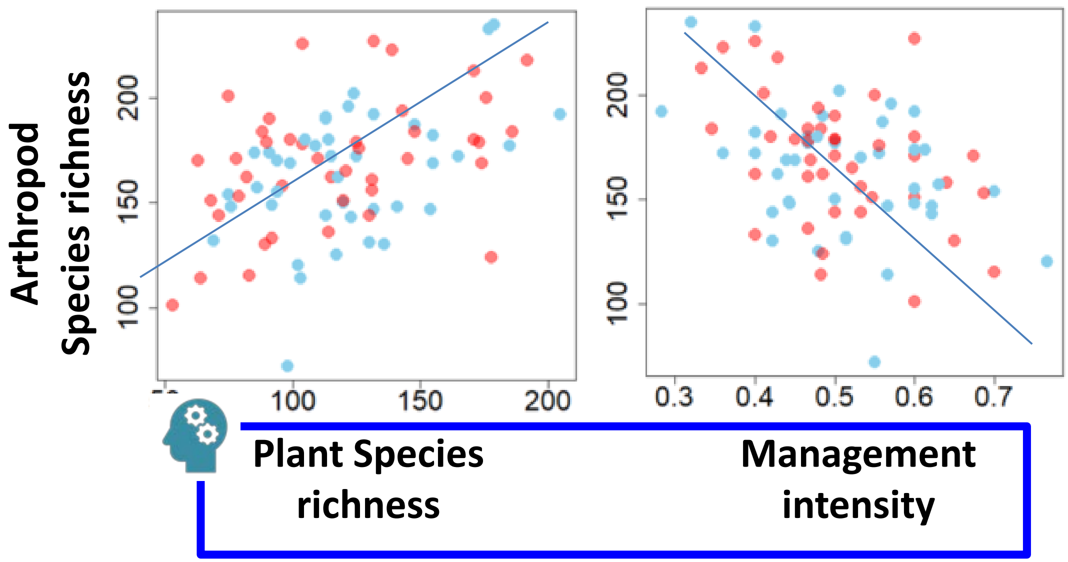
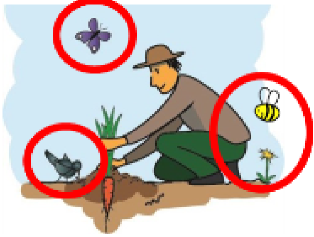
Invertebrates (13 weeks)
- ***N* species: ca. 1’200**
- *N* individuals: ca. 147’00
- Mean: 142
- Max: 201
- Min: 53

