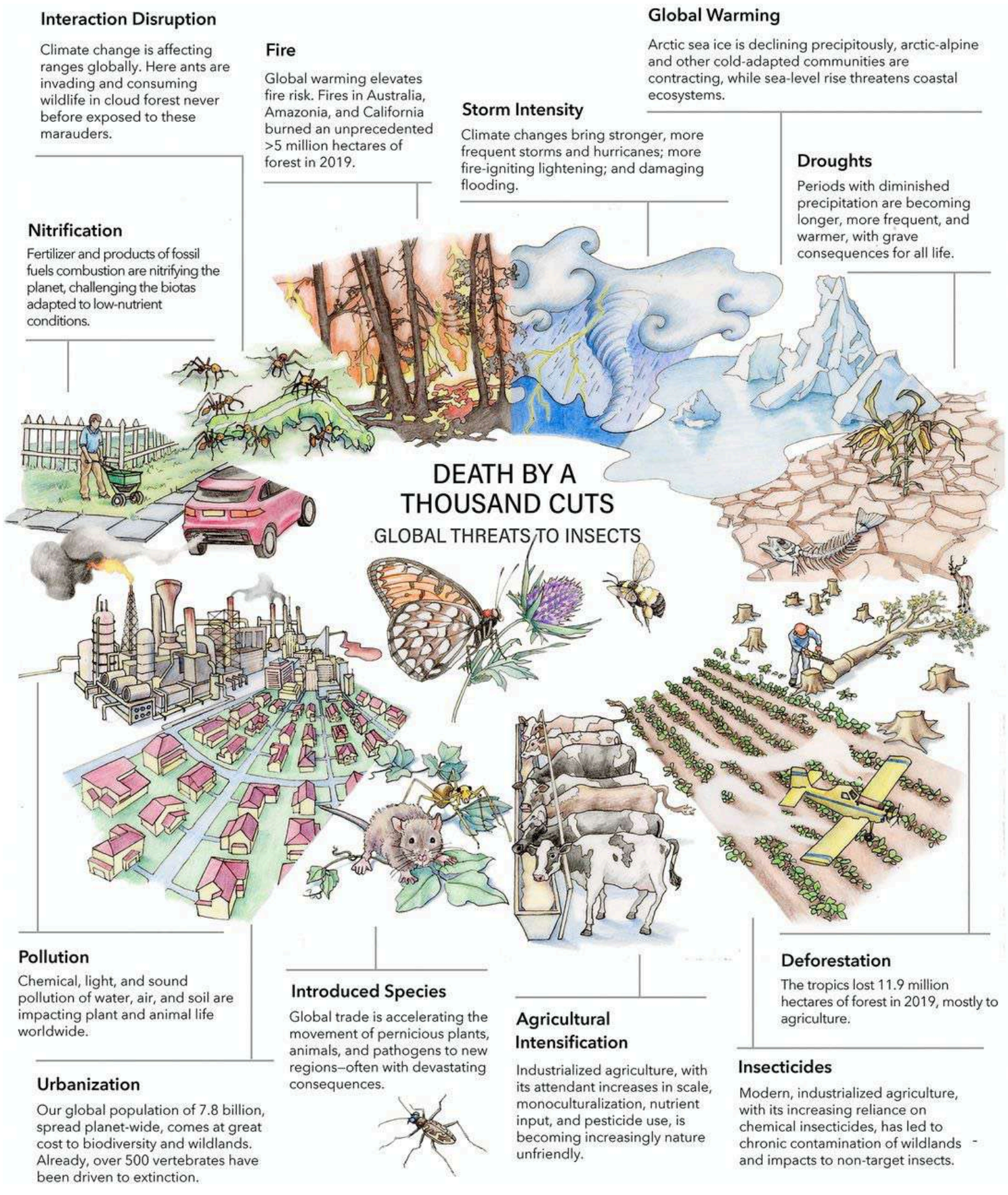
Urban greening in Europe: a pollinators' perspective is urgently needed to develop functional ecological infrastructures

Prof. Nicolas J. VEREECKEN
Université libre de Bruxelles (ULB)
Belgium

Insect decline in the Anthropocene: Death by a thousand cuts



(Image via Pesticide Action Network)

https://unsplash.com/@thomasstephan

https://unsplash.com/@thomasstephan

David L. Wagner et al. PNAS 2021;118:2:e2023989118

BIODIVERSITY

URBANIZATION

https://cpb-us-w2.wpmucdn.com/blog.nus.edu.sg/dist/2/6753/files/2016/09/1001405-crossroads-25nvfgd.jpg

http://www.politico.eu/wp-content/uploads/2015/04/Brussels_Verlauf_SW_zu_4c.jpg

Deadly air in our cities: the invisible killer

The Guardian

Last week scientists put **the number of early deaths caused worldwide by air pollution** at double previous estimates: **8.8 million a year**, according to research published in the *European Heart Journa*l, meaning **toxic air is killing more people than tobacco smoking**.

