AgriWeedClim

Emerging agricultural weeds under climate and land-use changes in Central Europe: identifying high-risk species, modelling their distribution, assessing impacts and management need

AgriWeedClim
weeds under climate and land use change

universität wien

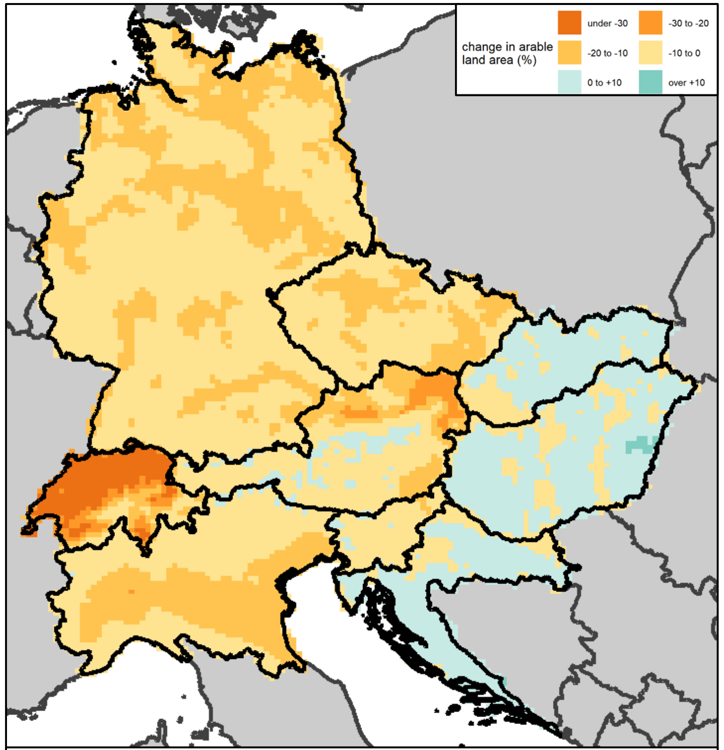
AGES

MUNI

Agriculture has changed

➔ land use change

- net decrease
- new/different crops and cultivars



Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2011) 20, 73–86

RESEARCH PAPER

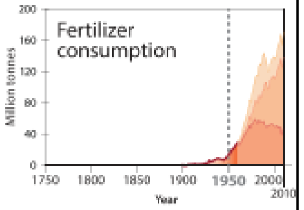
The HYDE 3.1 spatially explicit database of human-induced global land-use change over the past 12,000 years

Kees Klein Goldewijk*, Arthur Beusen, Gerard van Drecht and Martine de Vos

➔ land use intensification

mechanization

synthetic fertilizers

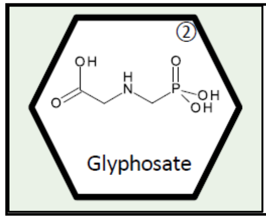


THE ANTHROPOCENE REVIEW

Review

The trajectory of the Anthropocene: The Great Acceleration

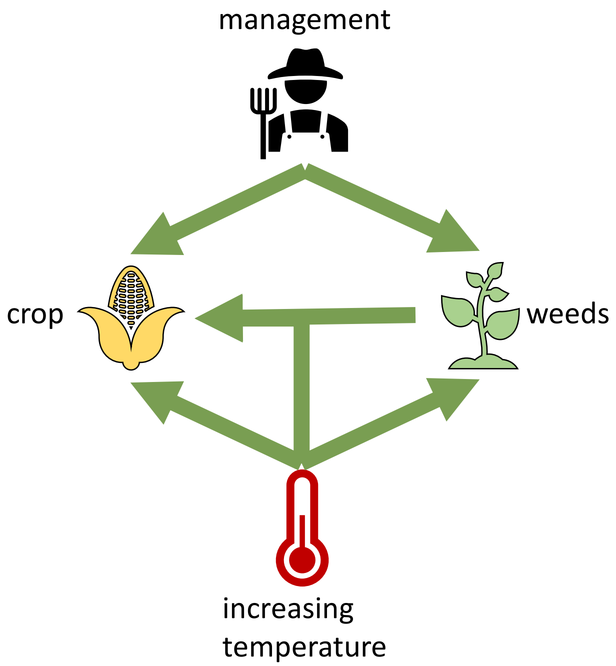
The Anthropocene Review
2015, Vol. 2(1) 81–98
© The Author(s) 2015
Reprints and permissions: sagepub.co.uk/journalsPermissions.nav
DOI: 10.1177/2053019614564785
anr.sagepub.com
SAGE

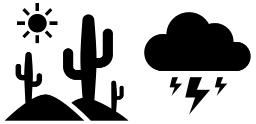


herbicides

+ climate change

potential influences on all aspects of agriculture, crop and weed management





+ extreme events?

Weeds

= *vascular plants, that occur in agricultural fields and that may cause substantial yield losses, disease transmission and human health impacts.*

"emerging weeds" = species that are spreading or newly introduced and haven't reached their full potential impact (yet)

reasons for emergence: climate and land use change, biological invasions, herbicide resistance etc.

Journal of Agricultural Science (2006), **144**, 31–43. © 2005 Cambridge University Press 31
doi:10.1017/S0021859605005708 *Printed in the United Kingdom*

CENTENARY REVIEW

Crop losses to pests

E.-C. OERKE

Institute for Plant Diseases, Rheinische Friedrich-Wilhelms-Universitaet Bonn, Nussallee 9, D-53315 Bonn, Germany

(*Revised MS received 9 August 2005*)

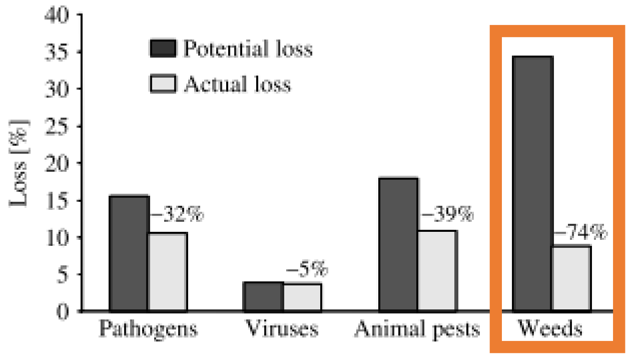
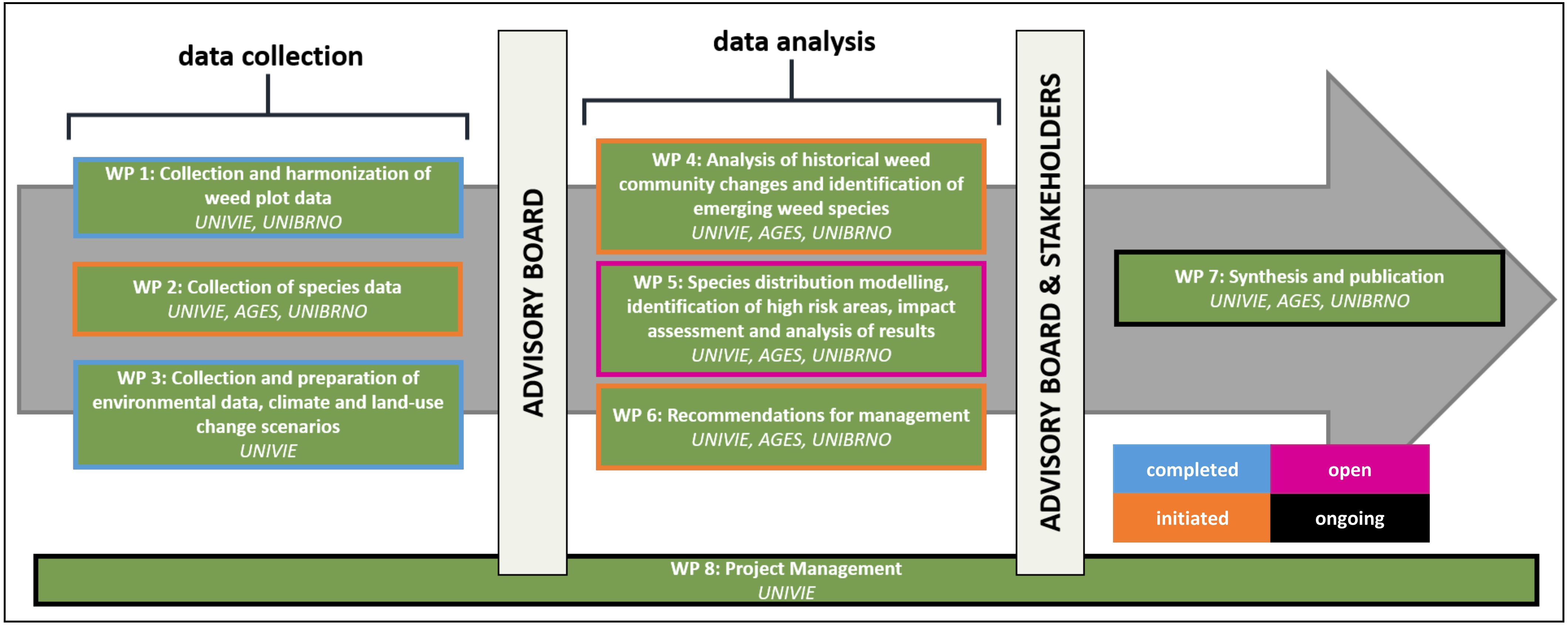


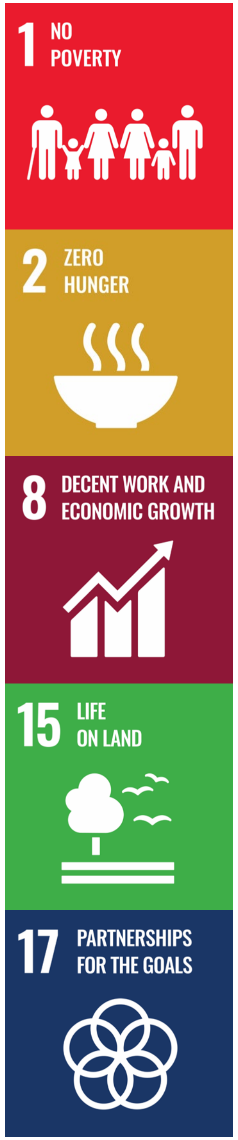
Fig. 7. Average efficacy of pest control practices worldwide in reducing loss potential of pathogens, viruses, animal pests, and weeds, respectively (reduction rates calculated from estimates of monetary production losses in barley, cottonseed, maize, oilseed rape, potatoes, rice, soybean, cotton, sugar beet, tomatoes and wheat, in 2001–03).

weeds are the **only** pest group that is **managed preemptively**

AgriWeedClim

I. Analysis of changes in Central European Weed flora and their drivers.
II. Identification of the Top 20 emerging weed species.
III. Predicting their future range and agricultural impact.
IV. Deriving methods for monitoring and management.
V. Combining this information in an "Emerging Weeds Management Toolkit".



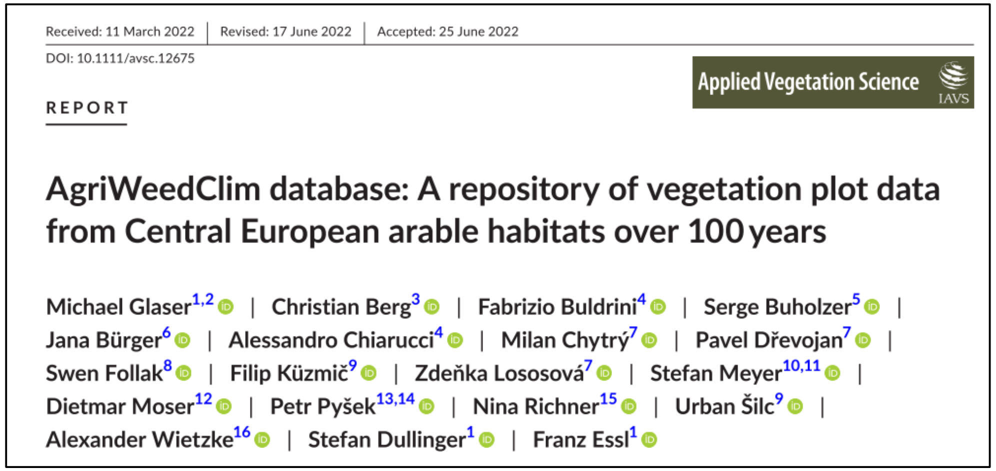


Results I – AgriWeedClim database

- European Vegetation Archive (EVA)
- other repositories
- individual dataholders
- digitization
- inclusion of agroscience plots

challenges:

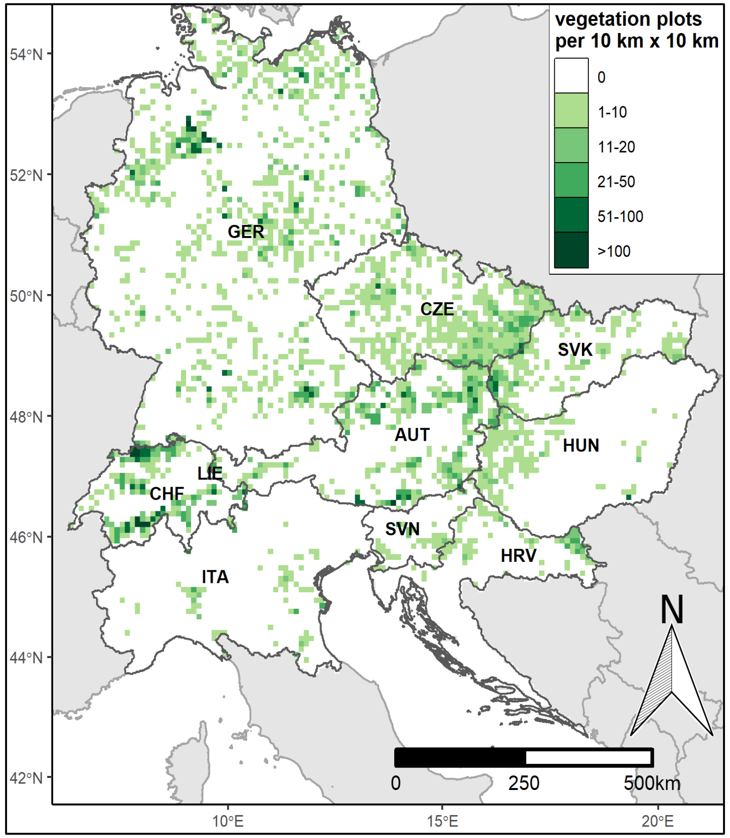
- EVA filtering
- crop identification
- management documentation
- poor availability of data

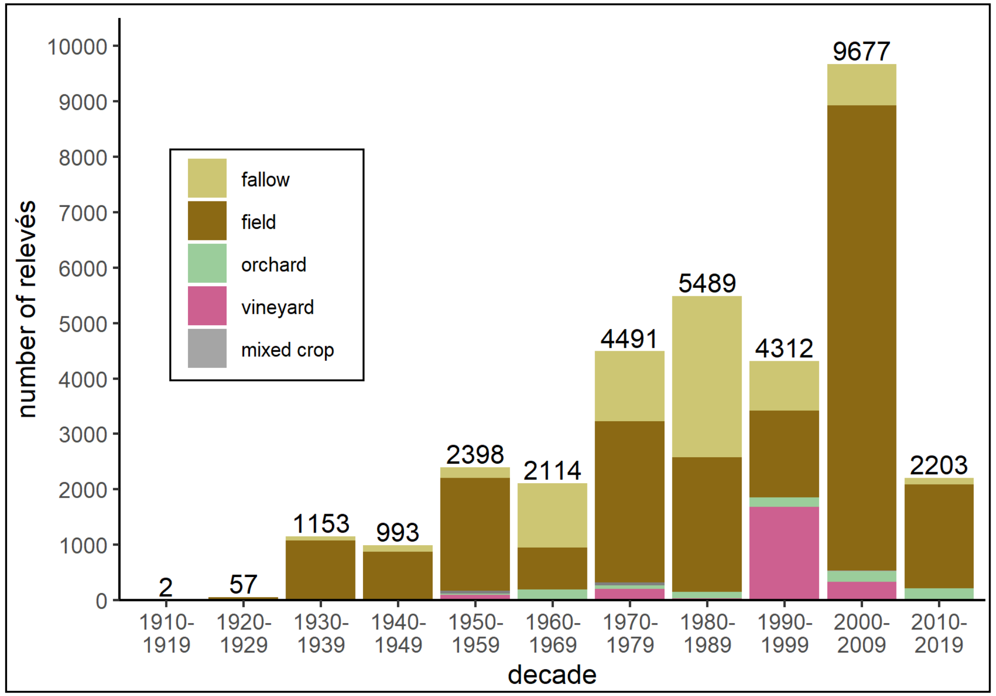


Received: 11 March 2022 | Revised: 17 June 2022 | Accepted: 25 June 2022
DOI: 10.1111/avsc.12675
Applied Vegetation Science IAVS
REPORT

AgriWeedClim database: A repository of vegetation plot data from Central European arable habitats over 100 years

Michael Glaser[1,2] | Christian Berg[3] | Fabrizio Buldrini[4] | Serge Buholzer[5] | Jana Bürger[6] | Alessandro Chiarucci[4] | Milan Chytrý[7] | Pavel Dřevojan[7] | Swen Follak[8] | Filip Küzmič[9] | Zdeňka Lososová[7] | Stefan Meyer[10,11] | Dietmar Moser[12] | Petr Pyšek[13,14] | Nina Richner[15] | Urban Šilc[9] | Alexander Wietzke[16] | Stefan Dullinger[1] | Franz Essl[1]