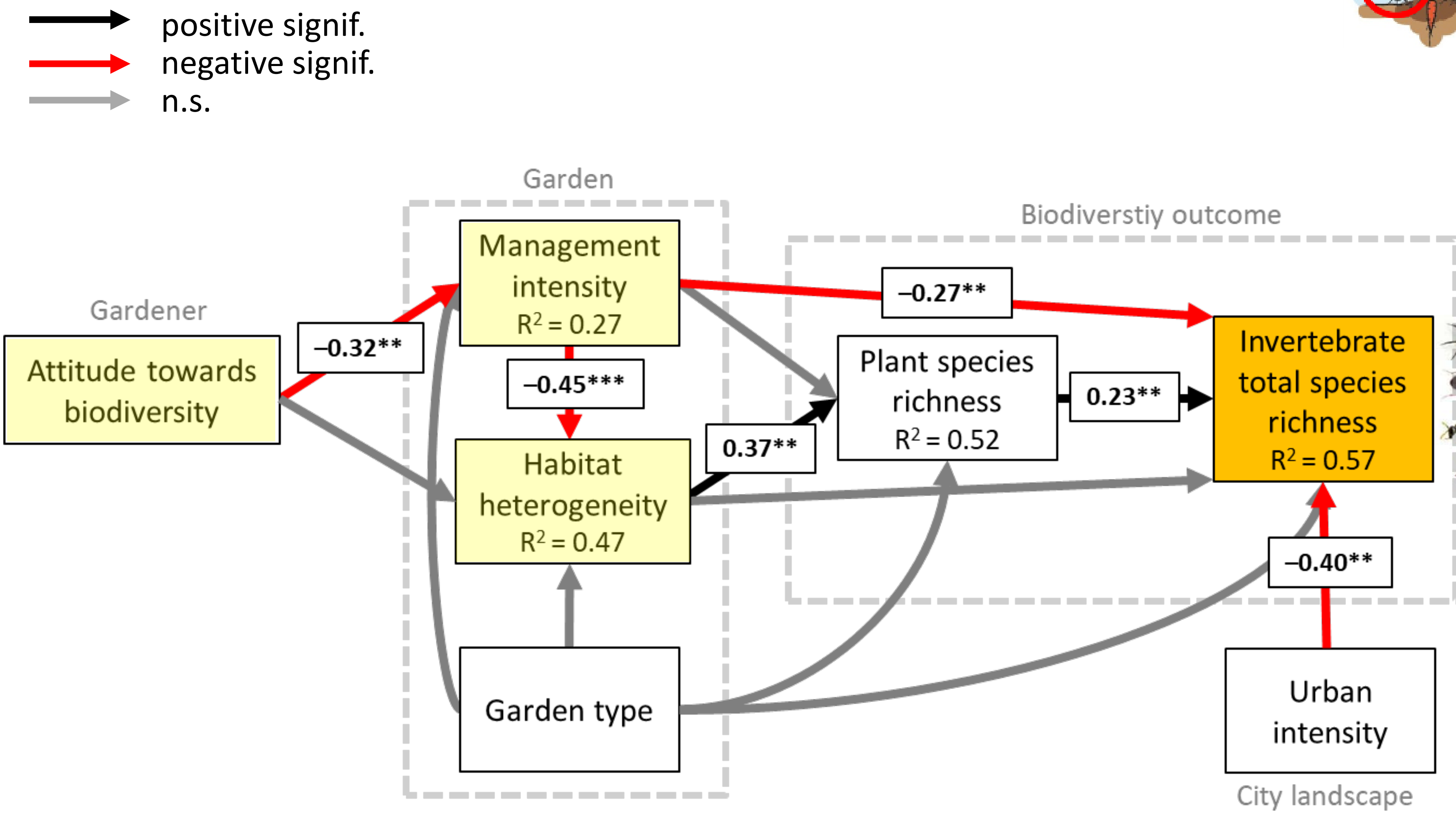
Domestic gardens *vs* Allotments



Frey 2019 *PhD thesis*

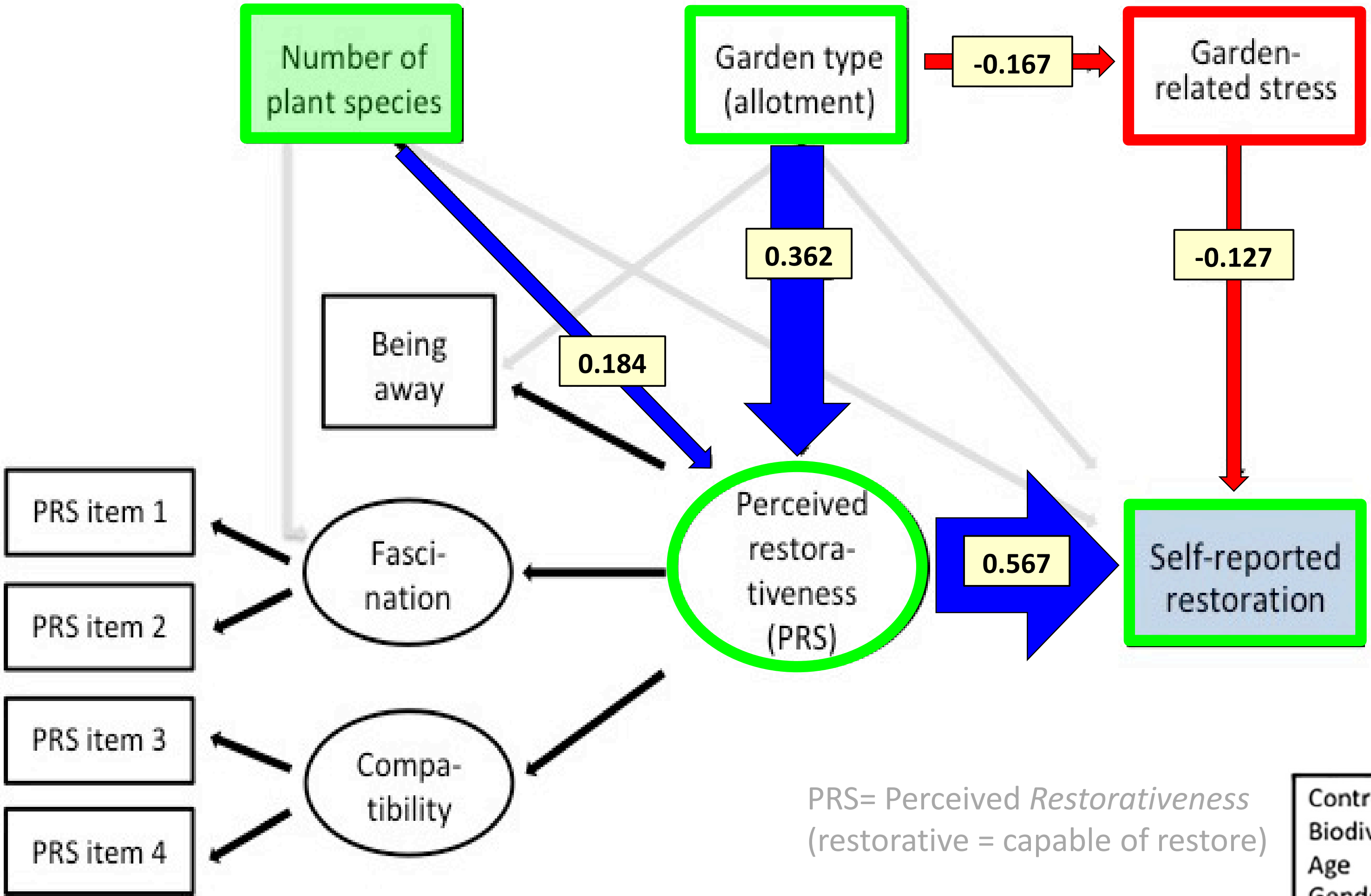
Do human factors influence the number of invertebrate species and how?