Tim Smedley

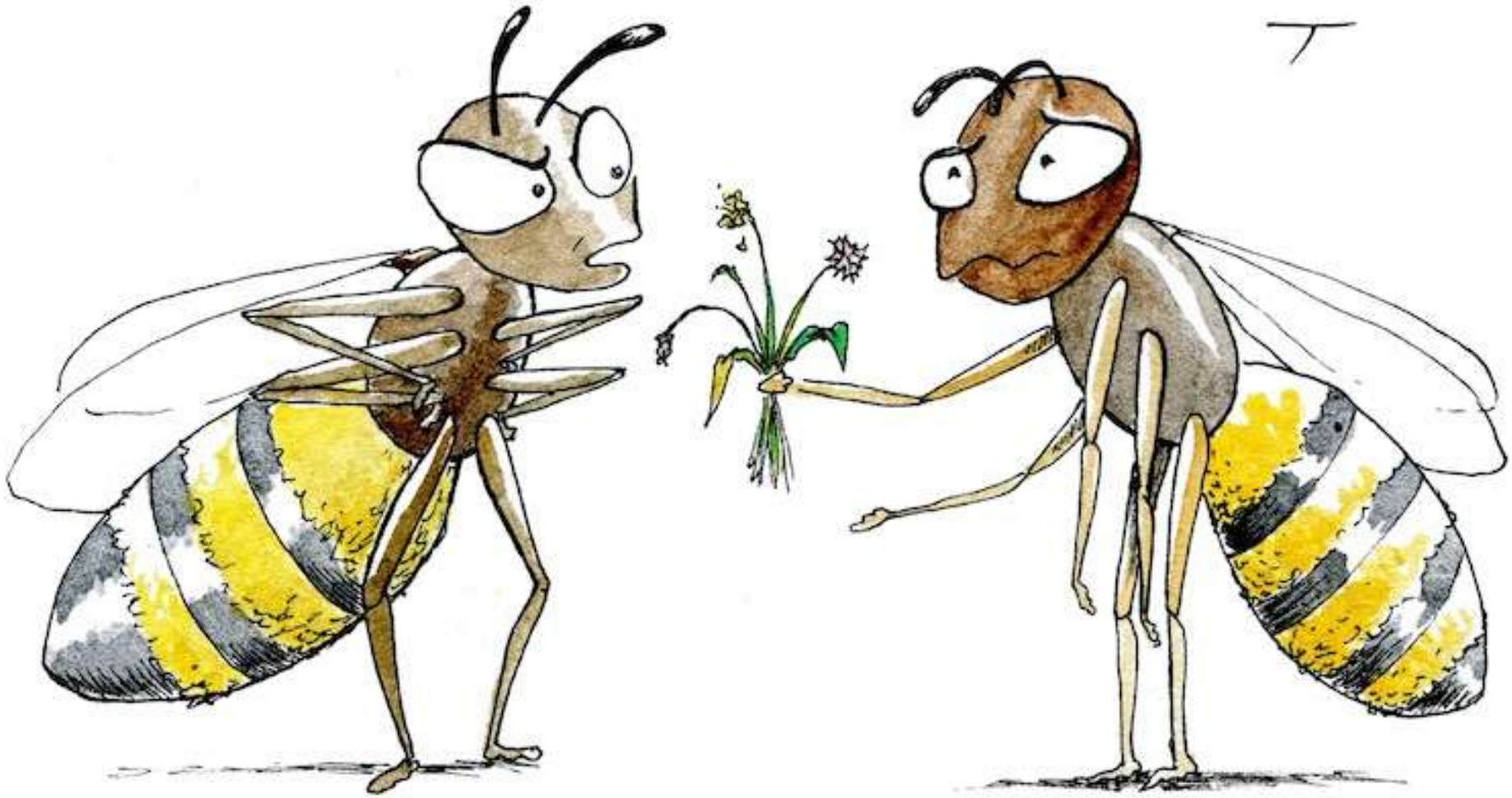
Sun 17 Mar 2019 06.00 GMT

▲ Aerial view south across the city of London in fog and or air pollution. Photograph: Andrew Holt/Getty Images

Wait...

That's all?!?

I am afraid it is, we're experiencing a major food shortage here!



PhiLiNE

Everyone knows « the bee »

The western honeybee (*Apis mellifera*) is just one species

Apis mellifera

Photo NJ Vereecken

Few people know « the bees »

Nos abeilles sauvages printanières

et leurs plantes associées

Nicolas J. Vereecken I meetyourneighbours.net


Osmia cornuta ♂


Osmia cornuta ♀


Osmia caerulescens ♀


Osmia caerulescens ♂


Ranunculus repens


Andrena fulva ♀


Andrena bicolor ♀


Andrena apicata ♀


Bombus terrestris ♀


Andrena nitida ♀


Nomada lathburiana ♀


Andrena vaga ♀


Salix caprea


Sphecodes albilabris ♀


Bombus lapidarius ♂


Osmia bicornis ♀


Osmia bicornis ♂


Bombus pratorum ♀


Andrena gravida ♀


Colletes cunicularius ♀


Vicia sativa


Andrena chrysosceles ♂


Andrena flavipes ♂


Salvia sylvestris


Anthophora plumipes ♀

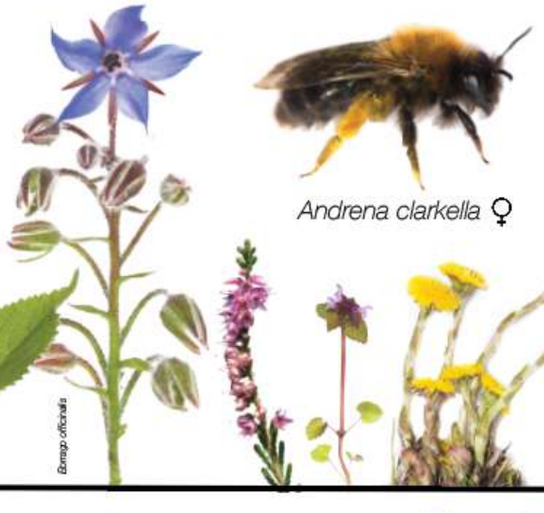

Anthophora plumipes ♂


Bombus hypnorum ♀


Andrena cineraria ♀


Melecta albifrons ♂


Nomada goodeniana ♀


Borago officinalis

Andrena clarkella ♀


Andrena haemorrhoa ♀


Lasioglossum cfr calceatum ♀


Forsythia sp.

Avec le soutien de :

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museum

Flanders State of the art

DEPARTEMENT LEEFMILIEU, NATUUR & ENERGIE

WEEK VAN DE BIJ eerste week juni

service public fédéral SANTE PUBLIQUE, SECURITE DE LA CHAINE ALIMENTAIRE ET ENVIRONNEMENT

Nos abeilles sauvages estivales

et quelques plantes associées

Nicolas J. Vereecken ~ meetyourneighbours.net

Andrena dorsata ♀

Megachile willughbiella ♀

Macropis fulvipes ♂

Andrena curvungula ♀

Anthidium manicatum ♂

Stelis punctulatissima ♀

Halictus scabiosae ♀

Bombus lucorum ♂

Andrena bicolor ♀

Melitta nigricans ♂

Anthidium oblongatum ♀

Anthophora quadrimaculata ♀

Lasioglossum morio ♀

Hylaeus signatus ♂

Coelioxys aurolimbata ♀

Chelostoma campanularum ♀

Chelostoma rapunculi ♀

Bombus lapidarius ♂

Osmia leaiana ♀

Megachile ericetorum ♀

Xylocopa violacea ♀

Megachile centuncularis ♀

Panurgus banksianus ♀

Bombus vestalis ♂

Osmia aurulenta ♀

Osmia bicolor ♀

Colletes daviesanus ♂

Lotus corniculatus

Vicia cracca

Centaurea nigra

Leucanthemum vulgare

Stachys byzantina

Borrago officinalis

Echium vulgare

Hypericum perforatum

Knautia arvensis

Cichorium intybus

Senecio jacobaea

Lythrum salicaria

Lavandula angustifolia

Lathyrus grandiflorus

Lysimachia vulgaris

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Wallonie

Plan Maya

museum

Flanders State of the art

DEPARTEMENT LEEFMILIEU, NATUUR & ENERGIE

WEEK VAN DE BIJ eerste week juni

service public fédéral SANTE PUBLIQUE, SECURITE DE LA CHAINE ALIMENTAIRE ET ENVIRONNEMENT

Publié en 2019 (FR/EN) — 600 pages

Ce guide constitue le premier volume d'une série sur les Hyménoptères d'Europe. Dans sa première partie une présentation générale est proposée sur leur morphologie, leur écologie, leur évolution et les méthodes pour établir une collection de spécimens. Nous proposons aussi une clé de détermination pour l'ensemble des super-familles recensées sur le continent européen.

Le guide développe ensuite une synthèse des connaissances sur les abeilles sauvages d'Europe et des régions limitrophes, en tenant compte des dernières avancées scientifiques. Cette diversité se décline en plus de 2000 espèces réparties en 77 genres sur tout le territoire couvert par cet ouvrage.

L'ouvrage aborde la biologie, la morphologie, l'écologie et la conservation des abeilles sauvages d'Europe. Il propose ensuite, pour la première fois, une clé d'identification illustrée des 77 genres, ainsi qu'un inventaire exhaustif des espèces et une description complète d'abeilles sauvages représentatives au sein de chaque genre (morphologie, écologie, distribution).

Un guide de référence complet accessible aux non-spécialistes à emporter partout pour découvrir l'étonnante diversité de ces pollinisateurs indispensables !