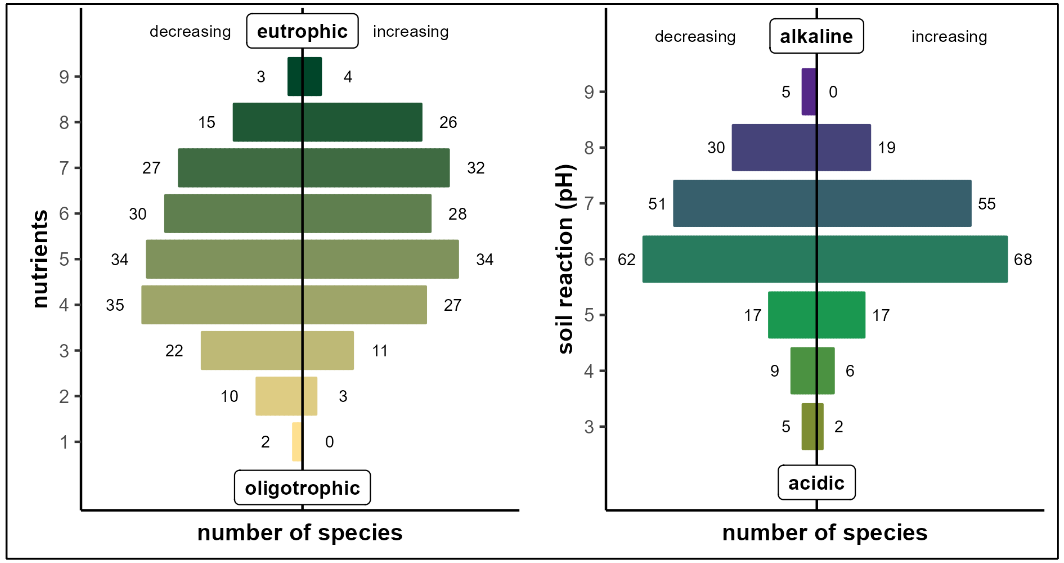


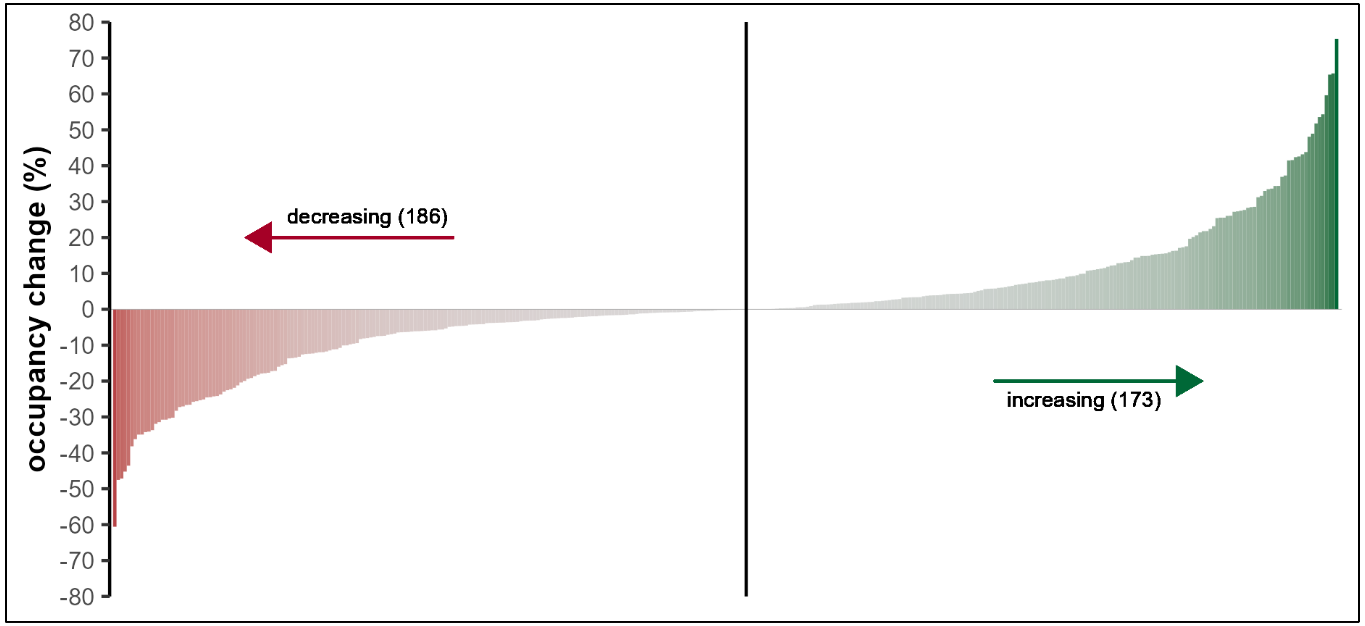


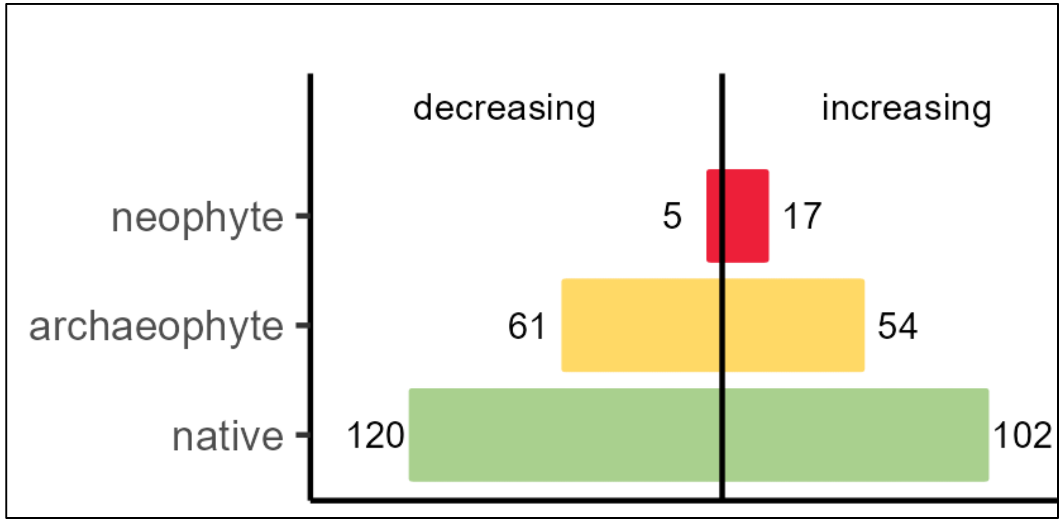
Results II – biodiversity turnover

➔ changes (1930s – 2010s) in range size of 359 most common vascular plant species in fields using the AgriWeedClim database
significant increases in:

- nutrient-preferring
- intermediate pH preferring
- neophyte species





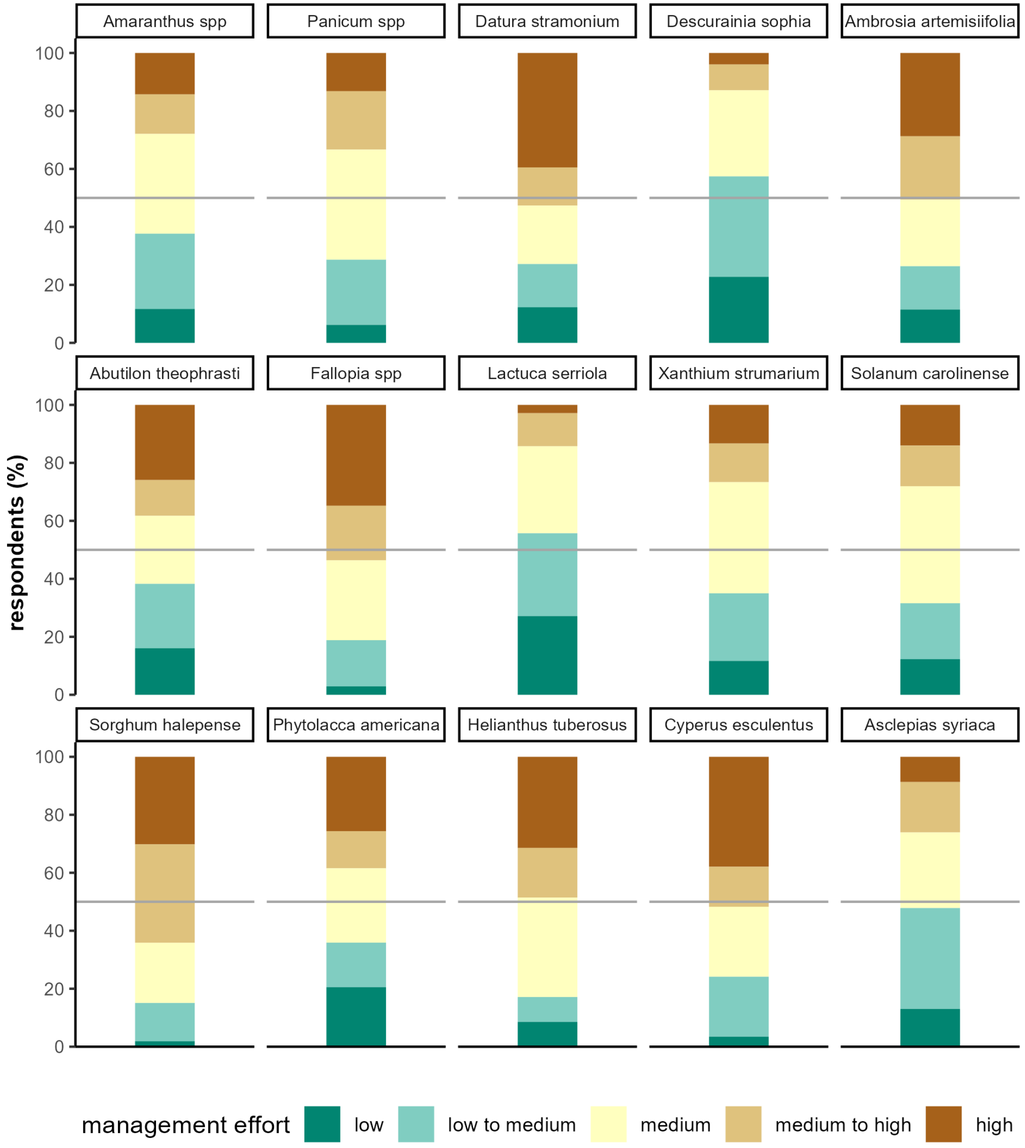


Results III – farm survey

farmers = primary decision-makers on the ground and witness changes in the weed flora early-on

- online survey (from Jan to Apr 2022)
- 181 Austrian farmers
- 15 pre-selected emerging weed species

Does this species occur on your land? If yes, how high is its management effort?



Results IV – emerging weeds

- long list of ca. 200 candidate species compiled in first version
  - biodiversity analysis
  - literature review
- requires (further) editing and standardization

Dissemination of results

Scientific

peer- reviewed publications
- data report on AgriWeedClim database
- biodiversity trends (submitted)
- farm survey (submitted)

presentations
- Neobiota conference 2019 (poster)
- EWRS symposium 2022 (talk)
- Neobiota conference 2022 (talk)
- Masaryk university seminar (talk)

Stakeholder

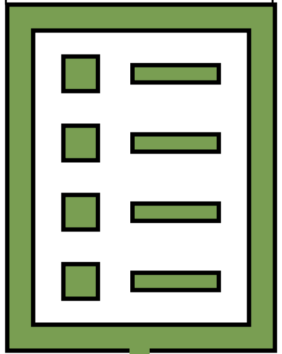
publications
- Der Pflanzenarzt
- Ackerbauprofi

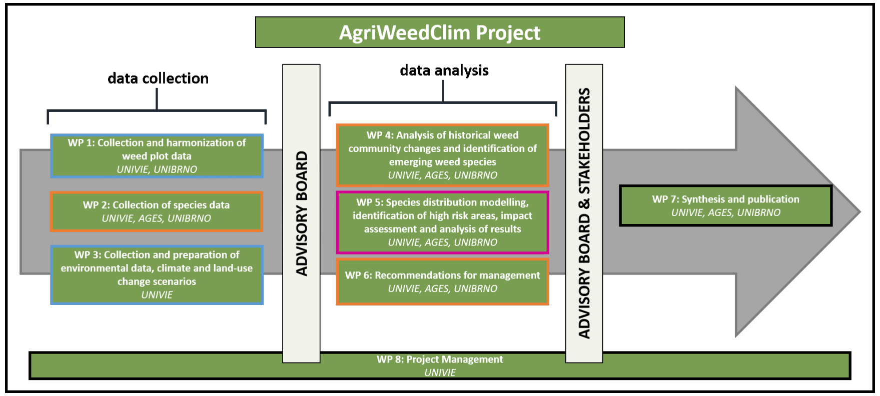
meetings, workshops etc
- Österreichische Pflanzenschutztage 2022

further stakeholder-relevant activities to be carried out in 2023, including workshops led by project partner AGES

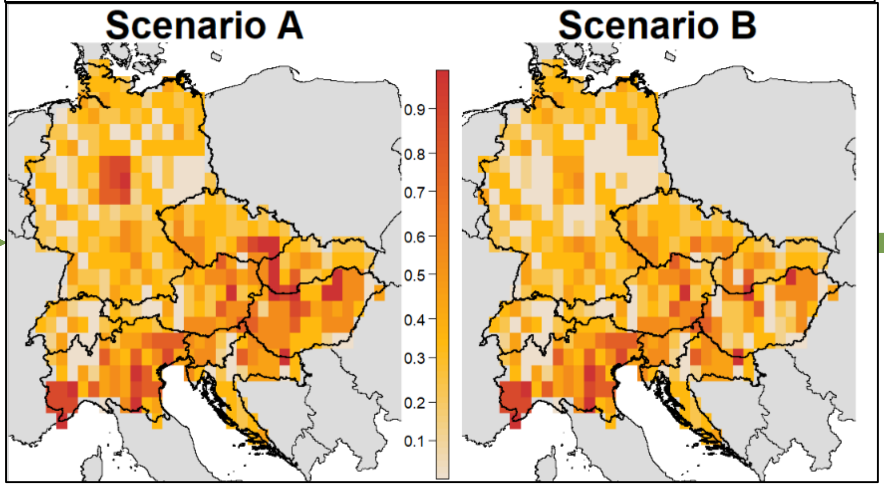
Outlook

Top 20





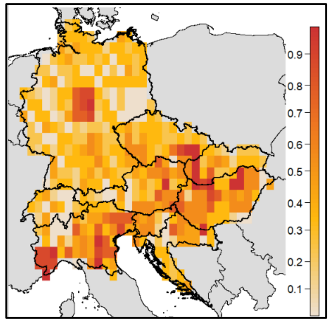
combined risk maps



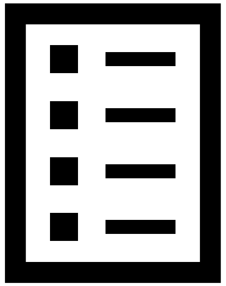
D. stramonium Management Toolkit

identification key

current distribution



future distribution



management methods

Thank you for your attention!

- Franz Essl, Stefan Dullinger
- Swen Follak, Zdeňka Lososová
- Christan Berg, Jana Bürger, Filip Küzmic, Urban Šilc, Siegrid Steinkellner
- Serge Buholzer, Fabrizio Buldrini, Alessandro Chiarucci, Milan Chytrý, Stefan Meyer, Alexander Wietzke, Irena Axmanova, Ilona Knollova, Pavel Dřevojan
- Andreas Gattringer, Bernhard Hülber, Dietmar Moser, Johannes Wessely

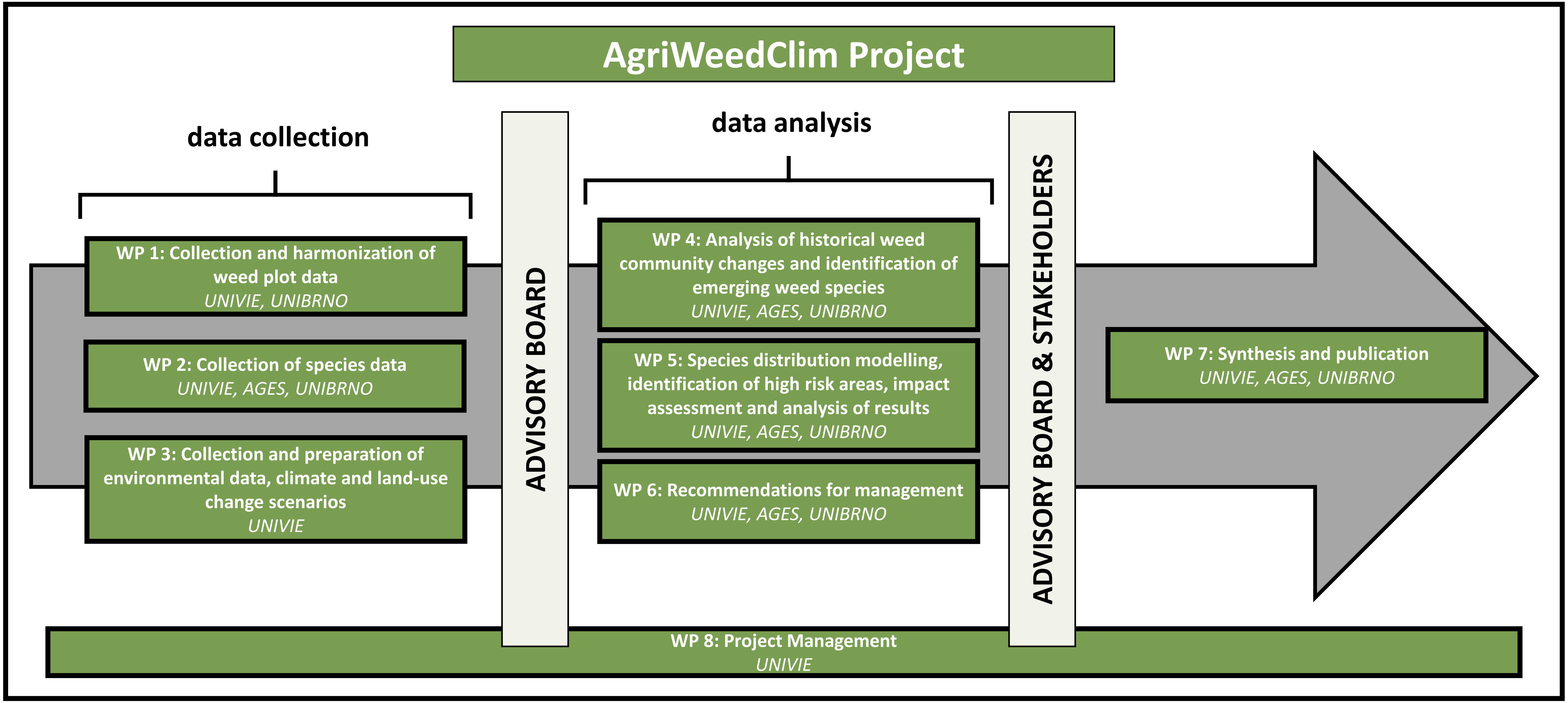
Slide Storage

Introduction

A brief "what's what" in the world of weeds

Ask questions any time!

What brings me here?



species labelled „weeds“ because:

- impact
- habitat
- mixed definitions

A: Depends ;-)

My definition

weeds = species of vascular plants growing in arable habitats that cause

"substantial"* damage to crops and/or livestock and/or humans

*enough to warrant intervention(s)

arable habitats = fields, vineyards, orchards and their fallows

sleeper weeds = weeds that appear harmless

emerging weeds = weeds showing a tendency towards spread

Are some weeds sleeping? Some concepts and reasons
Euphytica 2006 148: 111-120

R.H. Groves
CSIRO Plant Industry & CRC for Australian Weed Management, GPO Box 1600, Canberra, ACT 2601, Australia (e-mail: richard.groves@csiro.au)

Why study weeds?