Frey 2019 *PhD thesis*

But why people care about biodiversity in garden?



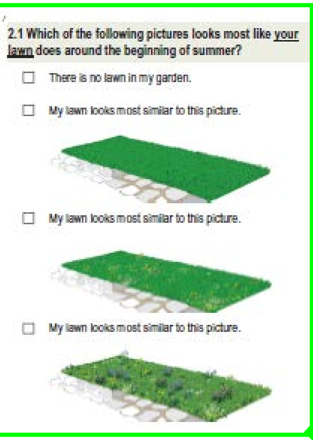
PRS= Perceived *Restorativeness*
(restorative = capable of restore)

Control variables:
Biodiversity preference
Age
Gender
Employment status
Job status

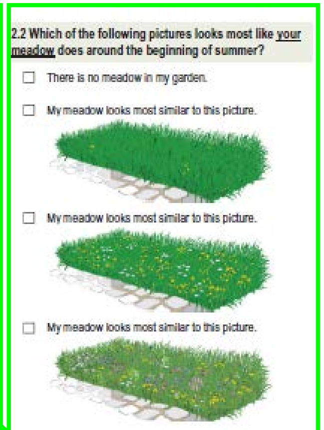
Young *et al.* 2020 *Land Urb Plan*, **198**, 103777

Since biodiversity is important to people, can people quantified it?