Remerciements à
Sophie Dufour, Michel Herlant,
Virginie et Uwe Otto

ISBN 978-2-913688-21-6
00 €

Denis Michez
Pierre Rasmont
Michaël Terzo
Nicolas J. Vereecken

Hyménoptères d'Europe • 1

ABEILLES D'EUROPE

Hyménoptères d'Europe • 1

ABEILLES D'EUROPE

Denis MICHEZ
Pierre RASMONT
Michaël TERZO
Nicolas J. VEREECKEN

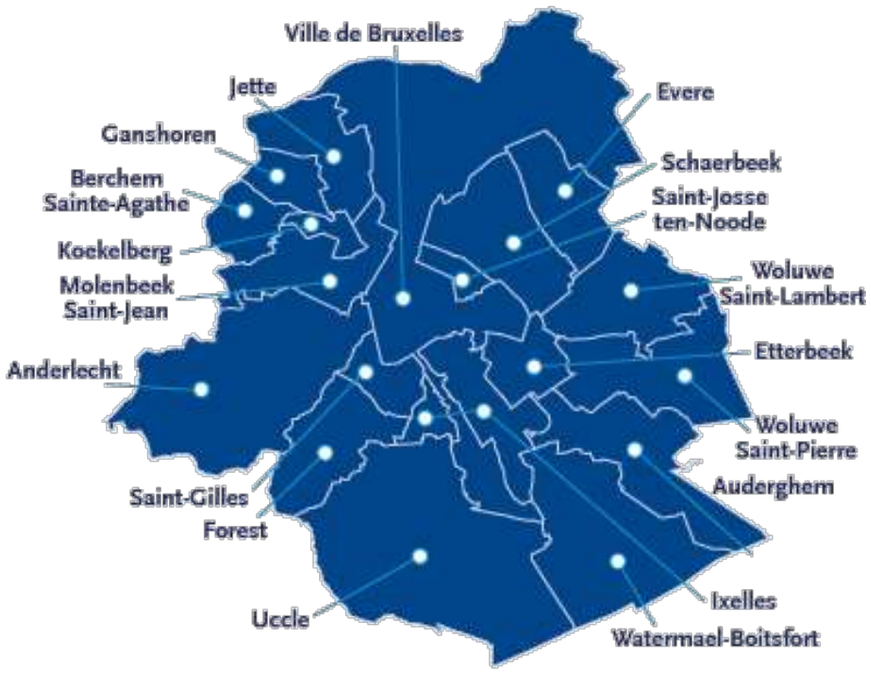
IUCN SSC

WILD BEE SPECIALIST GROUP

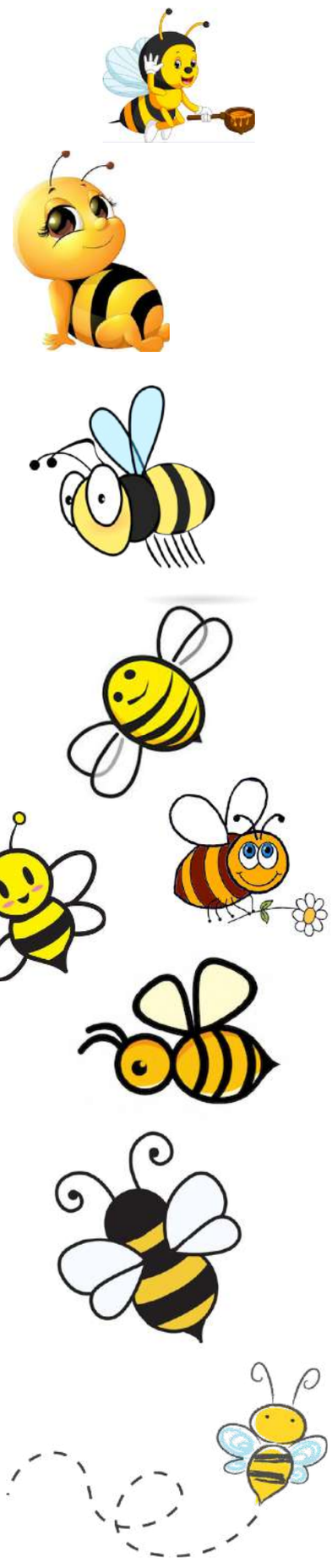
Europe Leadership Group

Prof. Nicolas J. VEREECKEN (Overall lead), Prof. Michael KUHLMANN (Lead), Dr. Thomas J. WOOD (Lead),
Dr. Vladimir RADCHENKO (Lead) & Mr. Stuart P.M. ROBERTS (Lead)

How many species of bees are there?