THE EVOLUTION OF WEEDS

Ann. Rev. of Ecology and Systematics 1974

Herbert G. Baker

Botany Department, University of California, Berkeley, California 94720

Trends in Plant Science 2020 25 (11)

CellPress REVIEWS

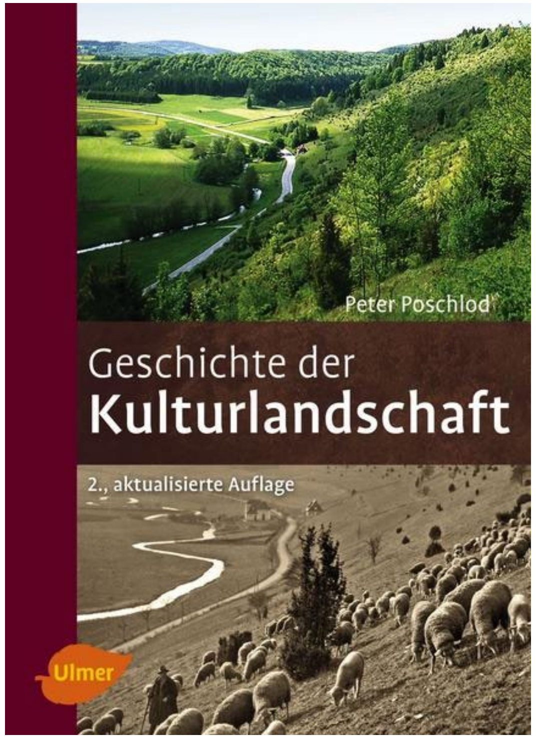
Review

Weeds: Against the Rules?

Lucie Mahaut,[1,*] Pierre-Olivier Cheptou,[1] Guillaume Fried,[2] François Munoz,[3] Jonathan Storkey,[4] François Vasseur,[1,5] Cyrille Violle,[1] and François Bretagnolle[6]

- weeds are highly **adaptable**
- weeds have **resisted** targeted eradication campaigns
- weeds **laugh at some basic principles of ecology and evolution**
  - rapid evolution
  - "chaotic" community assembly

Q: What has changed in agriculture?



BOTANY LETTERS
2019, VOL. 166, NO. 3, 356–365
https://doi.org/10.1080/23818107.2019.1638829

Taylor & Francis
Taylor & Francis Group

local

ARTICLE

Check for updates

Shifts of arable plant communities after agricultural intensification: a floristic and ecological diachronic analysis in maize fields of Latium (central Italy)

Emanuele Fanfarillo[a], Andrzej Kasperski[b], Alessandro Giuliani[c] and Giovanna Abbate[a]

[a]Department of Environmental Biology, "Sapienza" University of Rome, Rome, Italy; [b]Faculty of Biological Sciences, Department of Biotechnology, University of Zielona Góra, Zielona Góra, Poland; [c]Department of Environment and Health, Istituto Superiore di Sanità (ISS), Rome, Italy

meta-analysis

European Journal of Agronomy 13 (2000) 85–100

European Journal of Agronomy

www.elsevier.com/locate/eja

Changes in agriculture and land use in Europe

R. Rabbinge [a,*], C.A. van Diepen [b]

[a] Group Plant Production Systems, Laboratory for Theoretical Production Ecology, Wageningen University, P.O. Box 430, 6700 AK, Wageningen, The Netherlands
[b] Alterra, Wageningen University and Research Centre, P.O. Box 125, 6700 AA, Wageningen, The Netherlands

Received 19 February 1999; received in revised form 1 September 1999; accepted 14 March 2000

meta- analysis

ENVIRONMENTAL RESEARCH LETTERS

LETTER

OPEN ACCESS

RECEIVED
18 May 2020

REVISED
2 January 2021

Understanding the combined impacts of weeds and climate change on crops

Montserrat Vilà[1,2,*], Evelyn M Beaury[3], Dana M Blumenthal[4], Bethany A Bradley[3,5], Regan Early[6], Brittany B Laginhas[3], Alejandro Trillo[1], Jeffrey S Dukes[7], Cascade J B Sorte[8] and Inés Ibáñez[9]

A: What hasn't?

crops grown for profit

Changes during the 20th century in species composition of synanthropic vegetation in Moravia (Czech Republic)

Změny ve složení synantropní vegetace na Moravě v průběhu 20. století

local

Zdeňka Lososová[1,2] & Deana Simonová[1]

[1]*Department of Botany and Zoology, Faculty of Science, Masaryk University, Kotlářská 2, CZ-611 37 Brno, Czech Republic, e-mail: deanas@seznam.cz;* [2]*Department of Biology, Faculty of Education, Masaryk University, Poříčí 7, CZ-603 00 Brno, Czech Republic, e-mail: lososova@ped.muni.cz*

The impact of agricultural intensification and land-use change on the European arable flora

J. Storkey[1,*], S. Meyer[2], K. S. Still[3] and C. Leuschner[2]

[1]*Department of Plant and Invertebrate Ecology, Rothamsted Research, Harpenden, Herts AL5 2JQ, UK*
[2]*Albrecht-von-Haller Institute for Plant Sciences, Department of Plant Ecology and Ecosystem Research, University of Göttingen, Untere Karspüle 2, 37073 Göttingen, Germany*
[3]*Plantlife, 14 Rollestone Street, Salisbury, Wiltshire SP1 1DX, UK*

Red Lists

WEED RESEARCH
An International Journal of Weed Biology, Ecology and Vegetation Management

DOI: 10.1111/wre.12123

Reviewing change in the arable flora of Europe: a meta-analysis

N RICHNER*, R HOLDEREGGER†‡, H P LINDER§ & T WALTER*

*Agroscope Institute for Sustainability Sciences ISS, Zurich, Switzerland, †WSL Swiss Federal Research, Birmensdorf, Switzerland, ‡Department of Environmental Systems Sciences, Universitätsstrasse 16, Zurich, Switzerland, and §Institute of Systematic Botany, University of Zurich, Zurich, Switzerland

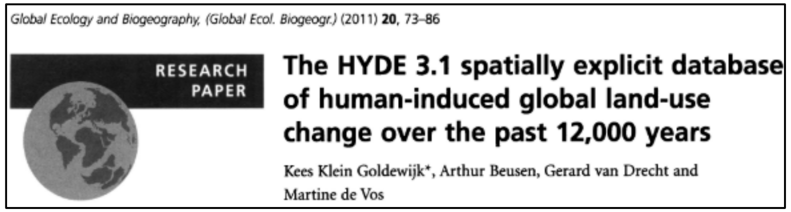
Received 8 April 2014
Revised version accepted 19 August 2014
Subject Editor: Paula Westerman, Rostock, Germany

meta-analysis

general trend:

- net decrease
- decrease in former West
- increase in former East/Yugoslavia

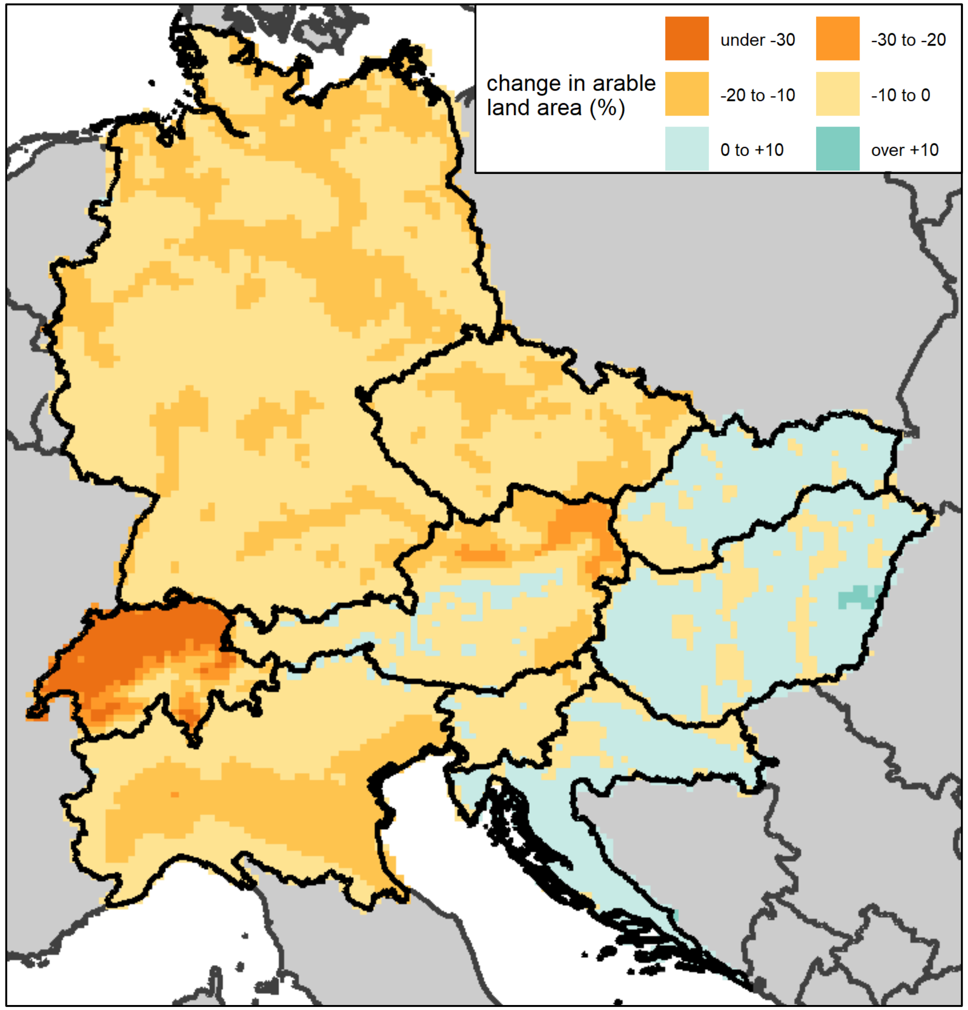
- ❖ "arable land" may include semi-permanent pastures/meadows
- ❖ other data sources may differ in "hindcasts"
- ❖ former East is normally "USSR, disaggregated" (~ Yugoslavia)


Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2011) **20**, 73–86

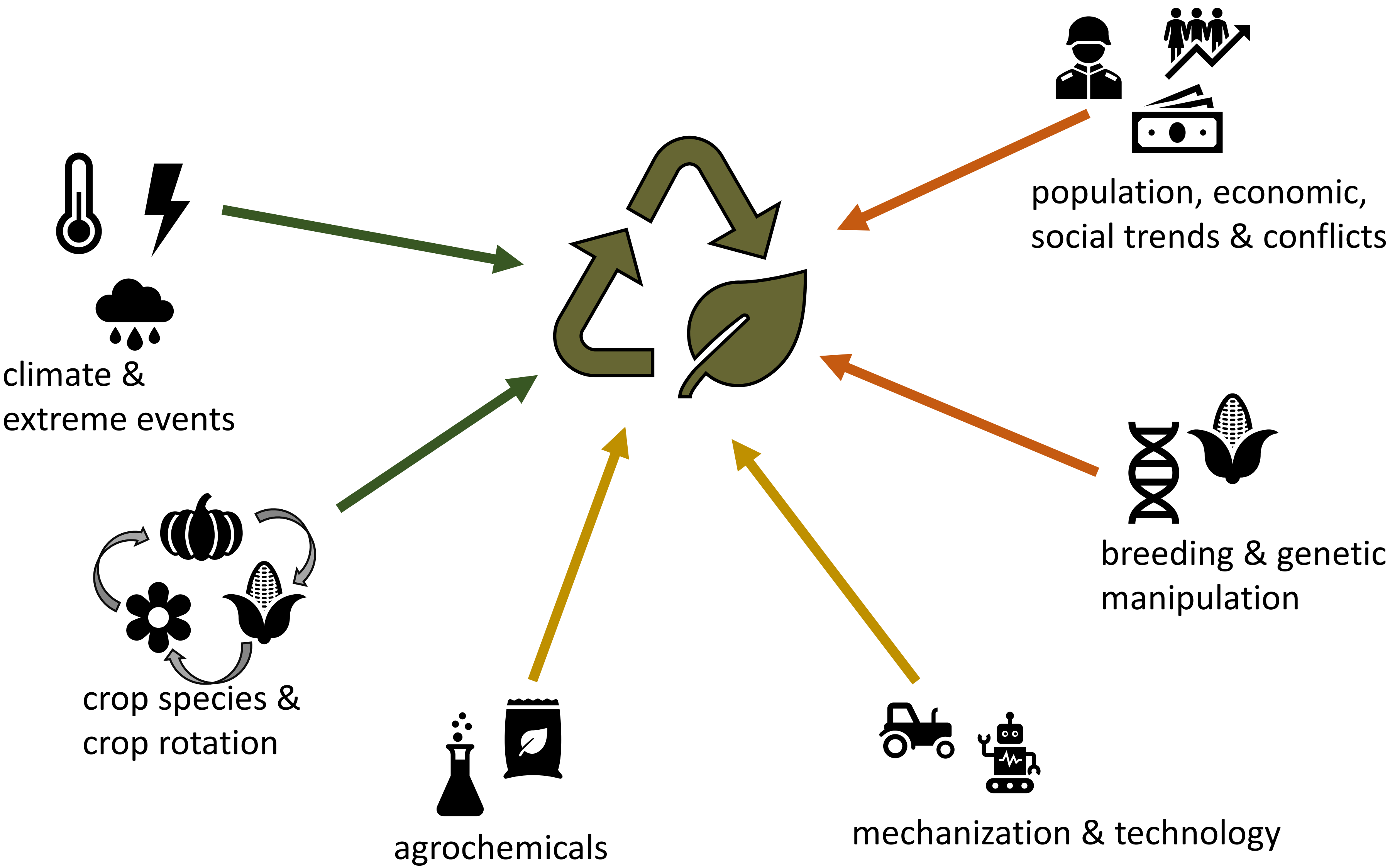
RESEARCH PAPER

The HYDE 3.1 spatially explicit database of human-induced global land-use change over the past 12,000 years

Kees Klein Goldewijk*, Arthur Beusen, Gerard van Drecht and Martine de Vos



Arable habitats



Database

step 1: get data!

Received: 11 March 2022 | Revised: 17 June 2022 | Accepted: 25 June 2022

DOI: 10.1111/avsc.12675

Applied Vegetation Science IAVS

REPORT

AgriWeedClim database: A repository of vegetation plot data from Central European arable habitats over 100 years

Michael Glaser[1,2] | Christian Berg[3] | Fabrizio Buldrini[4] | Serge Buholzer[5] | Jana Bürger[6] | Alessandro Chiarucci[4] | Milan Chytrý[7] | Pavel Dřevojan[7] | Swen Follak[8] | Filip Küzmič[9] | Zdeňka Lososová[7] | Stefan Meyer[10,11] | Dietmar Moser[12] | Petr Pyšek[13,14] | Nina Richner[15] | Urban Šilc[9] | Alexander Wietzke[16] | Stefan Dullinger[1] | Franz Essl[1]

What did we want?

the **perfect** dataset, of course

- exact positions (coordinates)
- crop data
  - species/cultivar
  - organic/conventional
  - management data
- even sampling

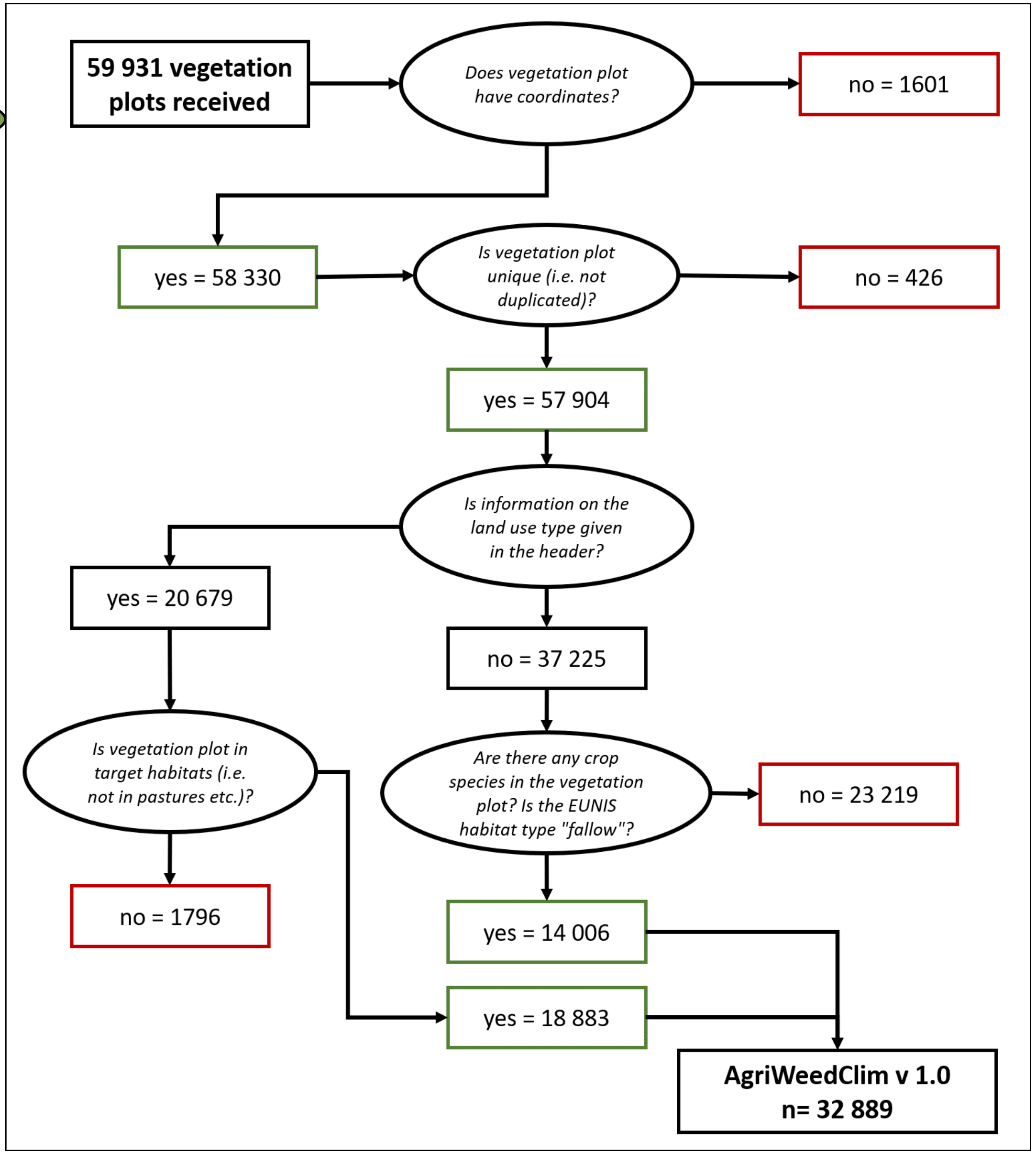
How did we try to get it?