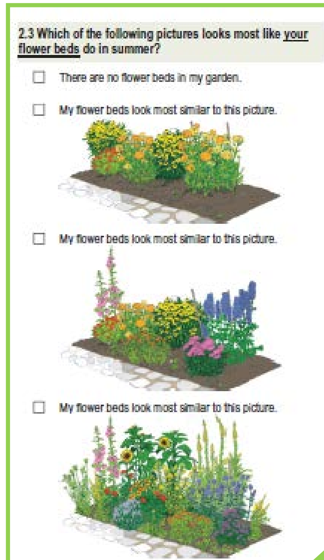
Lawn



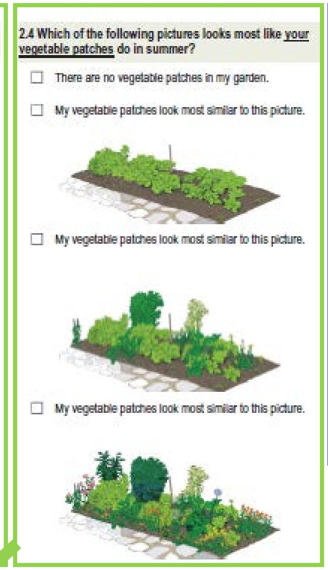
Meadow



Flower bed



Vegetable bed



Structure item

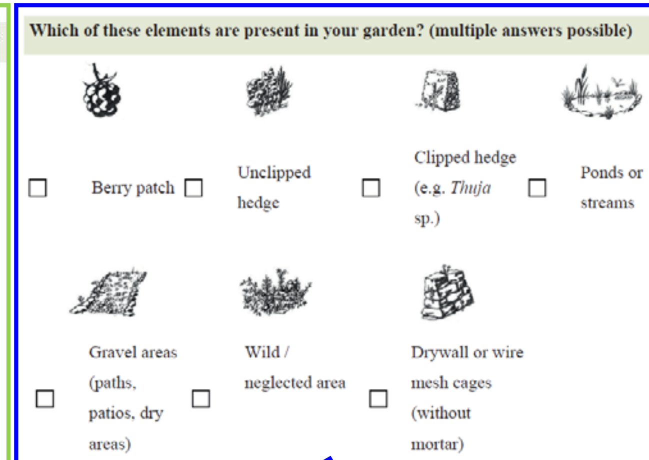


Table 1
Multiple linear regressions models with the two (standardized) additive index variables from the visual survey questions as explanatory variables and actual plant species richness (of all, native, cultivated and spontaneous plants) as dependent variable. The explanatory variables are garden-owner reported plant species richness and (mainly) garden-owner reported habitat heterogeneity. N = [illegible] urban gardens. SE: Standard error.

Dependent variable of each model	Intercept		Reported plant species richness		Reported habitat heterogeneity		Explained variance (Adjusted R^2)
	β_1	SE	β_2	SE	β_3	SE	R^2
Model 1: All plants	4.74***	0.02	0.08***	0.02	0.17***	0.02	0.50
Model 2: Native plants	4.14***	0.03	0.08**	0.03	0.18***	0.03	0.46
Model 3: Cultivated plants	4.28***	0.04	0.12**	0.04	0.23***	0.04	0.42
[illegible] aneous plants	3.67***	0.03	−0.00^{NS}	0.03	0.12***	0.03	0.15

NS = not significant.
** $P < 0.01$.
*** $P < 0.001$.

Young *et al.* 2019 *Land Urb Plan* **185**, 222

What type of green do people prefer?

www.biodiverCity.ch

What type of green do people prefer?