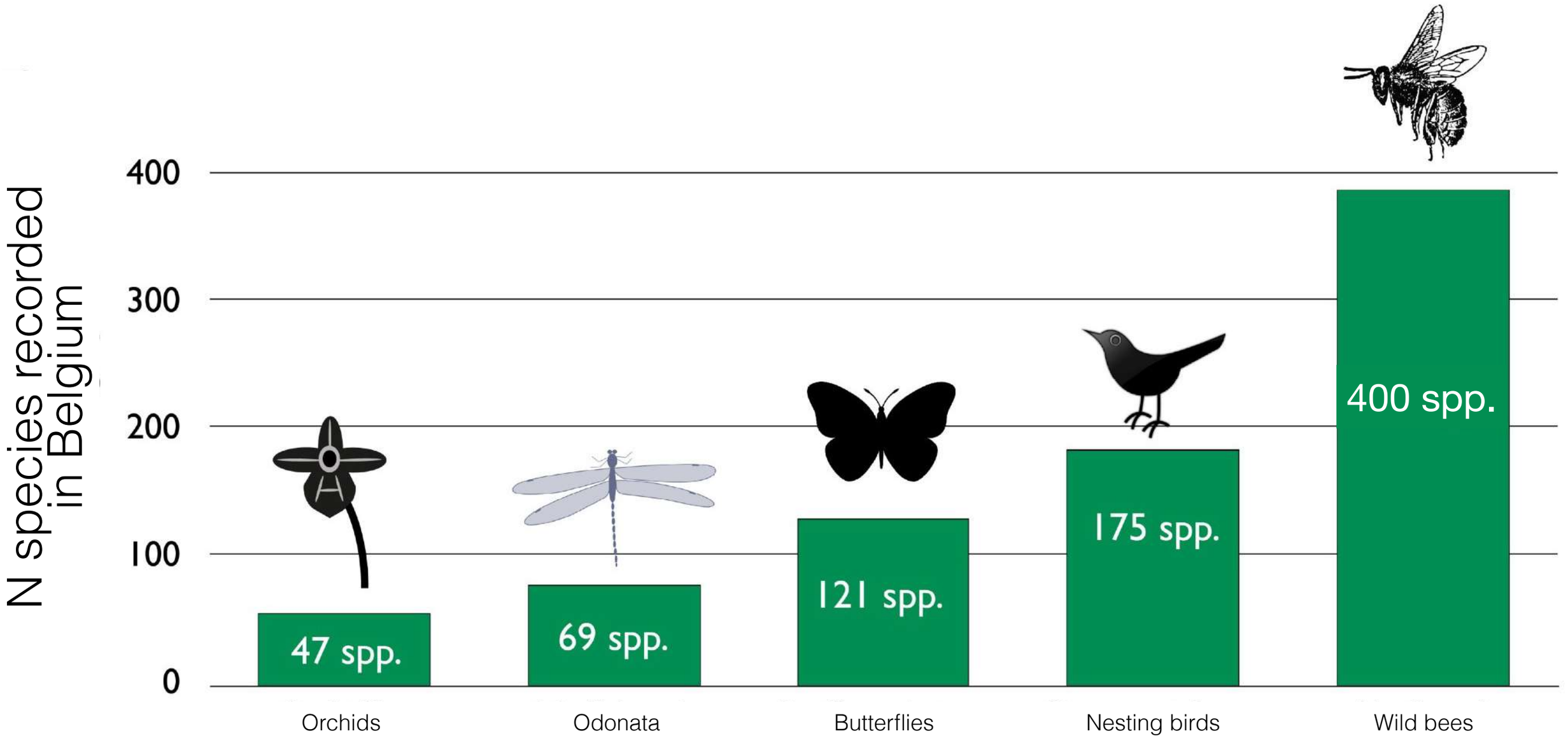
210 espèces



400 espèces

2000 espèces

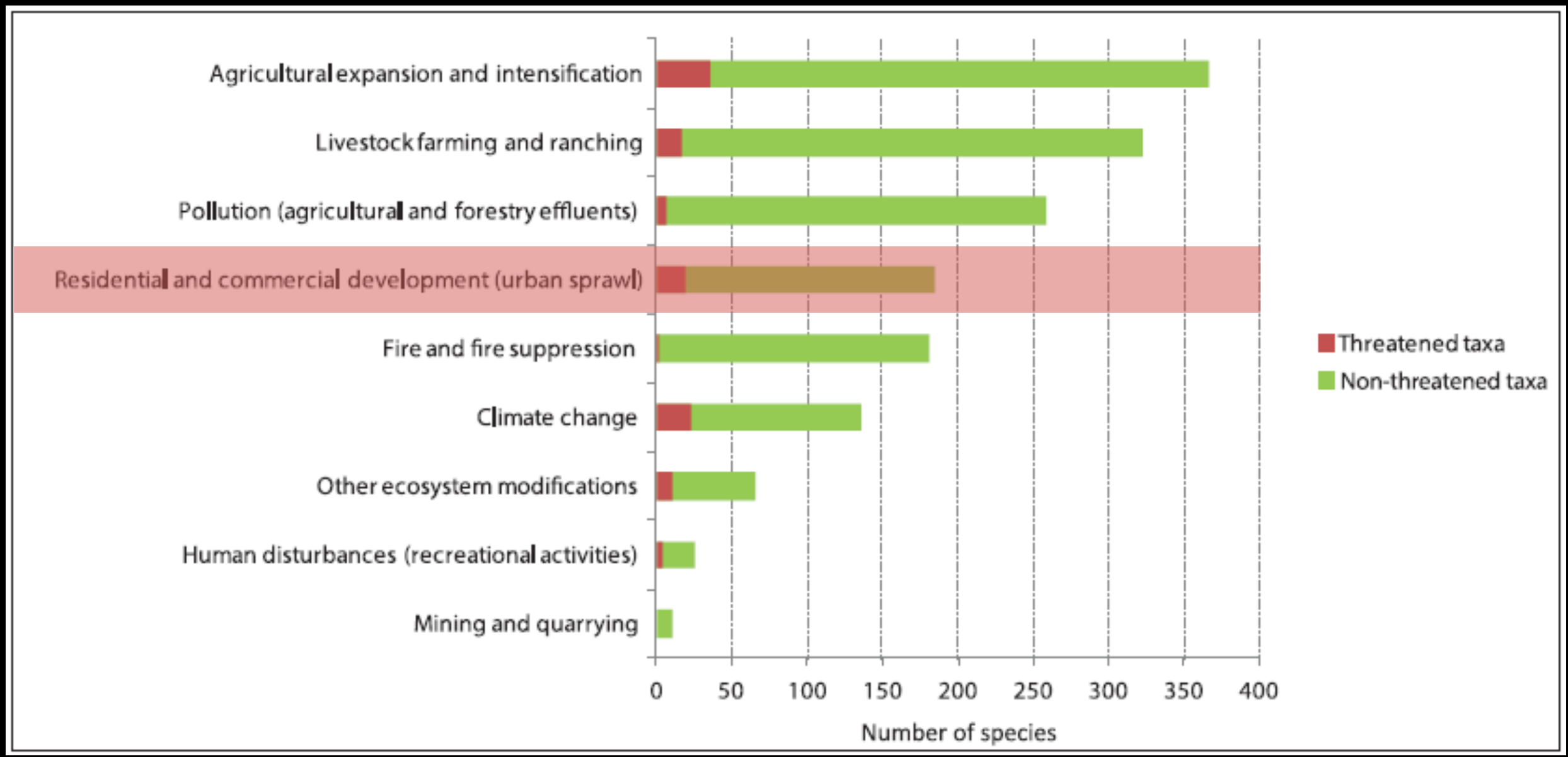
20.000 espèces


N species recorded in Belgium
400
300
200
100
0
47 spp.
69 spp.
121 spp.
175 spp.
400 spp.
Orchids
Odonata
Butterflies
Nesting birds
Wild bees

Facts on bee decline

Bees are having a bad buzz…

The major threats to wild bees following the IUCN



Nieto et al. (2015) European Red List of Bees. IUCN.

Belgian Red List of Bees

Maxime Drossart, Pierre Rasmont, Pieter Vanormelingen, Marc Dufrêne, Morgane Folschweiller, Alain Pauly, Nicolas J. Vereecken, Sarah Vray, Ella Zambra, Jens D'Haeseleer and Denis Michez

Drossart et al. (2019)

Overall, 32.8% of bees (i.e. 113 species) are considered threatened in Belgium. Considering the Near Threatened (i.e. 26 species; 6.8%) and Regionally Extinct (i.e. 45 species; 11.8%) bees, the present study suggests that more than half (i.e. 53.3%) of the assessed species (i.e. 184 species) are (nearly) threatened or extinct in Belgium.

Table 6. Summary of number of bee species within each IUCN category.

IUCN Red List Categories	No. species Belgium	No. species Europe
Extinct (EX)	0	0
Extinct in the Wild (EW)	0	0
Regionally Extinct (RE)	45	0
Critically Endangered (CR)	47	7
Endangered (EN)	32	46
Vulnerable (VU)	34	24
Near Threatened (NT)	26	101
Least Concern (LC)	161	663
Data Deficient (DD)	36	1,101
Total number of species assessed	**381**	**1,942**

*This table does not include the Not Applicable species in Belgium (22).