THANK YOU EVA team!

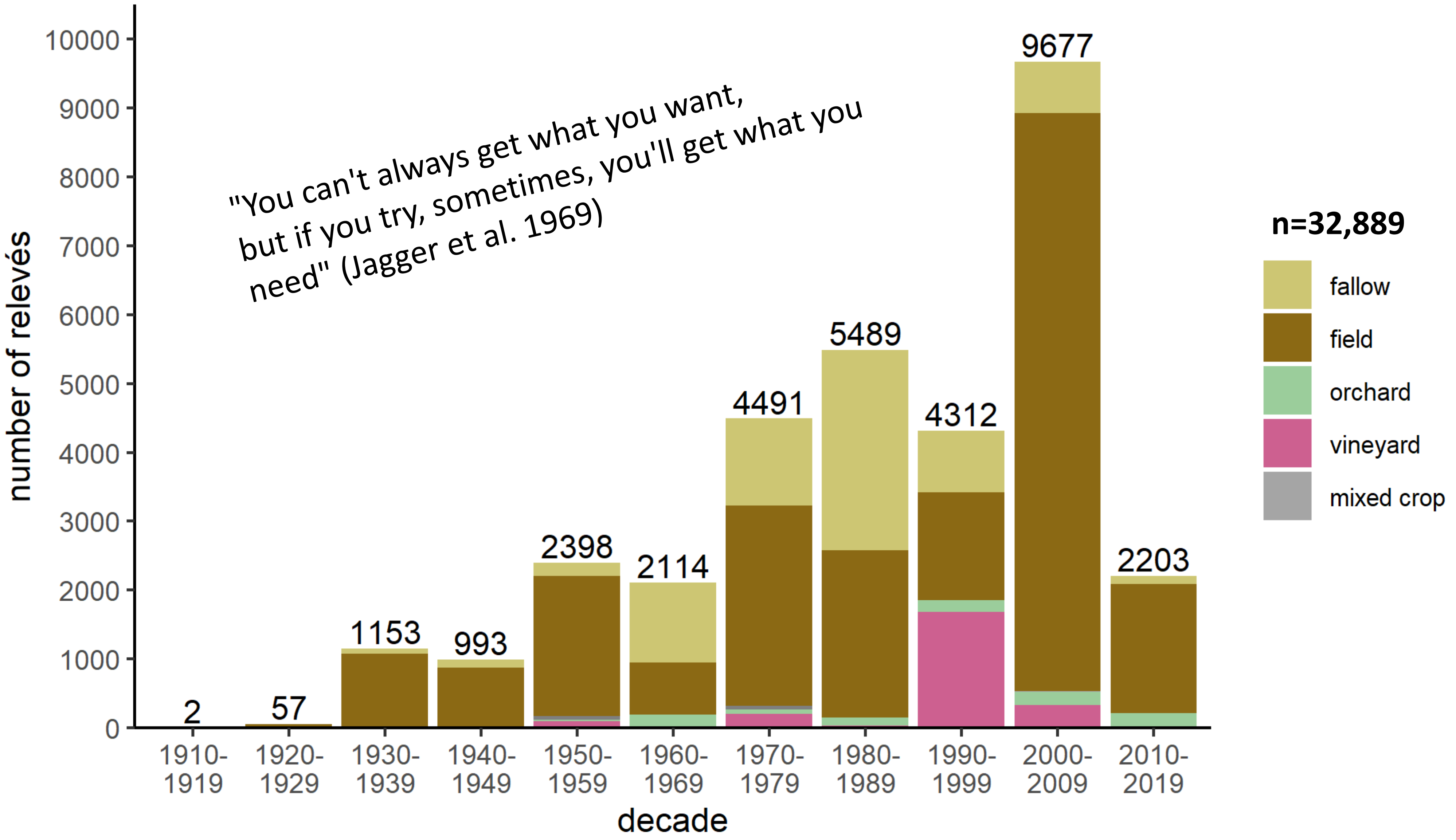
- European Vegetation Archive
- other databases
- individual data holders
- digitization
- inclusion of agricultural "plots"

different processing

- taxonomic standardization
- a lot of "fun" with R, Microsoft Excel & Access



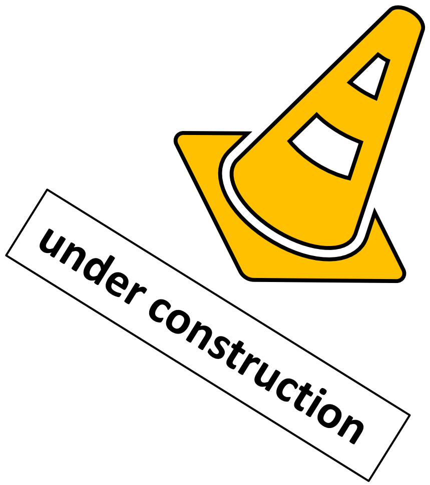
What did we get?



AgriWeedClim v2.0

- ✓ new data
- ✓ physical archives etc. open again (CoVid times)
- ✓ EVA "habitat column"
- ✓ more digitization

- ✓ new taxonomy? WorldFloraOnline? EuroPlusMed?
- ✓ "scraping" of GBIF



IF YOU FIND SOME UNLABELLED/UNKNOWN PLOT DATA SECURE THEM!

Biodiversity Change

step 2: analyze data

Glaser et al. 2022 (submitted to Global Ecology and Biogeography)

Arable fields have changed…

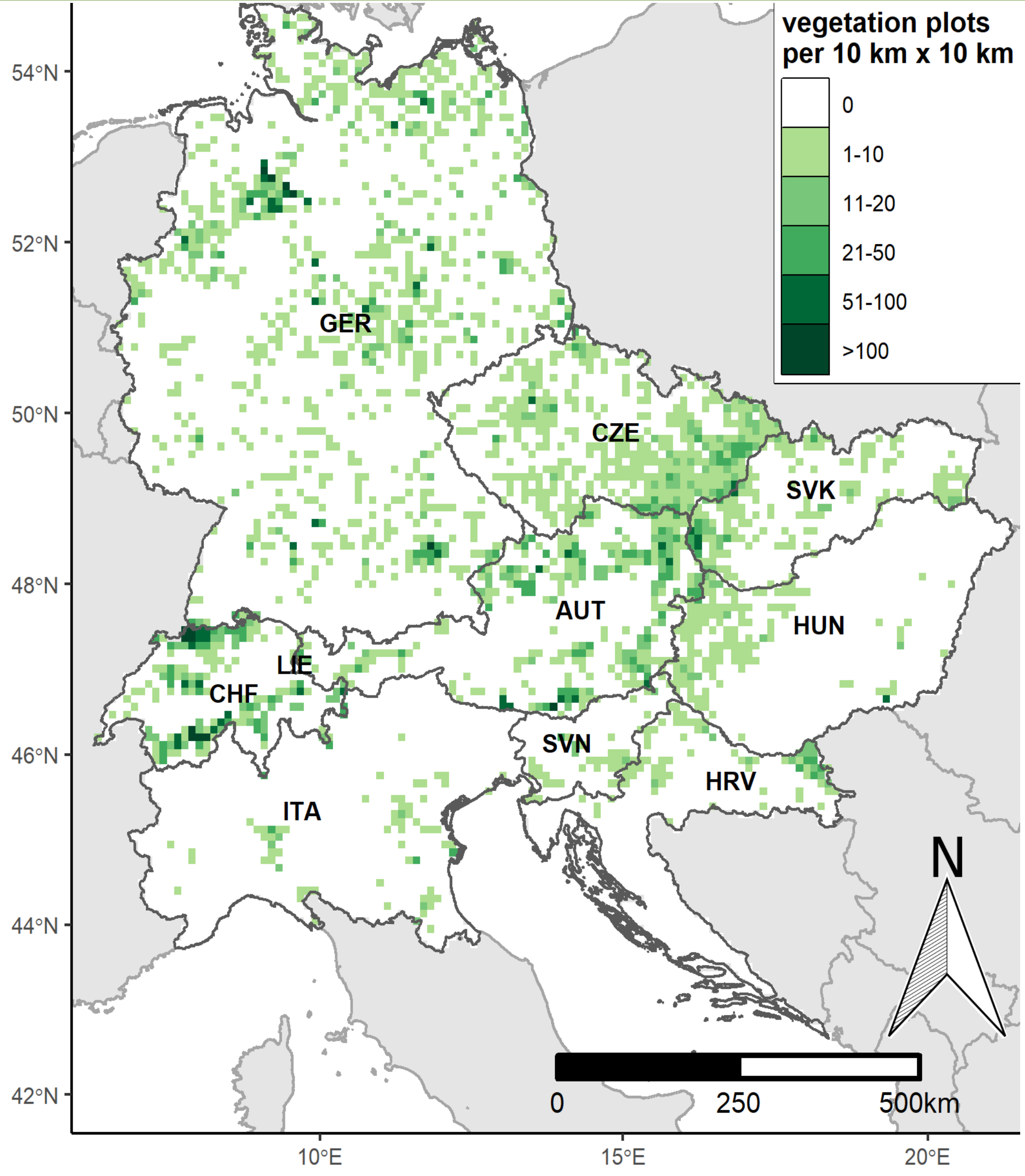
… and that raises questions:

I. **How have species changed over time?**

II. **How large is species turnover?**

III. **Do species with different traits show different trajectories of change?**

Study area & data source



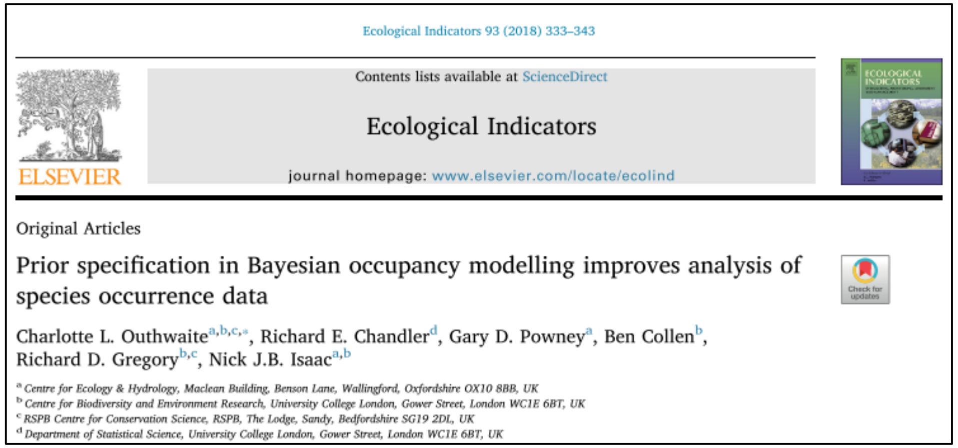
AgriWeedClim database (Glaser et al. 2022)

- plot data for arable habitats
  - fields (n= 21,955 plots)
  - species over 50 records (n=359)
- different sampling schemes

→ bias in a priori site selection between studies

field center and **field margin**

Occupancy modelling


Ecological Indicators 93 (2018) 333–343

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

ELSEVIER

Original Articles

Prior specification in Bayesian occupancy modelling improves analysis of species occurrence data

Charlotte L. Outhwaite[a,b,c,*], Richard E. Chandler[d], Gary D. Powney[a], Ben Collen[b], Richard D. Gregory[b,c], Nick J.B. Isaac[a,b]

[a] Centre for Ecology & Hydrology, Maclean Building, Benson Lane, Wallingford, Oxfordshire OX10 8BB, UK
[b] Centre for Biodiversity and Environment Research, University College London, Gower Street, London WC1E 6BT, UK
[c] RSPB Centre for Conservation Science, RSPB, The Lodge, Sandy, Bedfordshire SG19 2DL, UK
[d] Department of Statistical Science, University College London, Gower Street, London WC1E 6BT, UK

based on

- sites i (=10x10 km cells)
- visits v (=vegetation plots)
- time t (decades 1930s-2010s)

hierarchical Bayes (JAGS and R)

state model

$$z_{i,t} \sim dbern(\varphi_{i,t})$$

true occurence
probability of occurrence = occupancy

$$logit(\varphi_{i,t}) = b_t + u_i$$

random time effect
random site effect

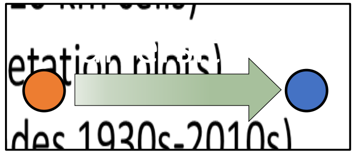
observation model

$$(y_{itv} \mid z_{it}) \sim dbern(z_{it} * p_{itv})$$

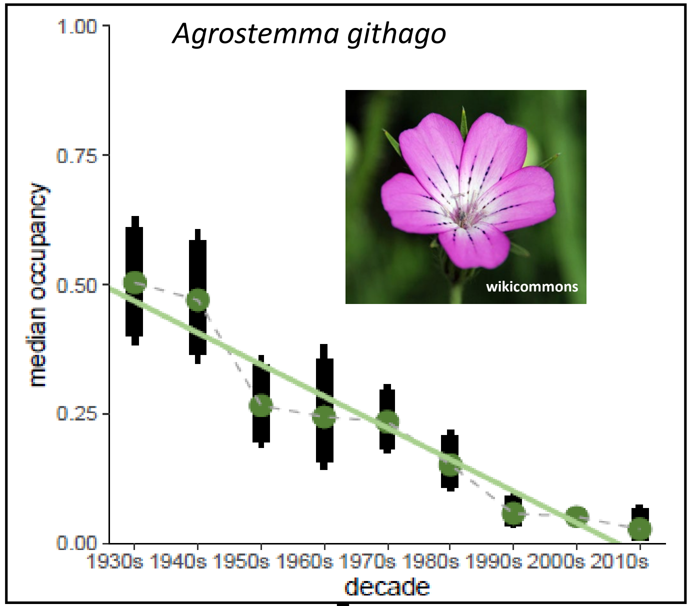
observed data
probability of observation

$$logit(p_{itv}) = a_t + c_v * \log L_v$$

random time effect
list length effect
list length

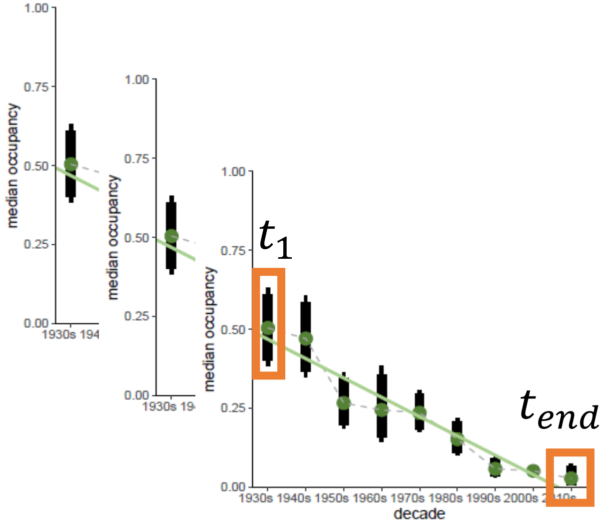


Analysis of results



x 359 species

occupancy change



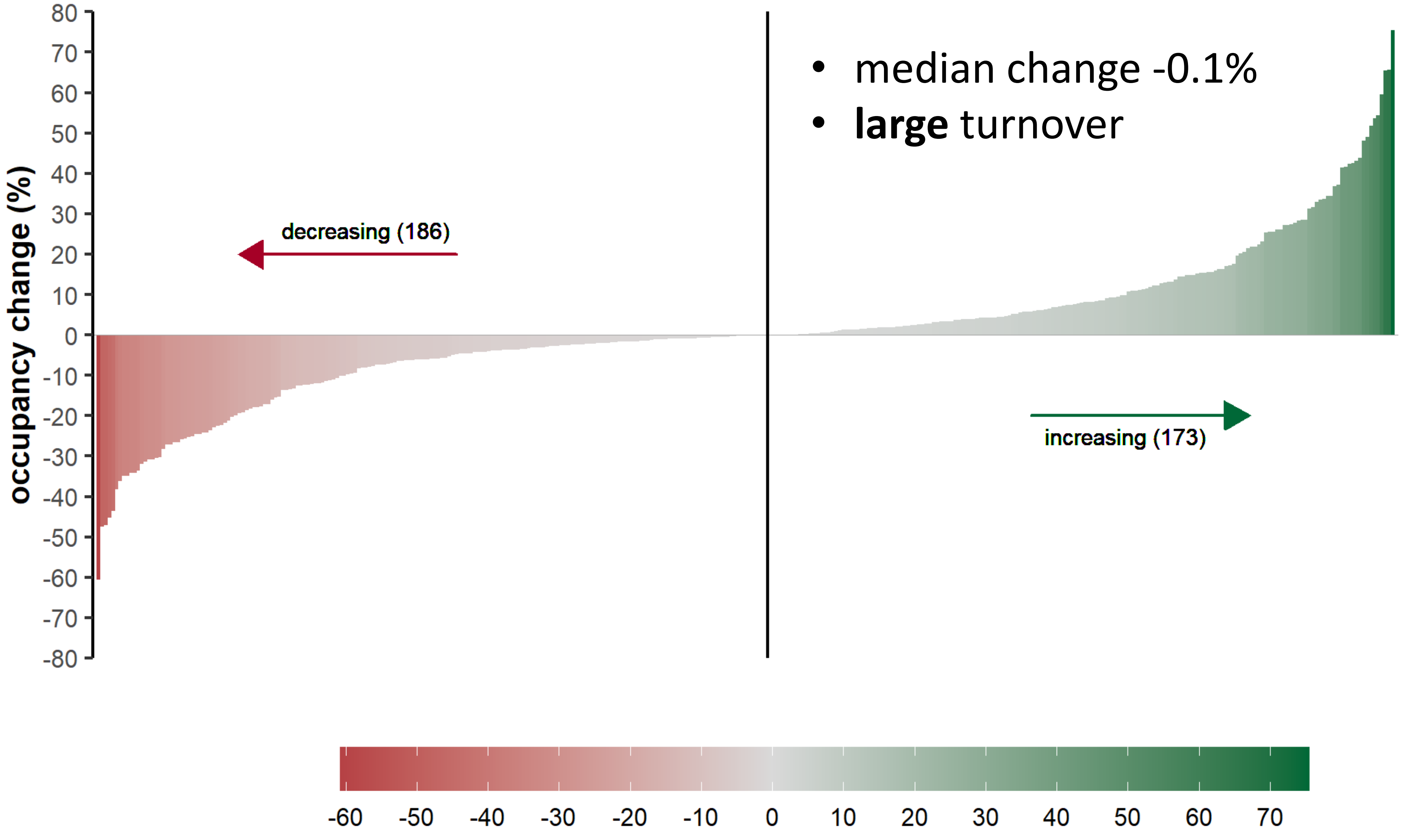
$t_{end} - t_1$

$$\log(\frac{t_{end}}{t_1}) \sim$$

different species attributes:

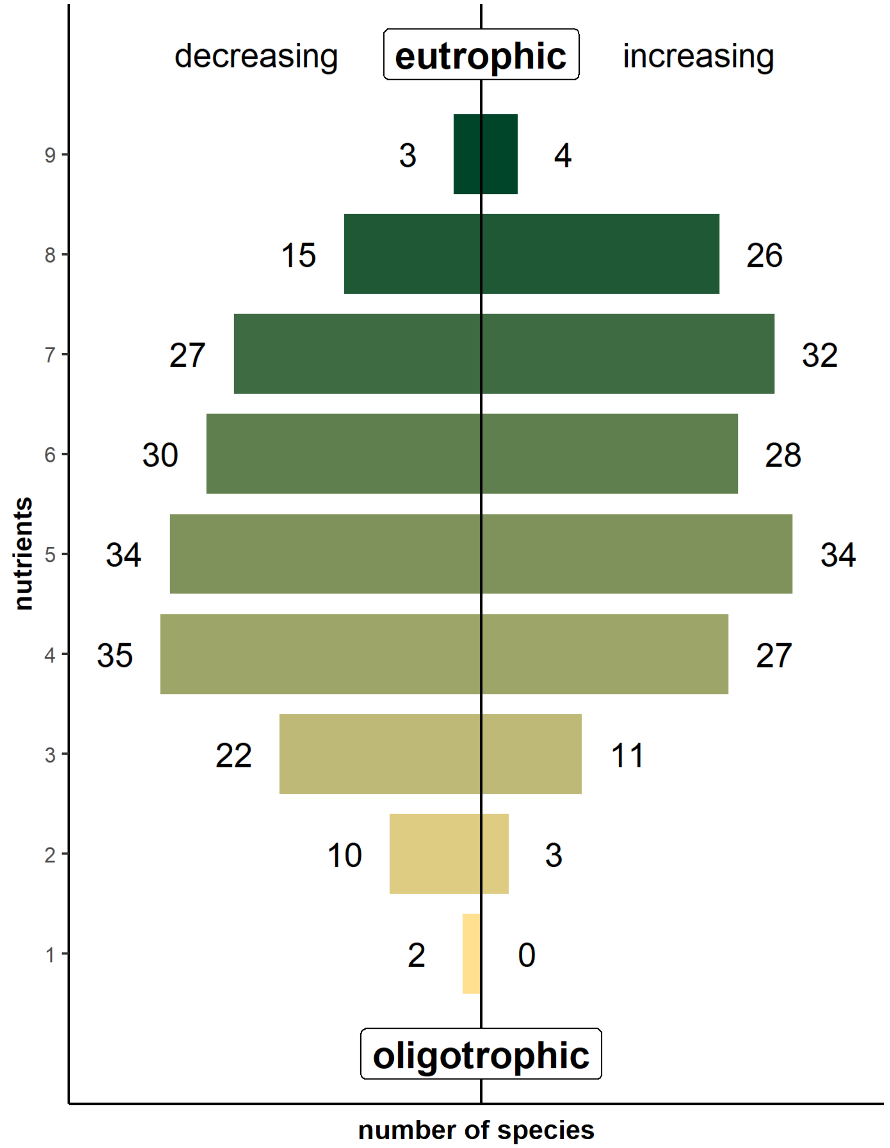
- Nutrients
- soil pH
- temperature
- soil moisture
- biogeography
- segetal affiliation

Overall Results

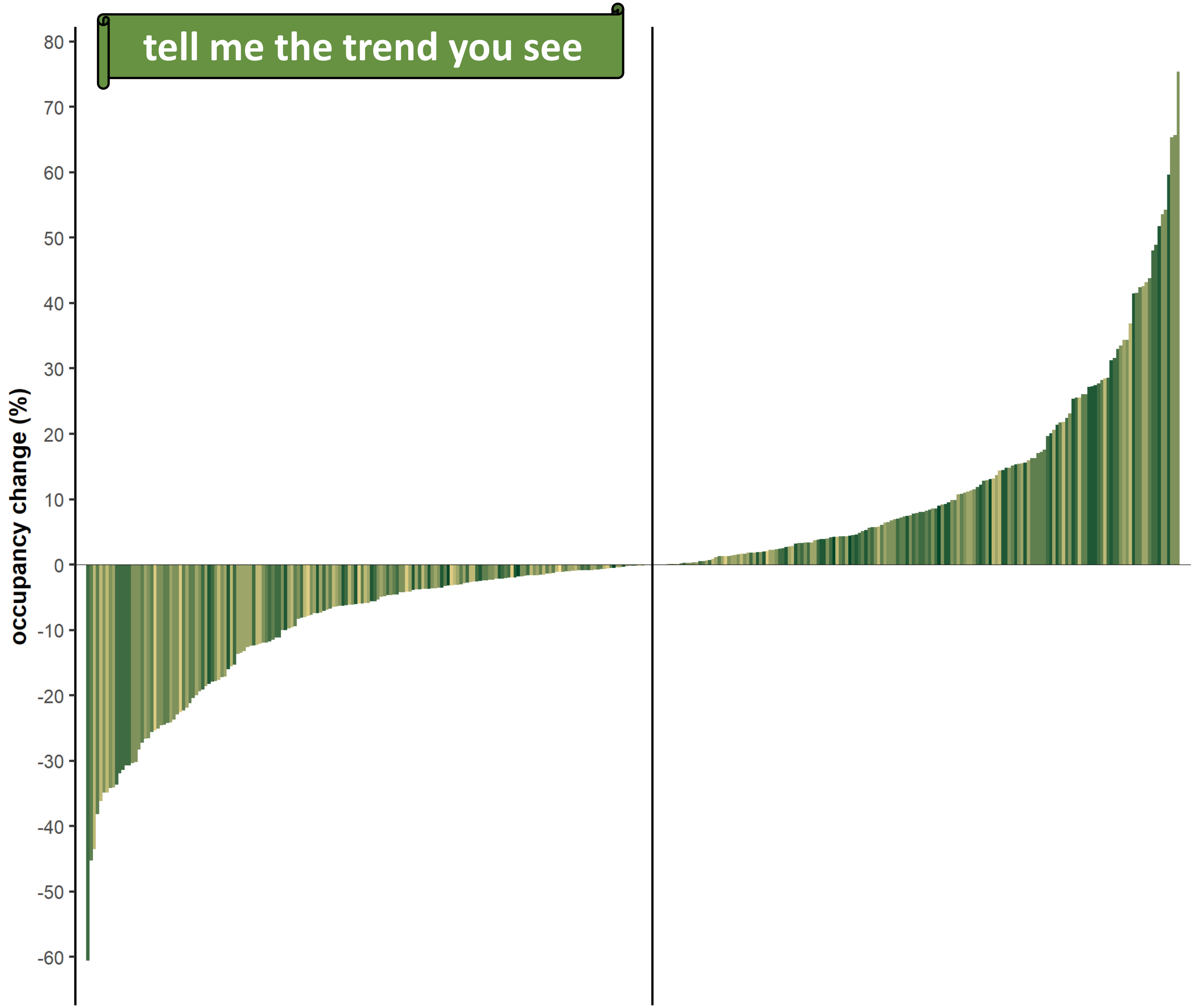


- median change -0.1%
- **large** turnover

Nutrients

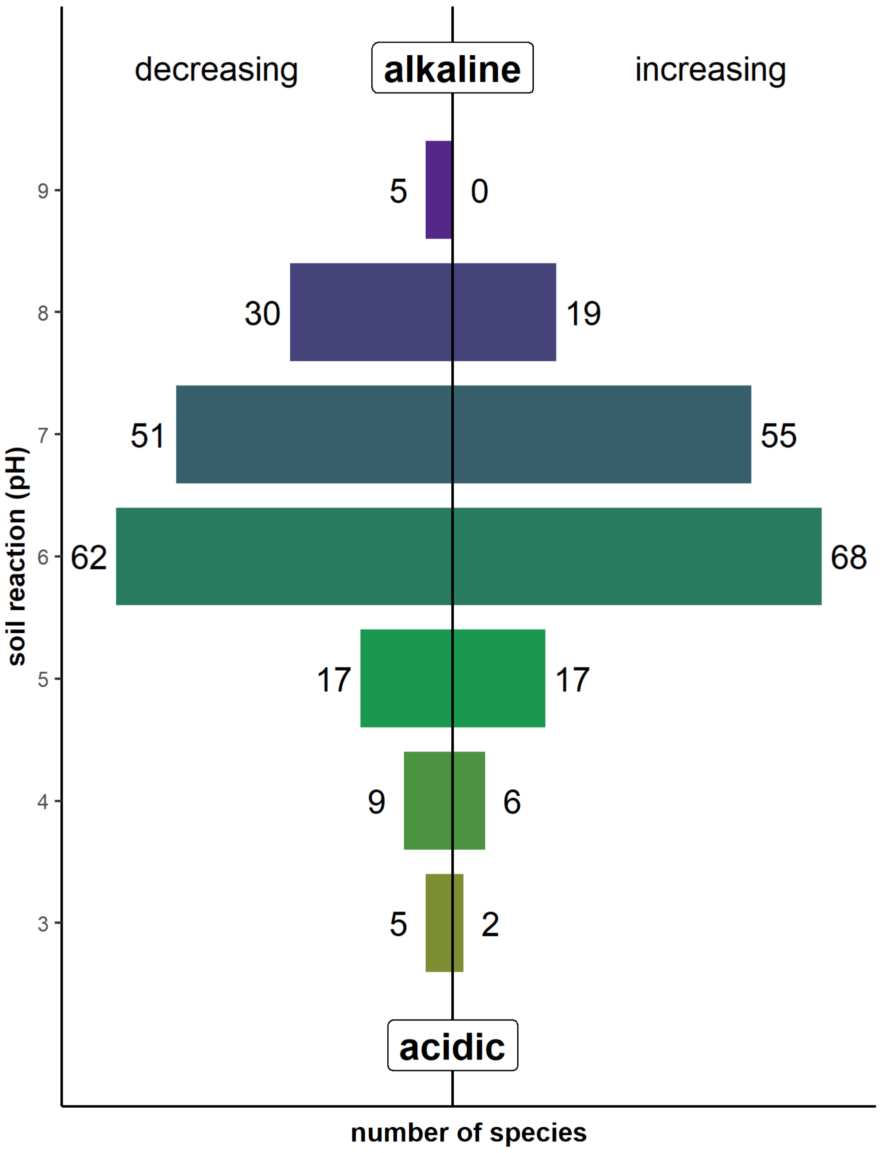


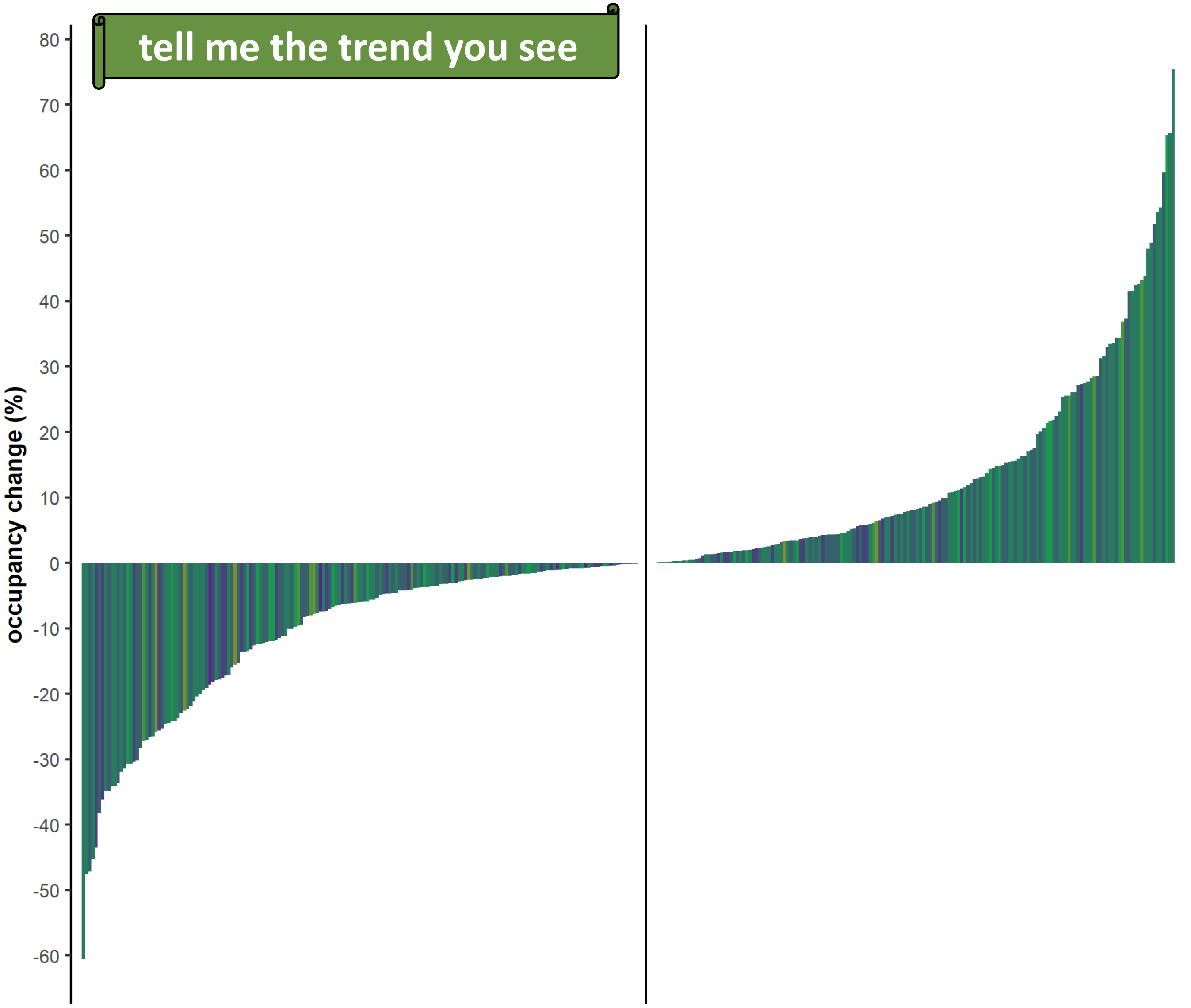
decreasing
eutrophic
increasing
3
4
15
26
27
32
30
28
34
34
35
27
22
11
10
3
2
0
oligotrophic
nutrients
9
8
7
6
5
4
3
2
1
number of species



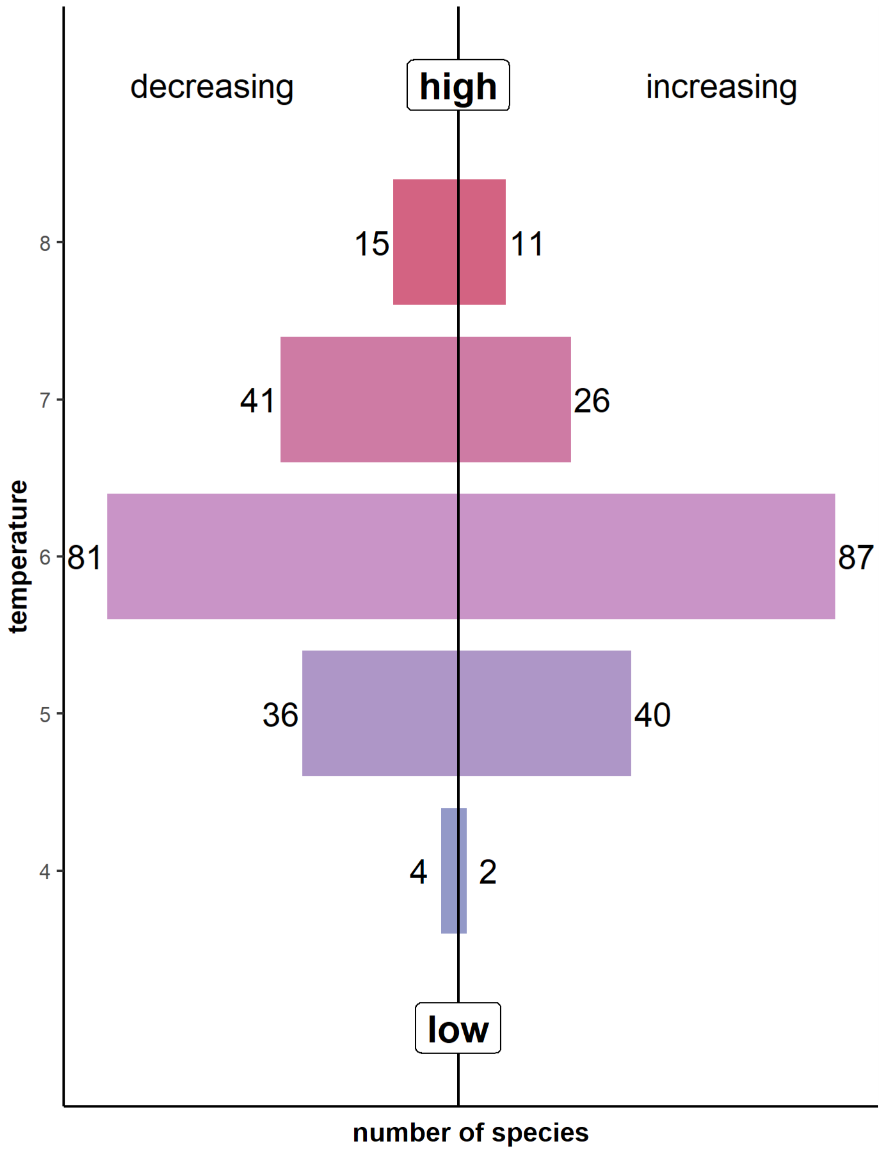
tell me the trend you see
occupancy change (%)
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60