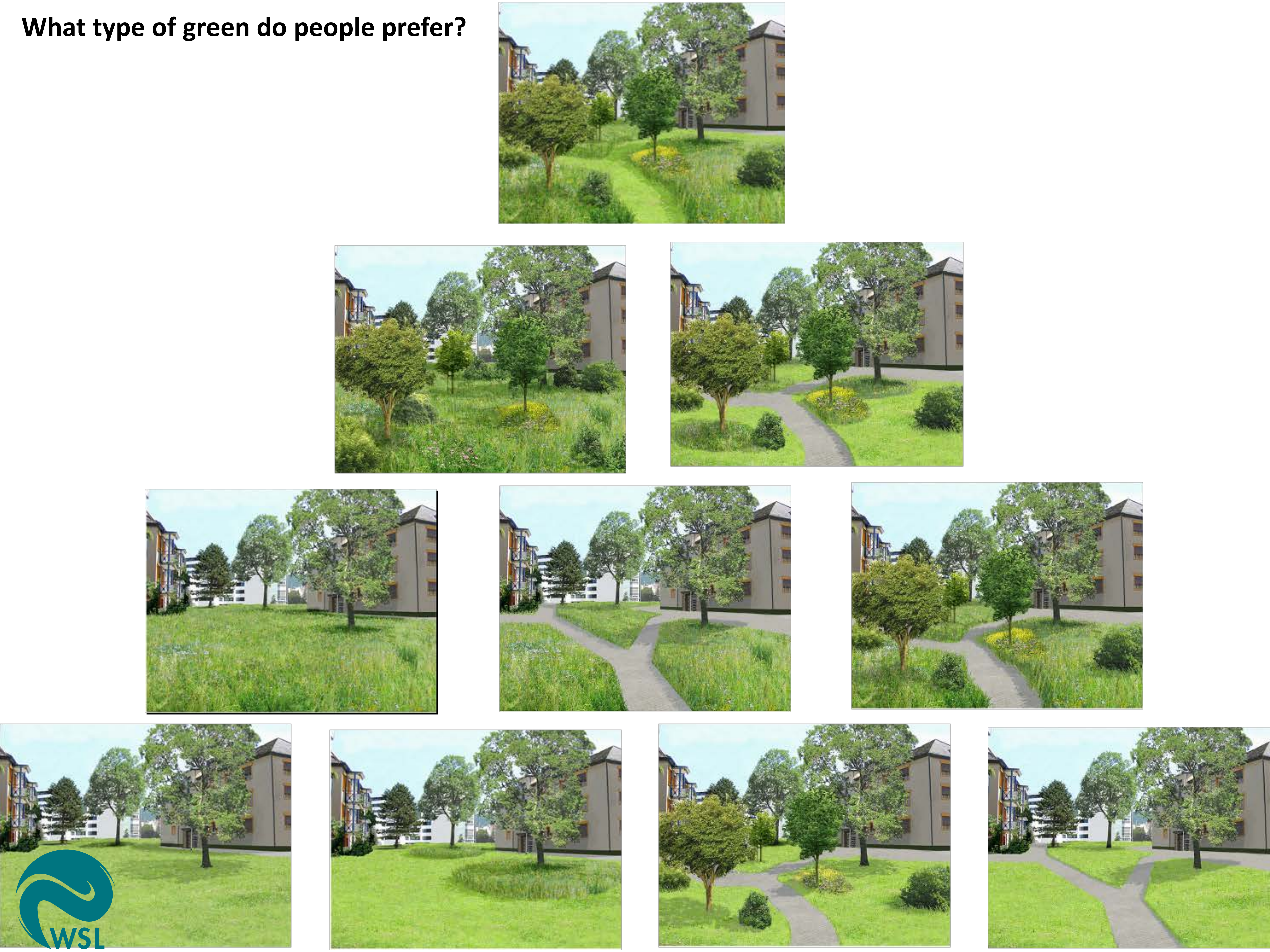
www.biodiverCity.ch

What type of green do people prefer?

www.biodiverCity.ch