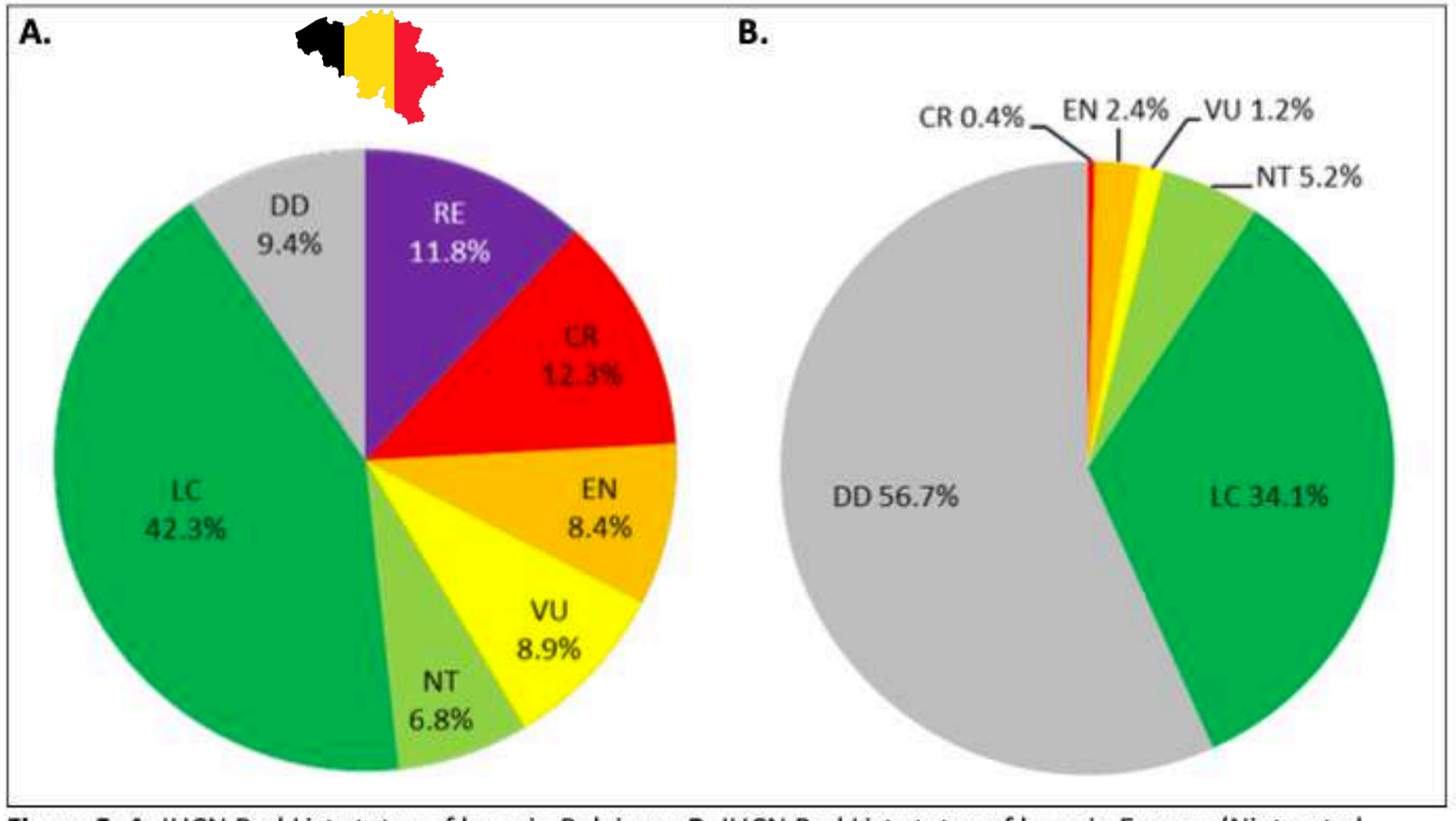
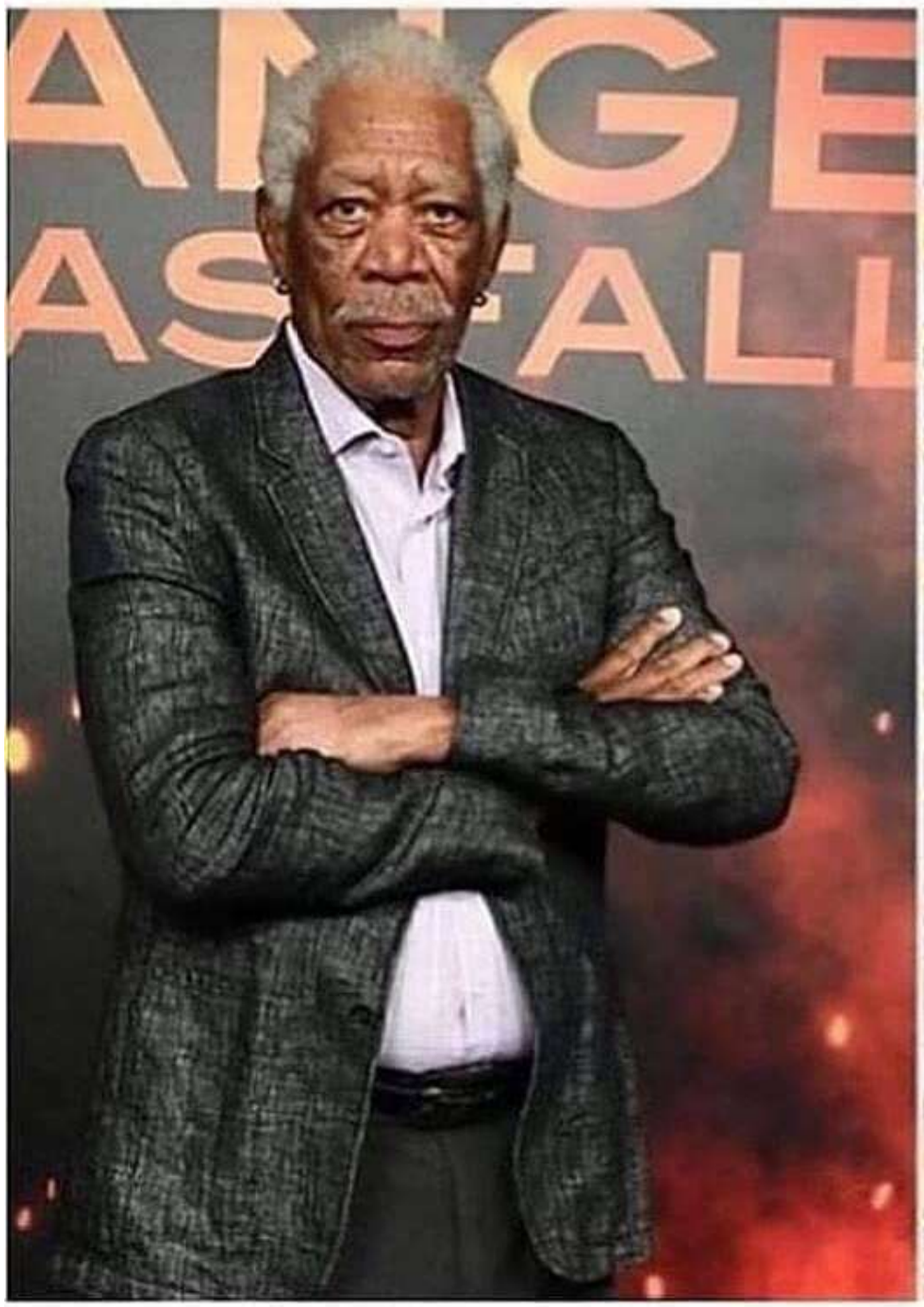