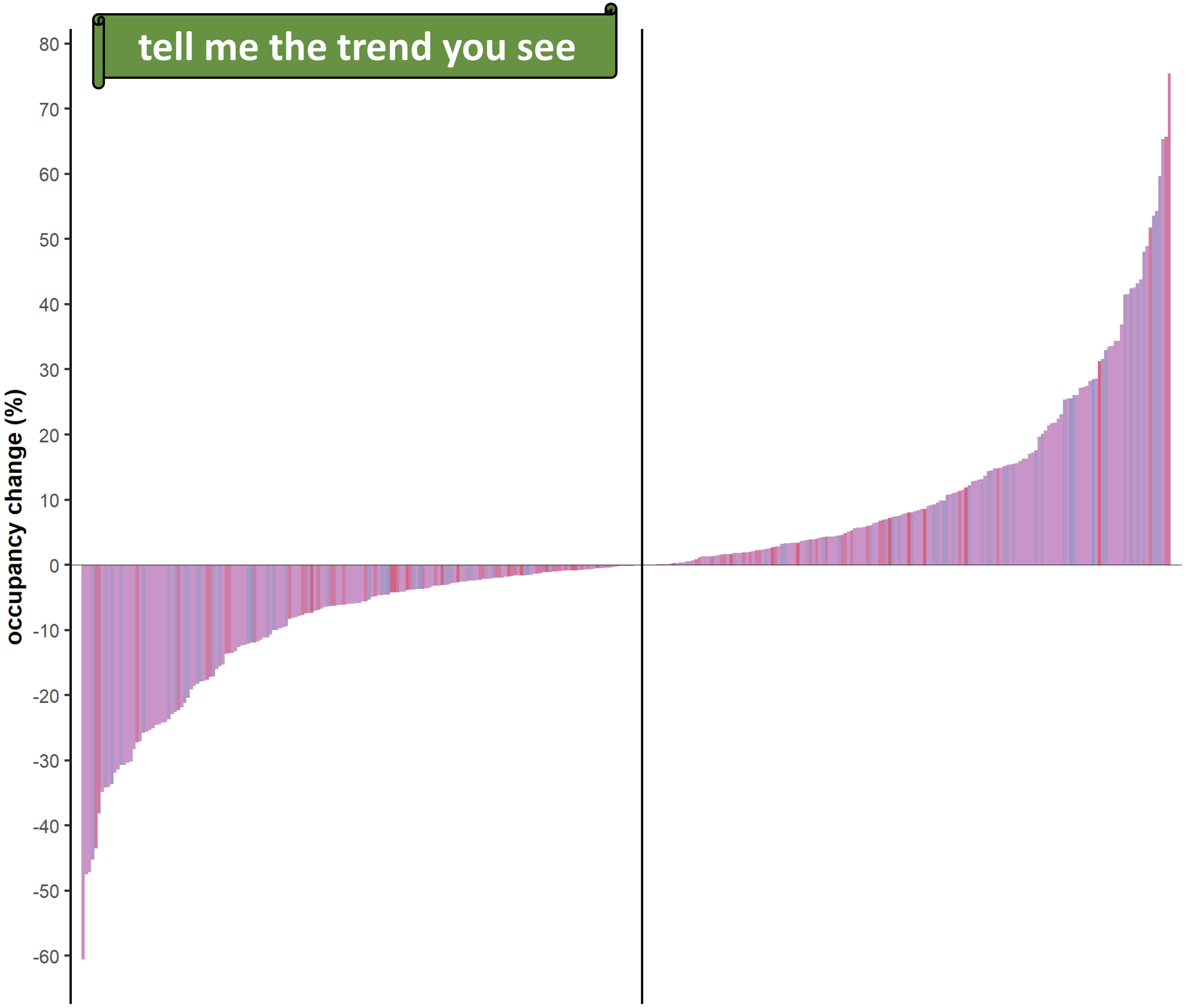
Soil reaction (pH)



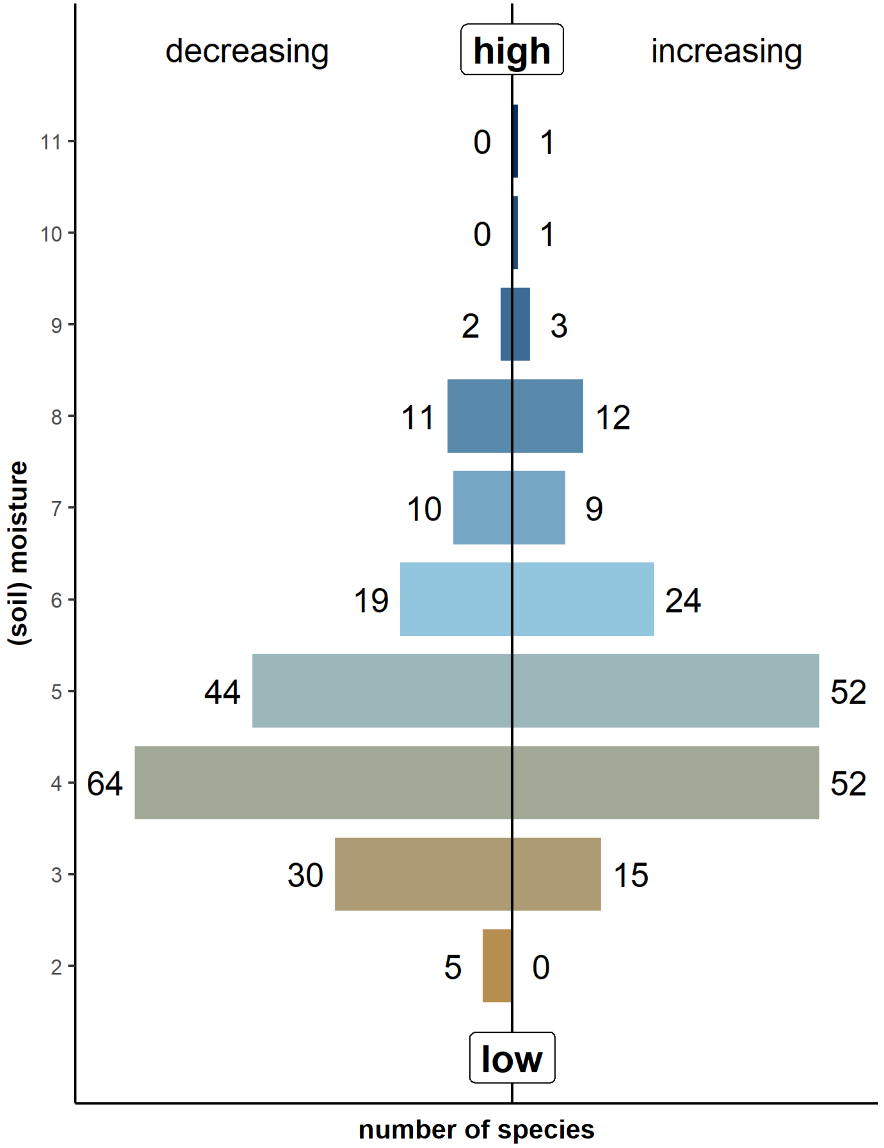


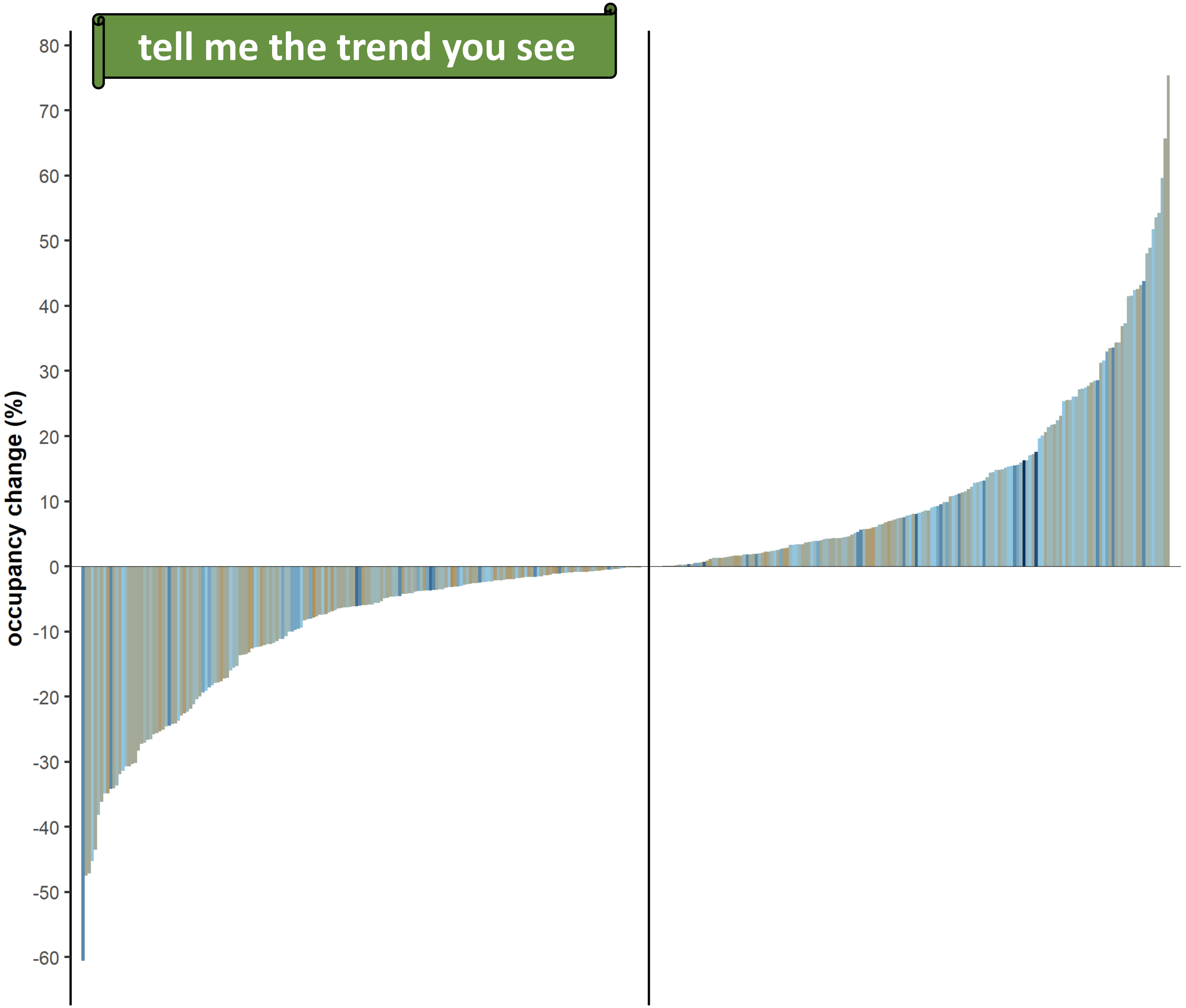
Temperature



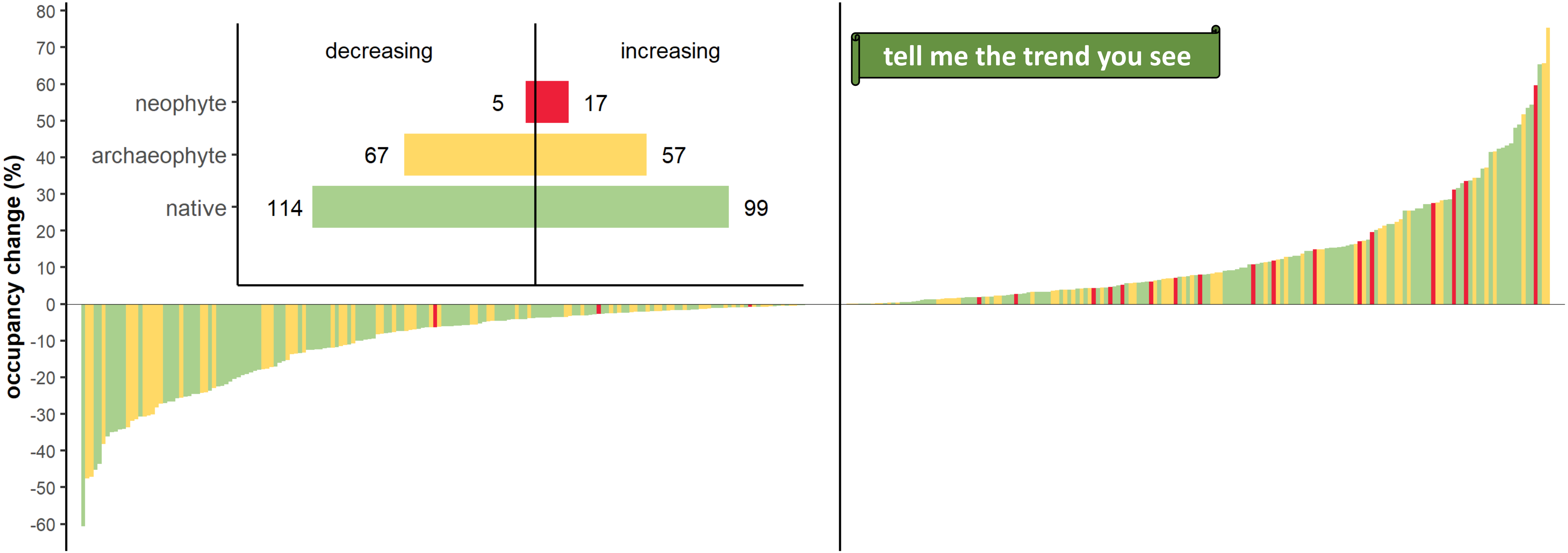


Moisture


decreasing
high
increasing
11
10
9
8
7
6
5
4
3
2
0
1
0
1
2
3
11
12
10
9
19
24
44
52
64
52
30
15
5
0
low
(soil) moisture
number of species


tell me the trend you see
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
occupancy change (%)

Biogeographic Origin



tell me the trend you see

Arable habitat affinity

Significant results

Nitrogen*** ↑

soil pH 2nd poly* ↓

biogeography* ↕

arable affiliation* ↓

↑ **neophytes*****
↓ **natives****
↓ **archaeophytes****

temperature ↓

soil moisture*** ↑

N-preference?
drainage/irrigation?

Conclusions

Limitations!

- a priori filtering of rare species
- neophytes underrepresented
- residual bias

I. **No “net loss”? Possible, but unlikely!**
II. **Large species turnover. Preceding species loss?**
III. **Habitat change, neophyte invasion and loss of typical species.**

consequences →

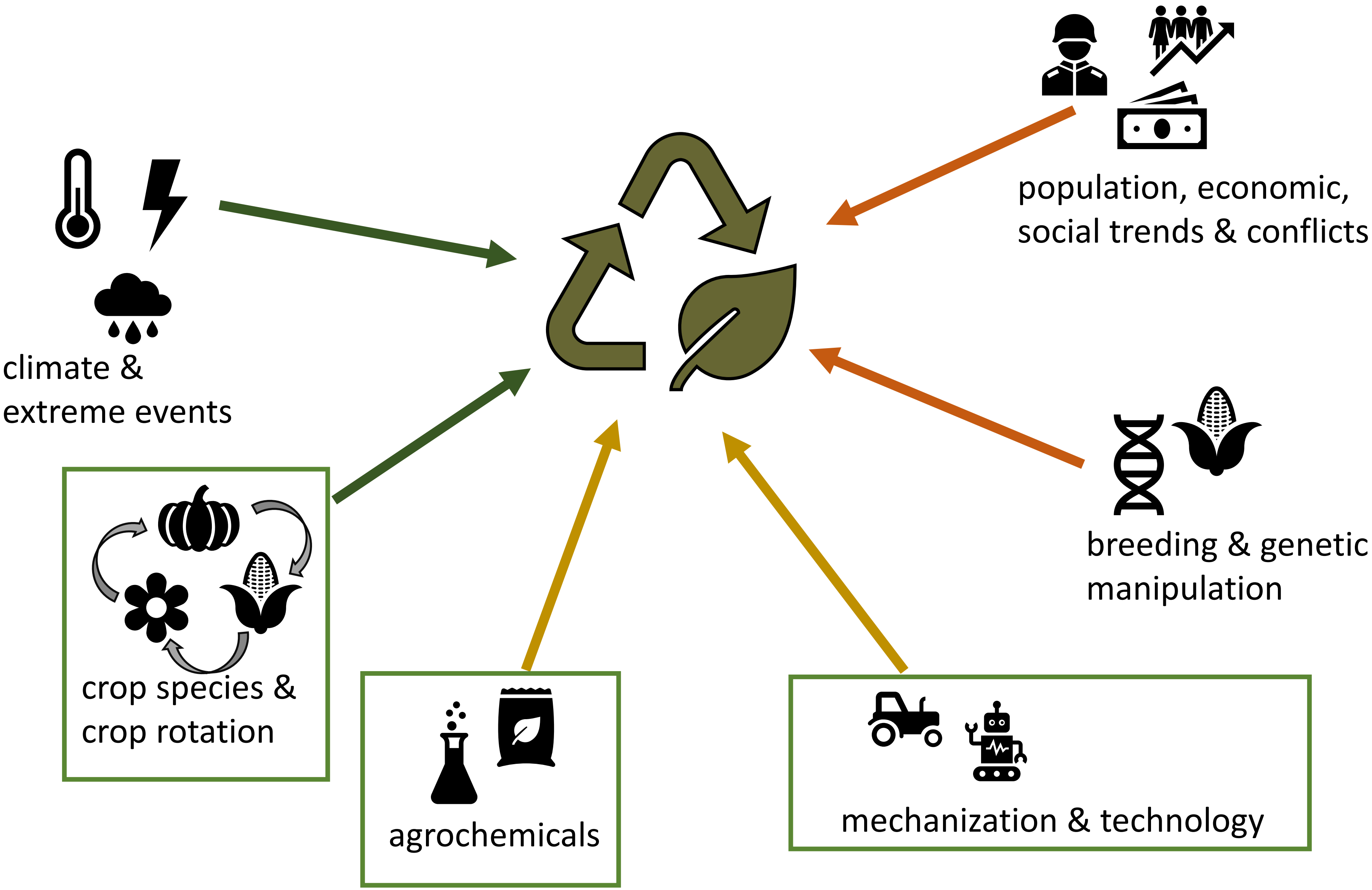
maintain/create extensively used sites
monitor neophytes (in root crops)
don't forget about future climate change

under construction

The Human Component

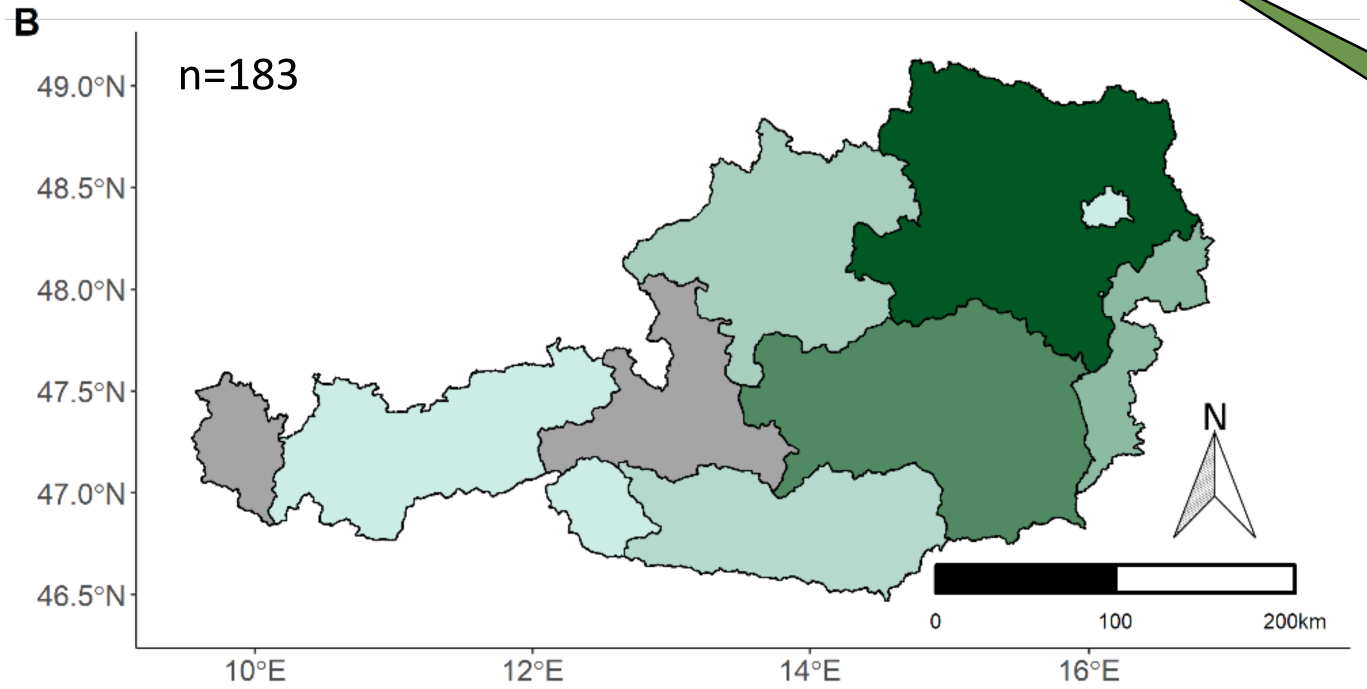
step 3: think hard about how human actions shaped arable habitats