What type of green do people prefer?

What type of green do people prefer?



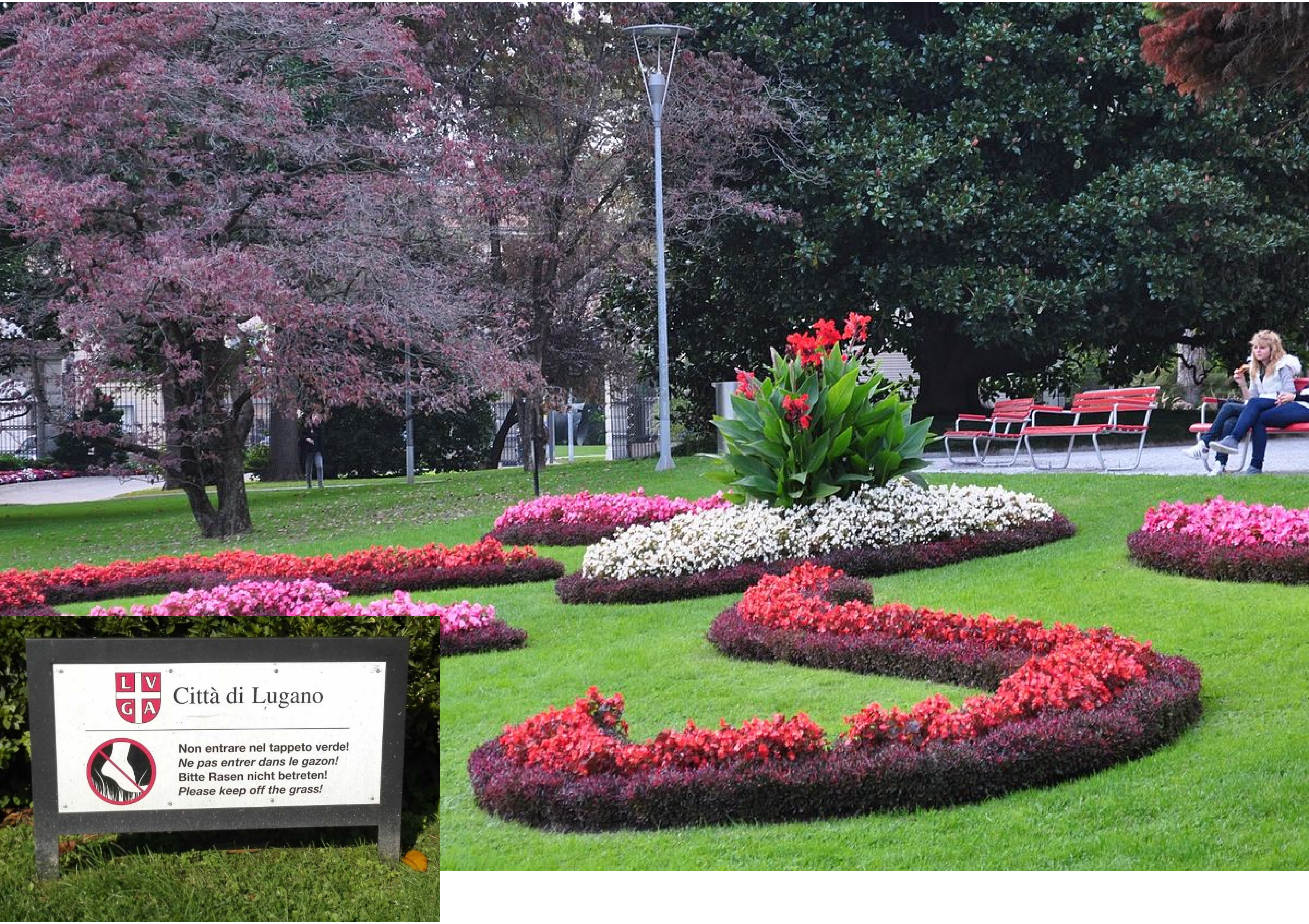
What type of green do people prefer?