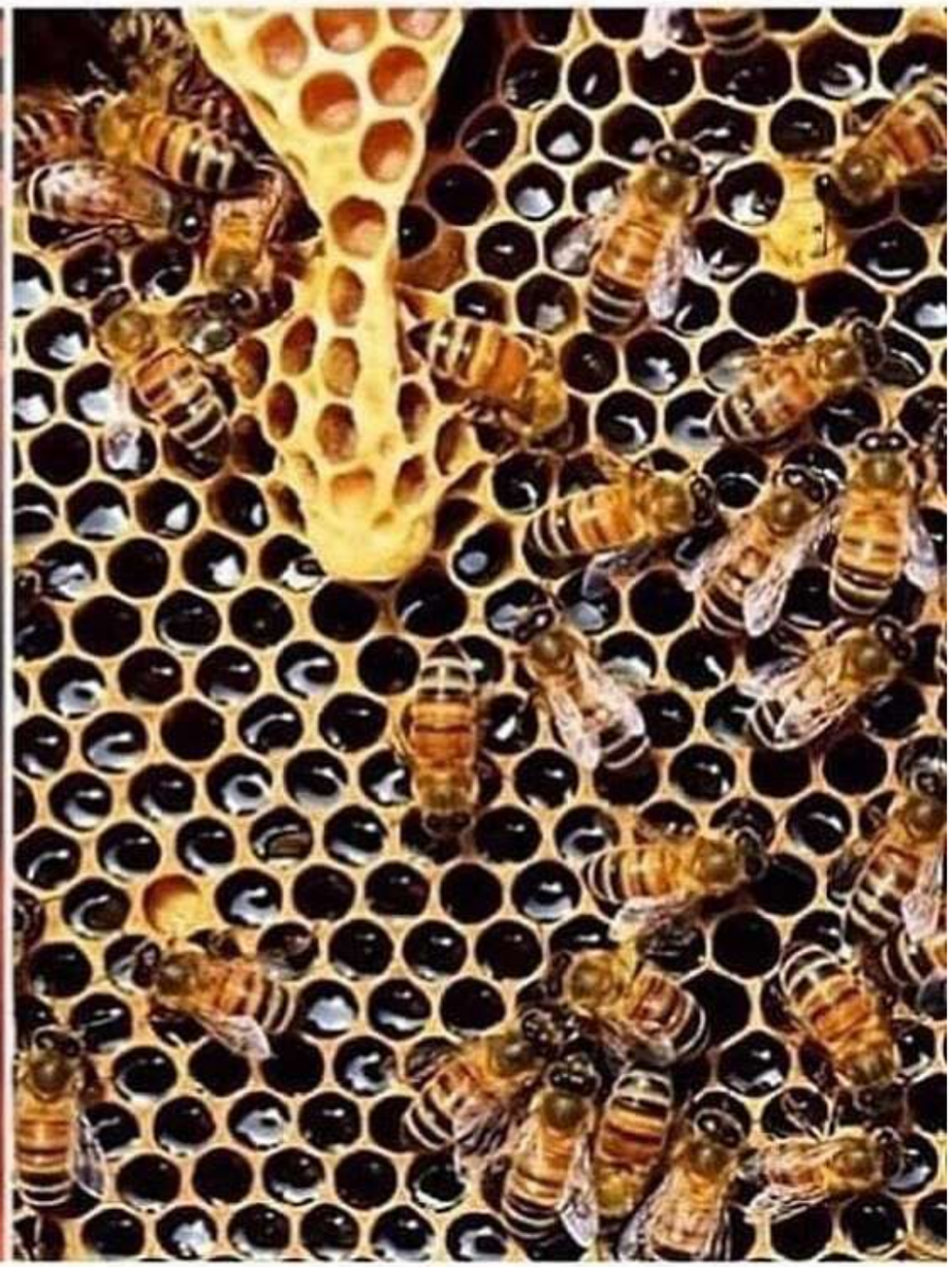
Figure 5. A. IUCN Red List status of bees in Belgium ; **B.** IUCN Red List status of bees in Europe (Nieto et al. 2014).

The honey bee is probably the least threatened of all bees in Europe

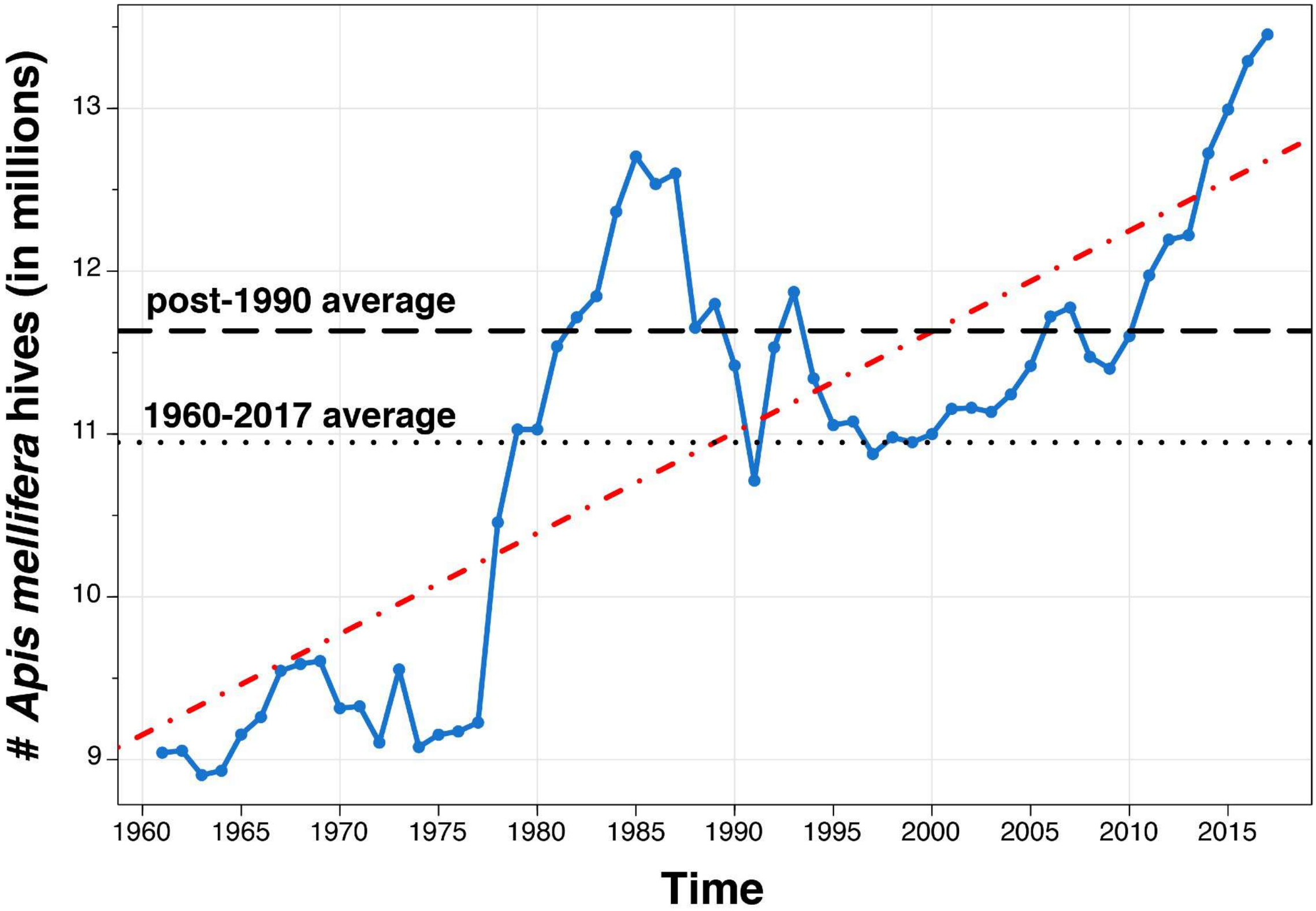
Morgan Freeman converted his 124-acre ranch into a giant sanctuary to protect honey bees

@globalpositivenews





The honey bee is probably the least threatened of all bees in Europe



Wood *et al.* (2020) Managed honey bees as a radar for wild bee decline? *Apidologie* 51: 1100–1116.

Apidologie
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DOI: 10.1007/s13592-020-00788-9

Review Article

(2020)

Managed honey bees as a radar for wild bee decline?