Let's think about this for a minute



Farm Questionnaire

- Austrian farmers (language barrier)
- survey link distributed to ca. 40,000 farmers
- Jan-Apr 2022
- 15 pre-selected emerging weed species



Do you recognize this species?

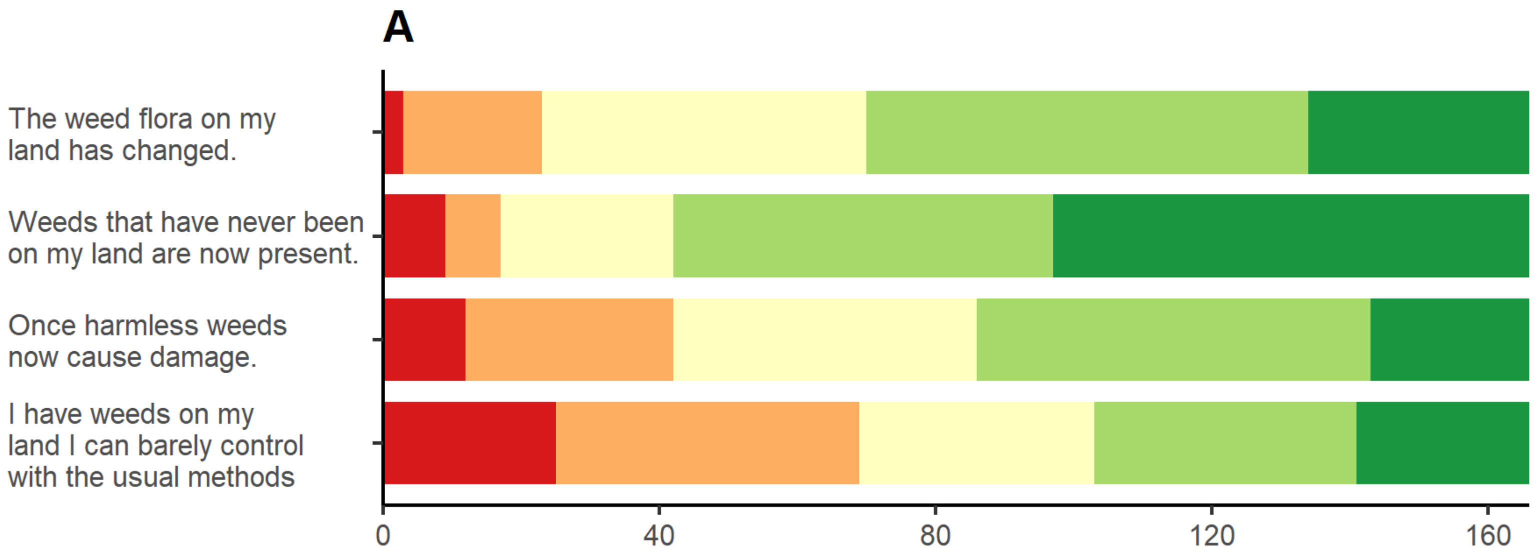
How high would you estimate management effort for this species?

high | medium to high | medium | low to medium | low

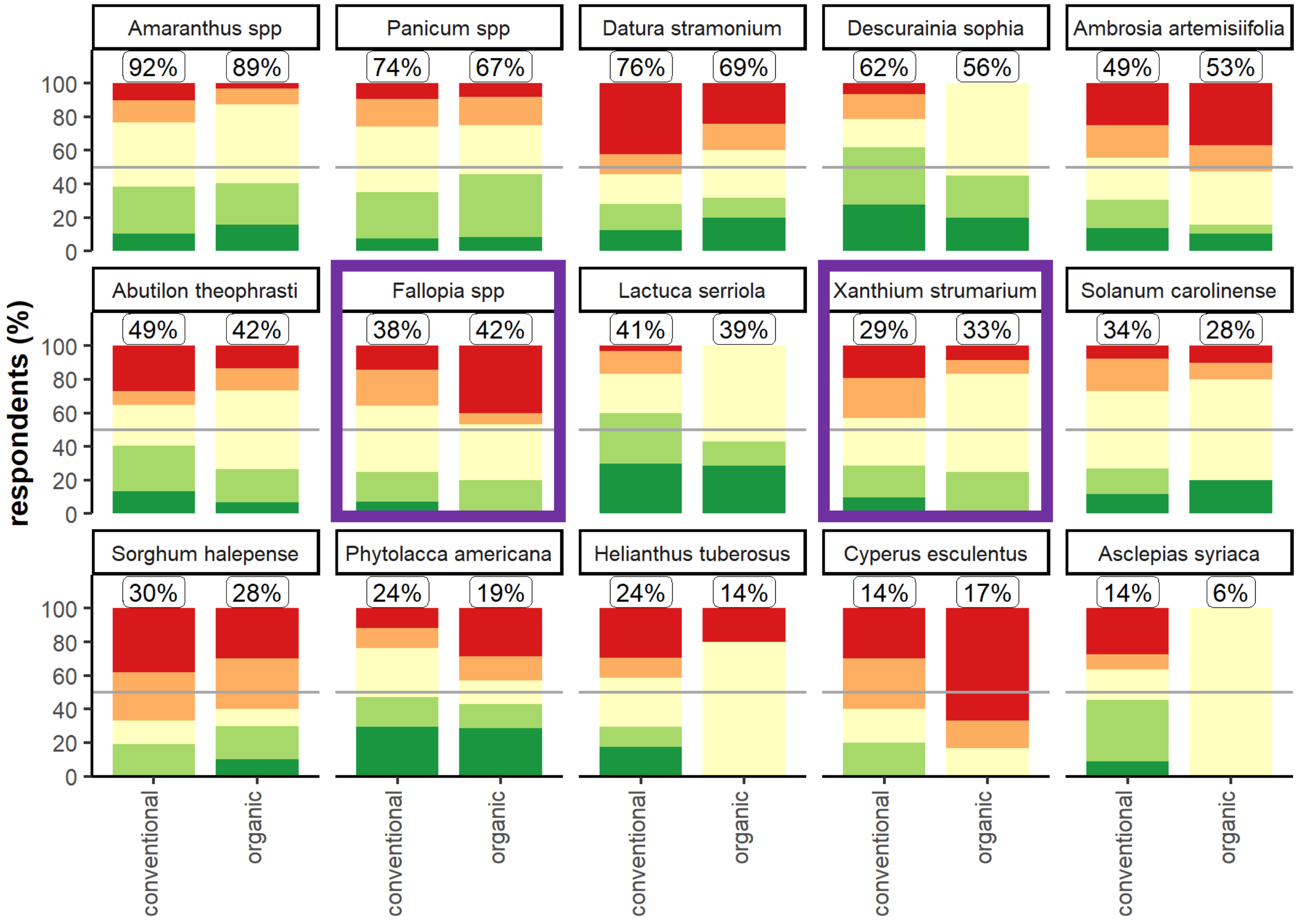
Results I – changes in weed flora

farmers see change first

- biodiversity change
- new weeds
- hard to control with commonly known measures



Results II – emerging weeds



n=144 (78 conventional, 36 organic)

management effort: high, medium to high, medium, low to medium, low

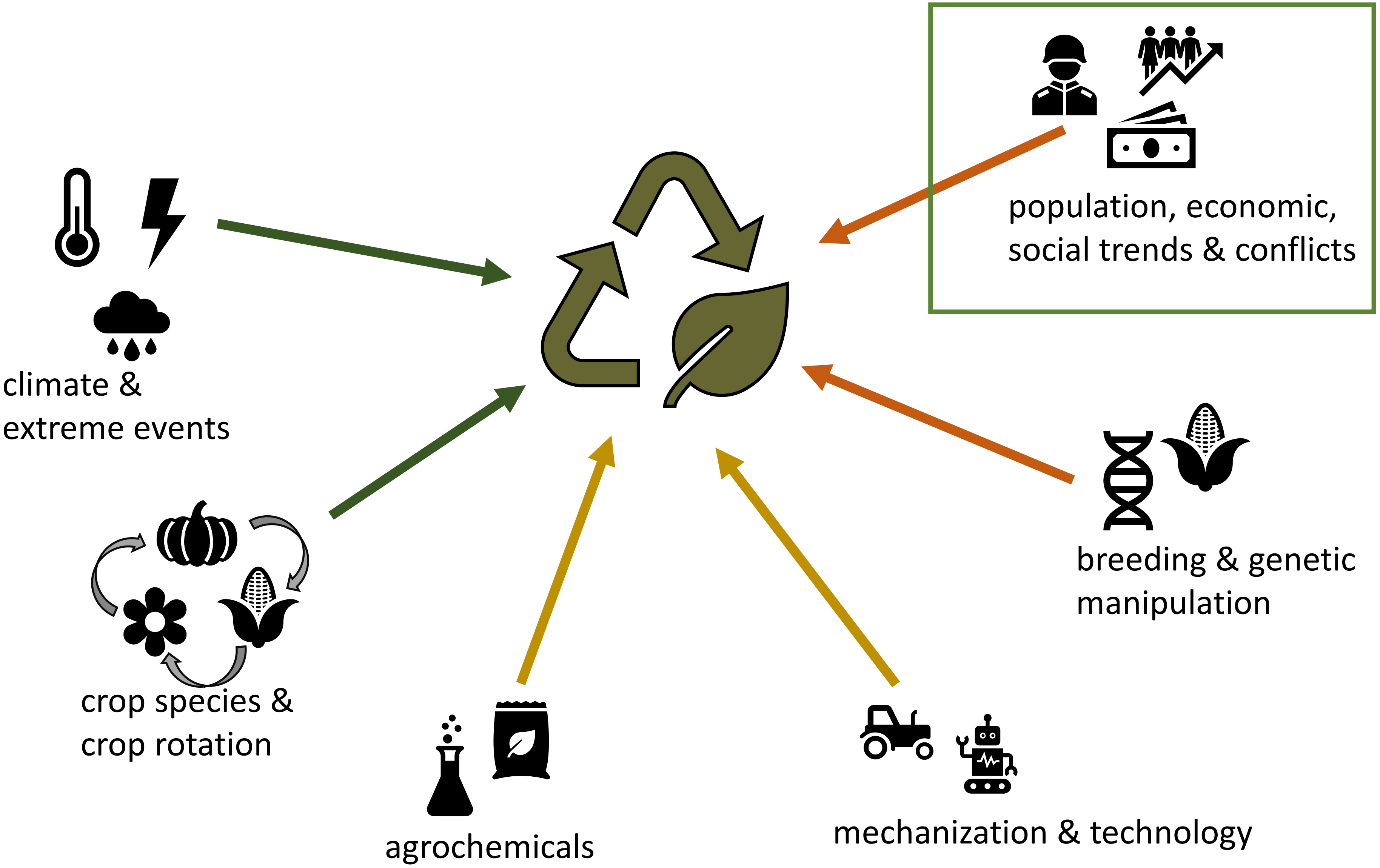
- median # of species recognized = 6 (0-15)
- **n.s.** organic vs. conventional

differences

- frequency of recognition
- management effort organic vs conventional
  - expected: *Fallopia* spp
  - unexpected: *Xanthium strumarium*

sample size?
tillage difference?
herbicide efficacy/resistance?

Let's think about this for a minute



What we know…

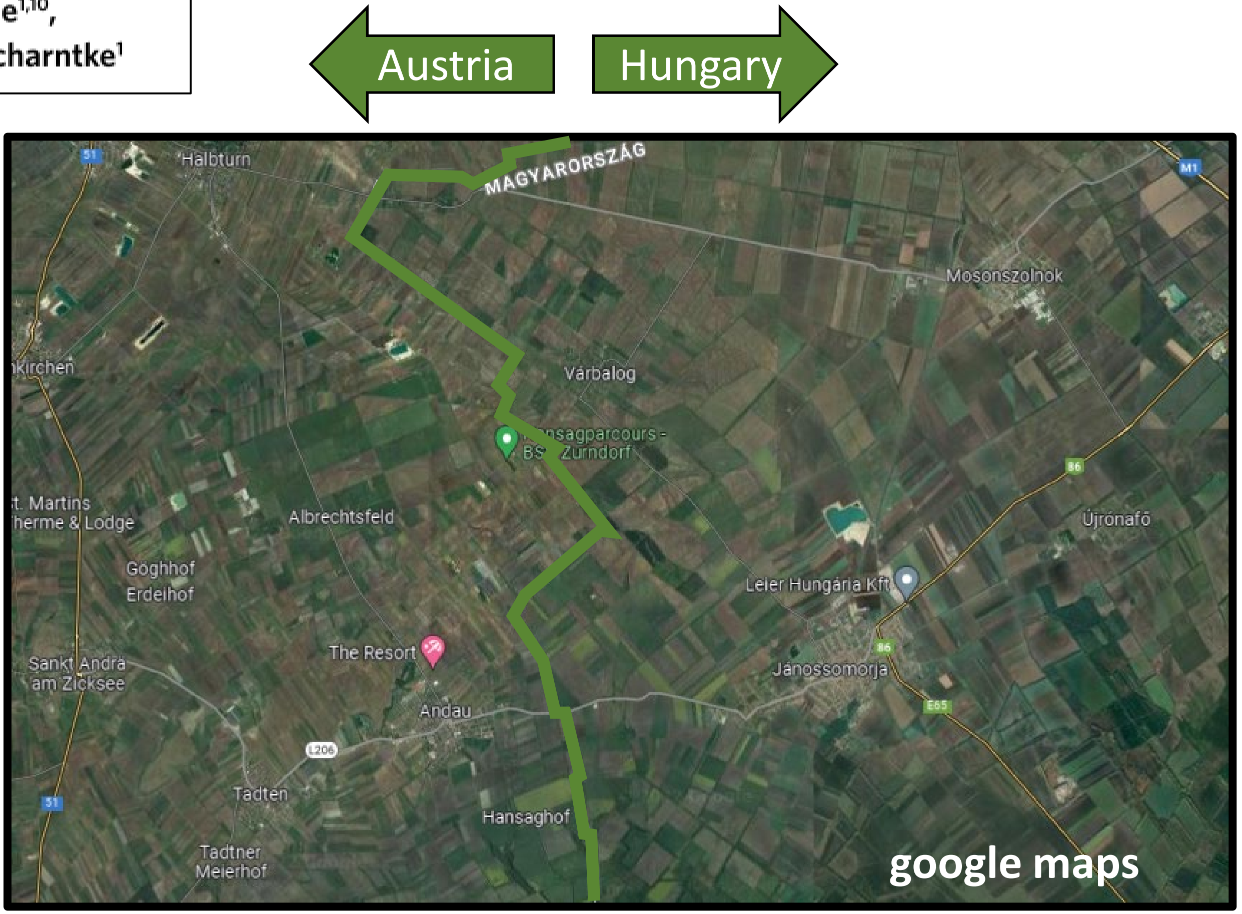
The former Iron Curtain still drives biodiversity–profit trade-offs in German agriculture

nature ecology & evolution Vol 1 September 2017

Péter Batáry[1,2*], Róbert Gallé[1,3], Friederike Riesch[1,4], Christina Fischer[5], Carsten F. Dormann[6], Oliver Mußhoff[7], Péter Császár[3], Silvia Fusaro[1,8], Christoph Gayer[1,9], Anne-Kathrin Happe[1,10], Kornélia Kurucz[1,11], Dorottya Molnár[1], Verena Rösch[1,12], Alexander Wietzke[13] and Teja Tscharntke[1]

- is on a **highly local scale**
  - a few villages, n=324 plots

- larger fields in East
  - shorter edges/margins
- more intensive fields in West
  - fewer within-field patches?



Socioeconomic differences

West	VS	East
market	**economy**	planned
private	**ownership**	government
small	**field size**	large
high	**intensity**	low
within	**trade**	within
early	**mechanization**	late

What happened after the "separation" ended? What happened after countries joined the EU? What about (former) Yugoslavia?