Most preferred

WSL

What type of green do people prefer?

What type of green do people prefer?



What type of green do people prefer?



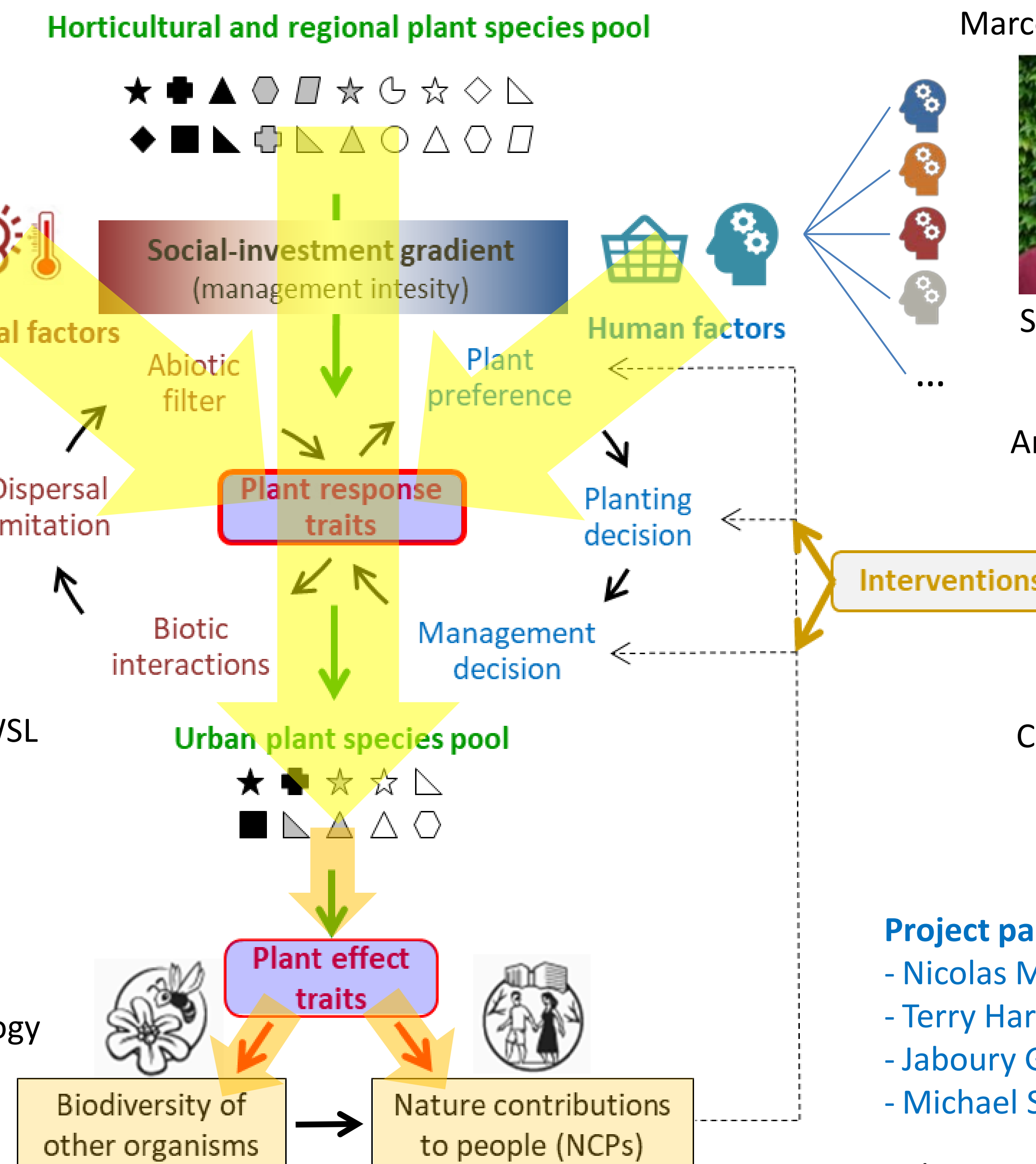

WSL

Plants and People in Urban Systems [PAPPUS]

"How human and biophysical factors jointly shape biodiversity and nature's contributions to people in cities"

Bertrand Founier
Univ. Potsdam, D

Landscape ecology and modelling



Marcel Hunziker, WSL

Social science

Angela Bearth, ETHZ

Consumer behaviour

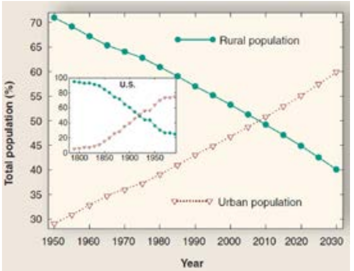
Marco Moretti, WSL

Community ecology

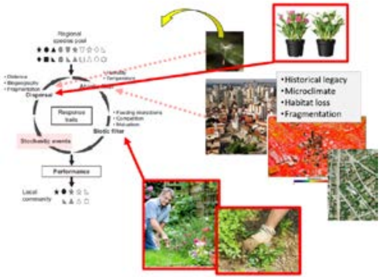
Project partners
- Nicolas Mouquet, CNRS, F
- Terry Hartig, Uni Uppsala, S
- Jaboury Ghazoul, ETH Zurich
- Michael Siegrist , ETH Zurich

Moretti *et al., Sinergia project*, in prep.

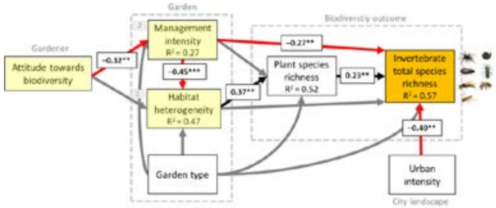
What have we learned?



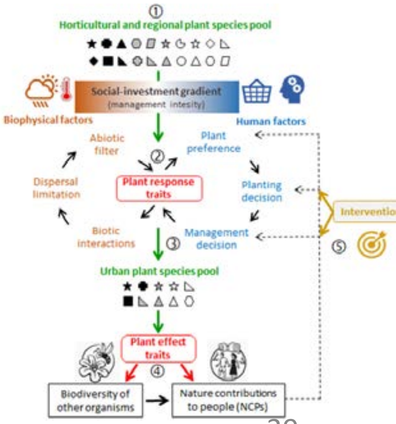
1) **Urbanization is growing at an unprecedented rate.**
We need to understand how urbanization affect biodiversity and integrate it into biodiversity conservation strategies



2) **Integrating social-ecological aspects** will allow us to improve our understanding of urban biodiversity



3) **Human factors play a primary role in the assembly of species** and effects on urban ecosystem functioning



4) **The use of integrated approaches based on functional traits** sensitive to biophysical and human factors can lead us toward a more predictive urban ecology