T. J. Wood[1], D. Michez[1], R. J. Paxton[2,3], M. Drossart[1], P. Neumann[4], M. Gérard[1], M. Vanderplanck[1], A. Barraud[1], B. Martinet[1], N. Leclercq[5], N. J. Vereecken[5]

[1]Laboratory of Zoology, Université de Mons, Avenue du Champs de Mars 6, Mons, Belgium
[2]Institute of Biology, Martin Luther University Halle-Wittenberg, Hoher Weg 8, 06120, Halle, Germany
[3]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Deutscher Platz 5e, 04103, Leipzig, Germany
[4]Institute of Bee Health, Vetsuisse Faculty, University of Bern, Bern, Switzerland
[5]Agroecology Lab, Université Libre de Bruxelles, Brussels, Belgium

Received 13 March 2020 – Revised 27 May 2020 – Accepted 30 June 2020

Abstract – Wild and managed bees are essential for global food security and the maintenance of biodiversity. At present, the conservation of wild bees is hampered by a huge shortfall in knowledge about the trends and status of individual species mainly due to their large diversity and variation in life histories. In contrast, the managed Western honey bee *Apis mellifera* is one of the best studied and monitored insects in existence. Since similar drivers may be relevant for the decline of wild bees and losses of managed honey bees, this raises the possibility that monitoring of honey bees may help to detect threatened regions for wild bees, thereby fostering urgently required conservation measures. However, this possible relationship has not yet been explicitly tested for. Moreover, research currently focused on honey bees as a model species may yield important insights into wild insect susceptibility to stressors and vice versa. Here we use the bees of Europe as a model to show that managed honey bees are not suitable surrogates for detecting declines in wild bees. A direct comparison of the response of wild bees and honey bees to the same threats (nutritional deficiencies, parasites and pathogens, pesticides, and a changing climate) shows that, whilst some of their responses may be similar at the individual level, when considered at the reproductive level (individuals versus colonies), many of their responses diverge. These results reinforce the need for basic research into wild bee biology, the need for national monitoring schemes for wild bee populations, and the call for conservation actions tailored to the individual ecologies of wild bee species.

wild bees / indicator species / species specific / sociality / populations

1. INTRODUCTION

Declines in wild bee populations and losses in managed bee populations have been reported from around the world (Neumann and Carreck 2010; Cameron et al. 2011), but particularly from Europe, where extensive records of historical bee distributions exist (Biesmeijer et al. 2006; Potts et al. 2010a; Senapathi et al. 2015). Evidence of declines in wild bee species has come primarily from studies that have assessed aggregate changes in species richness across regions over time; evidence from species-specific, quantitative, and year-to-year assessments of changes in population sizes is much rarer, though they are becoming the focus of more attention as the quality of both datasets and computational techniques improves (Ogilvie et al. 2017; Powney et al. 2019).

As the response of different species to a changing environment can vary hugely, even within the

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s13592-020-00788-9) contains supplementary material, which is available to authorized users.

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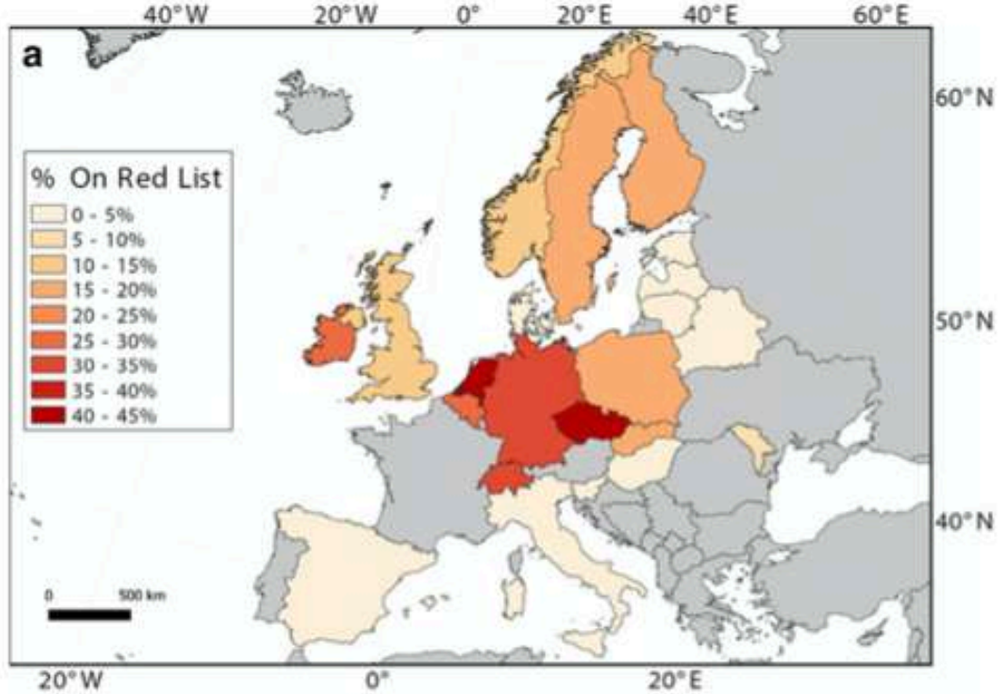
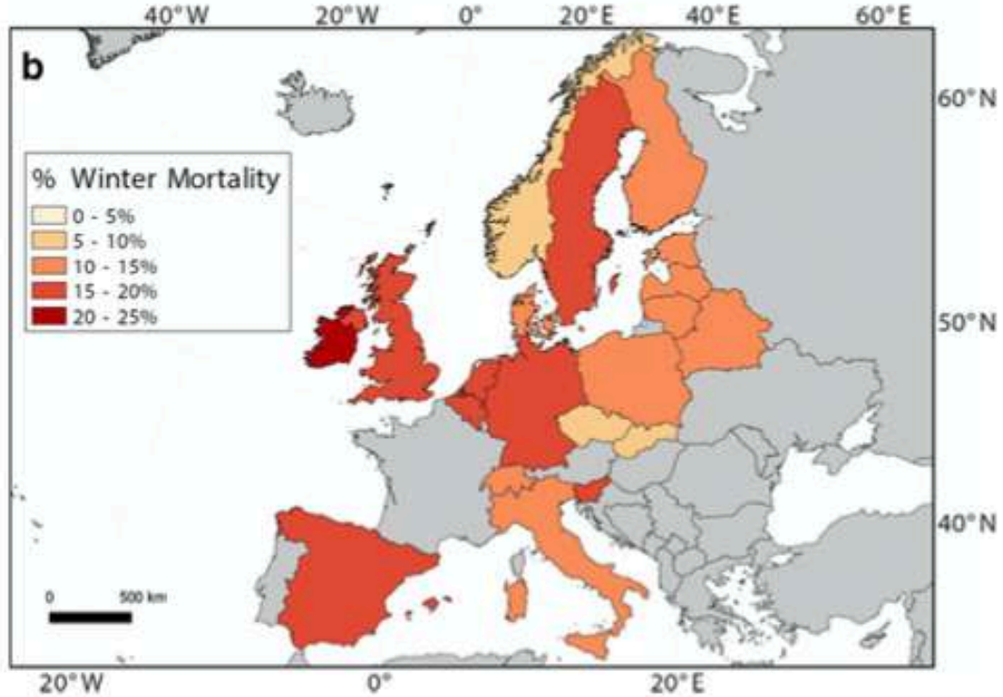
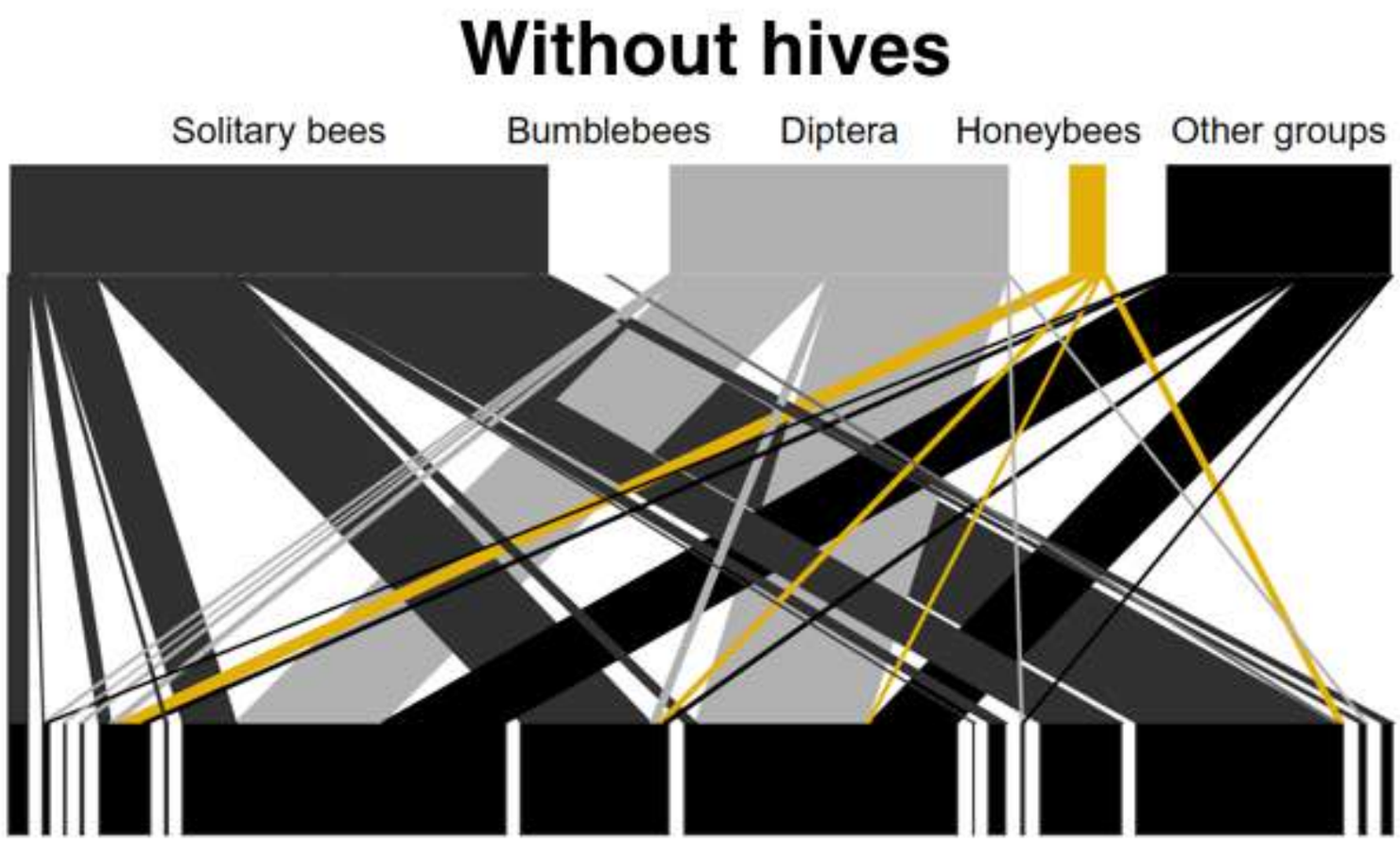
Handling Editor: Mathieu Lihoreau