***othering** = seeing one side (West) as normal and the *other* side as the divergence

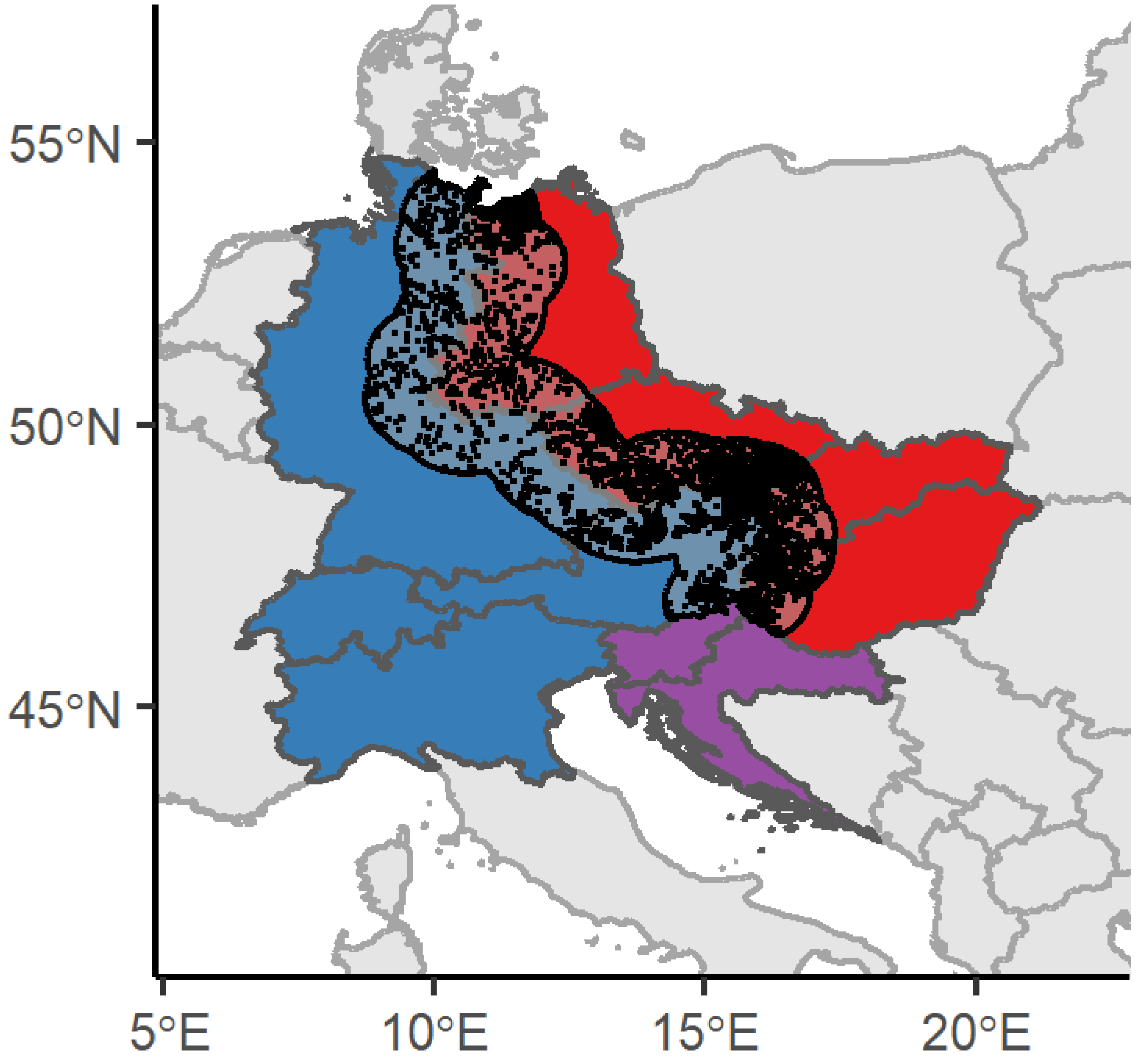
The idea

Q: How did the socioeconomic differences in (former) Western and Eastern Europe influence…

- ❑ species number?
- ❑ number of neophytes?
- ❑ individual species?

The approach

1. regression 1: n~climate
2. mixed model: $r_n \sim socio * time$



Acknowledgements

Austrian Climate Research Program [FA772033]

AgriWeedClim

weeds under climate and land use change

universität wien

AGES

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- Christan Berg, Jana Bürger, Filip Küzmic, Urban Šilc, Siegrid Steinkellner
- Serge Buholzer, Fabrizio Buldrini, Alessandro Chiarucci, Milan Chytrý, Stefan Meyer, Alexander Wietzke, Irena Axmanova, Ilona Knollova, Pavel Dřevojan
- Andreas Gattringer, Bernhard Hülber, Dietmar Moser, Johannes Wessely

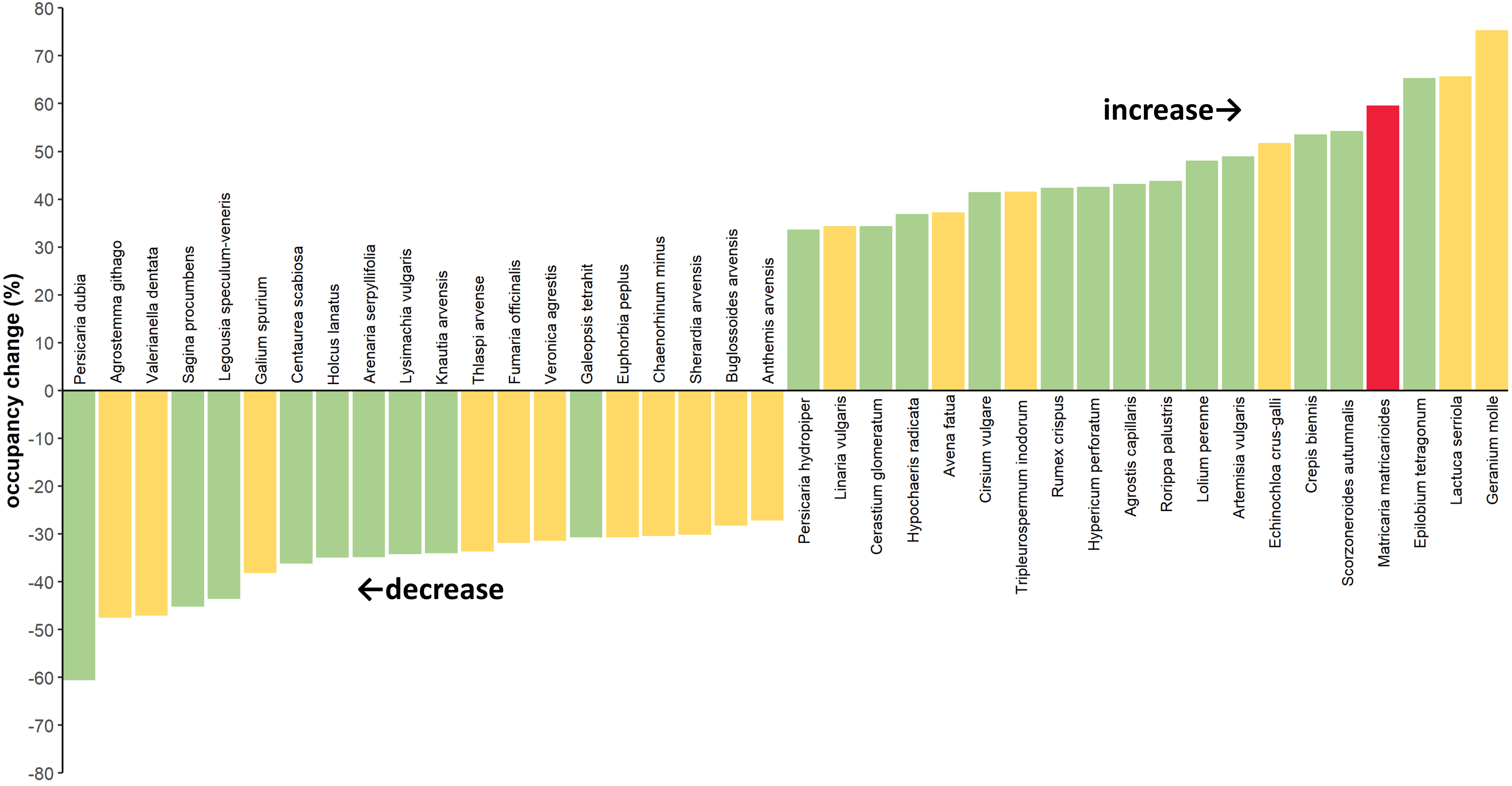
Thank you!

…any questions?

Slide Storage

for the really deep questions…

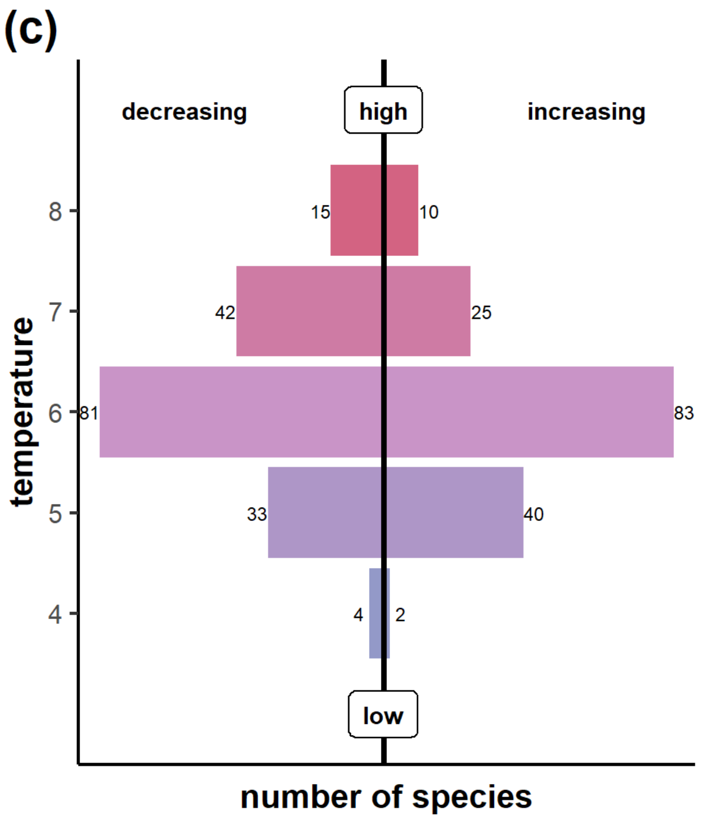
Top Winners/Losers

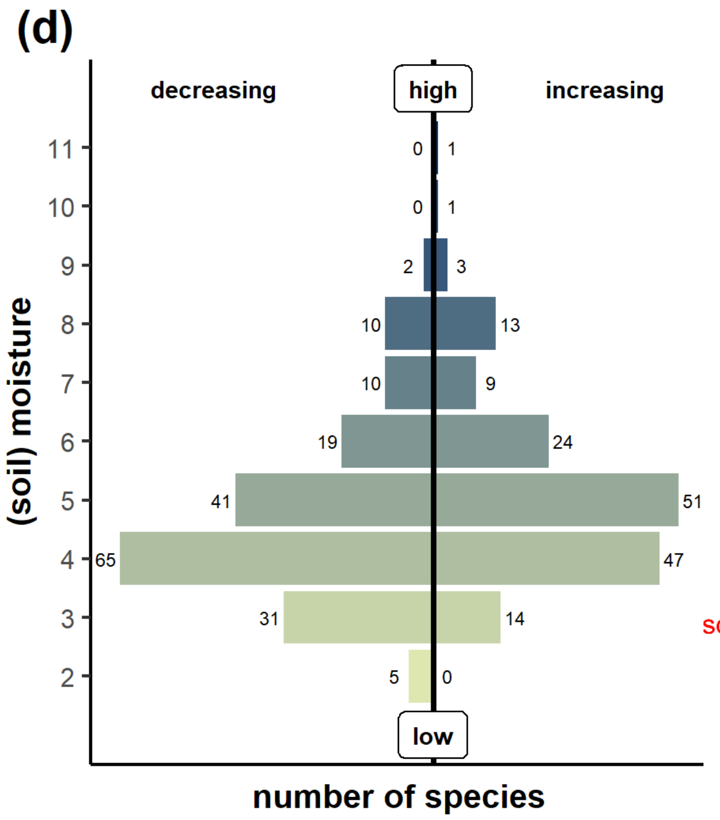


Method - Details

	Model	Prior	Hyperprior	Variables
State	$z_{i,t} \sim Bernoulli(\varphi_{i,t})$ $logit(\varphi_{i,t}) = b_t + u_i$	$b_1 \sim Normal(\mu_b, 0.001)$ $b_t \sim Normal(b_{t-1}, \tau_b)$ $u_i \sim Normal(0, \tau_u)$	$\tau_b = 1/(\sigma_b * \sigma_b)$ $\sigma_b \sim \lvert Cauchy(df = 1) \rvert$ $\tau_u = 1/(\sigma_u * \sigma_u)$ $\sigma_u \sim \lvert Cauchy(df = 1) \rvert$	$\boldsymbol{z_{i,t}}$ … true occupancy (unknown) $\boldsymbol{\varphi_{i,t}}$ … probability of occupancy $\boldsymbol{b_1}$, $\boldsymbol{b_t}$ … decade effect on state $\boldsymbol{u_i}$ … site effect on state
Observation	$(y_{itv} \mid z_{it}) \sim Bernoulli(z_{it} * p_{itv})$ $logit(p_{itv}) = a_t + c_v * logL_v$	$a_t \sim Normal(\mu_a, \tau_a)$ $c \sim Uniform(-10,10)$	$\tau_a = 1/(\sigma_a * \sigma_a)$ $\sigma_a \sim \lvert Cauchy(df = 1) \rvert$	$\boldsymbol{y_{itv}}$… observed occurrence $\boldsymbol{p_{itv}}$ … probability of detection $\boldsymbol{a_t}$ … decade effect on observation $\boldsymbol{c_v}$ … effect size for L_v $\boldsymbol{L_v}$ … list length (log-transformed)

What about Climate?

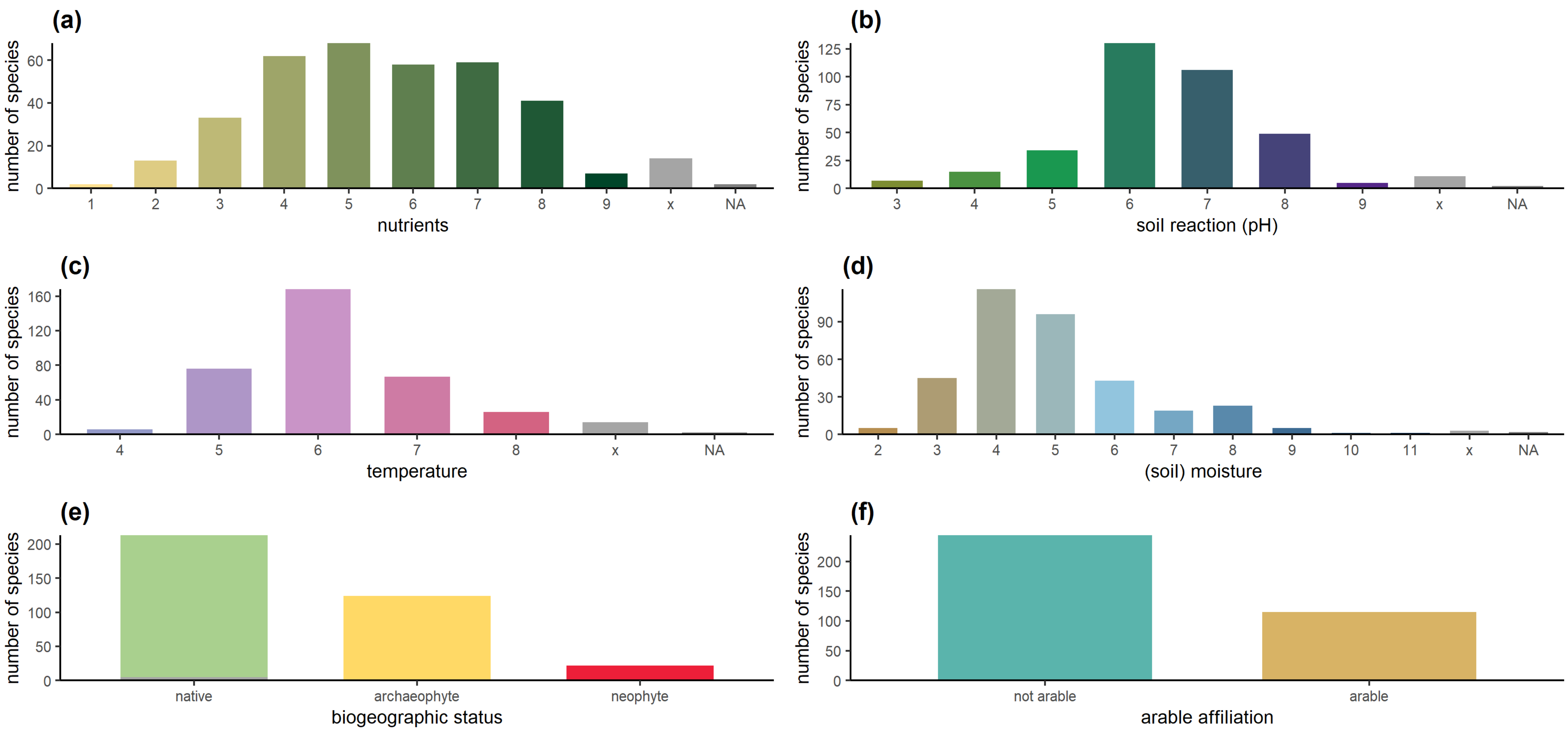




	nutrients	soil reaction (pH)	temperature	(soil) moisture	arable
nutrients	1.00	0.17	-0.10	0.41	0.12
soil reaction (pH)	0.17	1.00	0.32	-0.14	-0.03
temperature	-0.10	0.32	1.00	-0.46	0.07
(soil) moisture	0.41	-0.14	-0.46	1.00	-0.09
arable	0.12	-0.03	0.07	-0.09	1.00

- irrigation has increased
- wet meadows possibly drained and converted
- soil moisture pos. correlated with nutrients
- temperature neg. correlated with soil moisture

Predictor completeness



Model Runtimes

there *are* more sophisticated methods!
but they require
- more data
- more runtime/computing power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PRIMARY RESEARCH ARTICLE

Global Change Biology WILEY

Widespread decline in Central European plant diversity across six decades

David Eichenberg[1,2] | Diana E. Bowler[1,2,3] | Aletta Bonn[1,2,3] | Helge Bruelheide[1,4] | Volker Grescho[1,2] | David Harter[5] | Ute Jandt[1,4] | Rudolf May[5] | Marten Winter[1] | Florian Jansen[6]