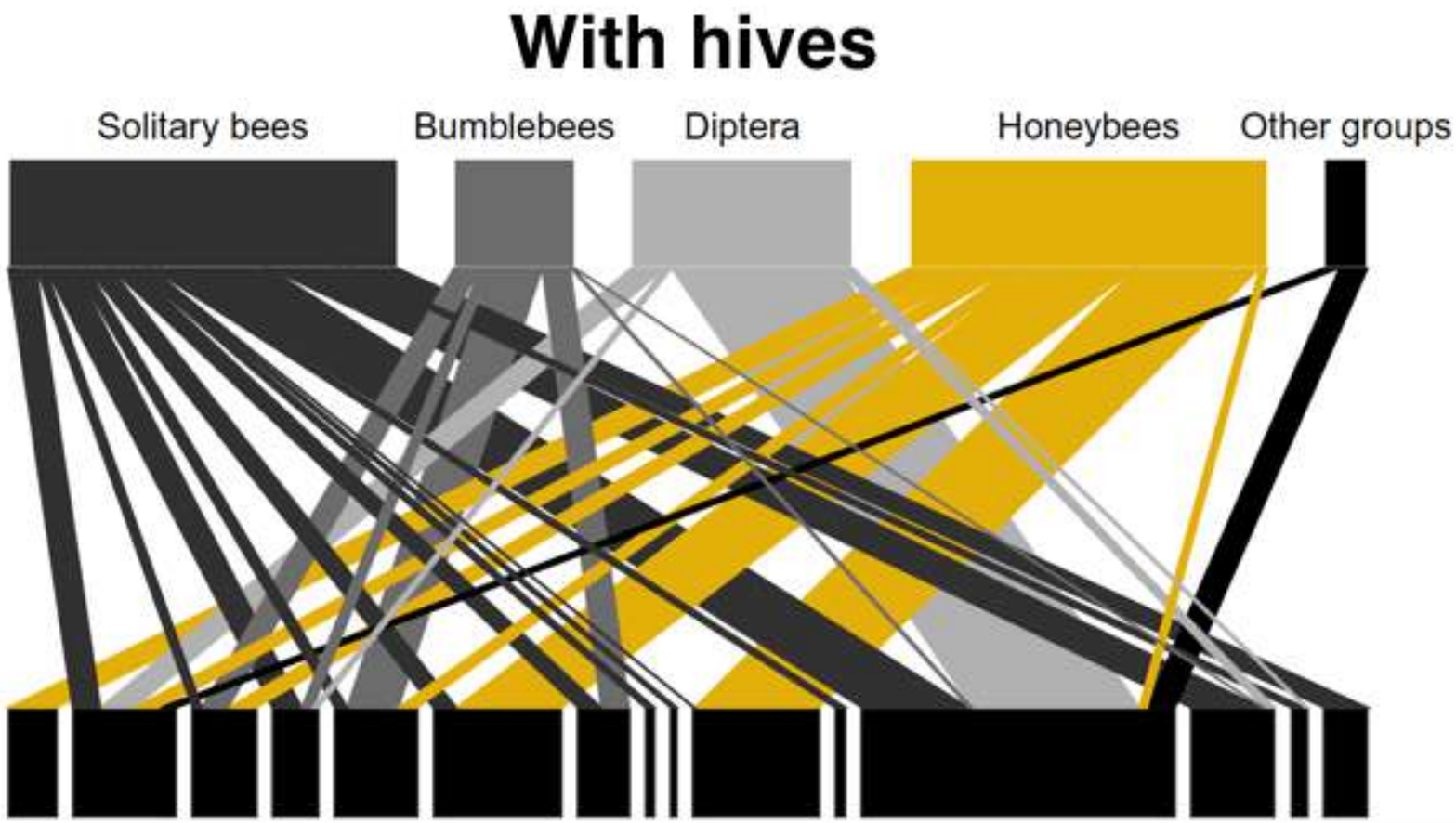




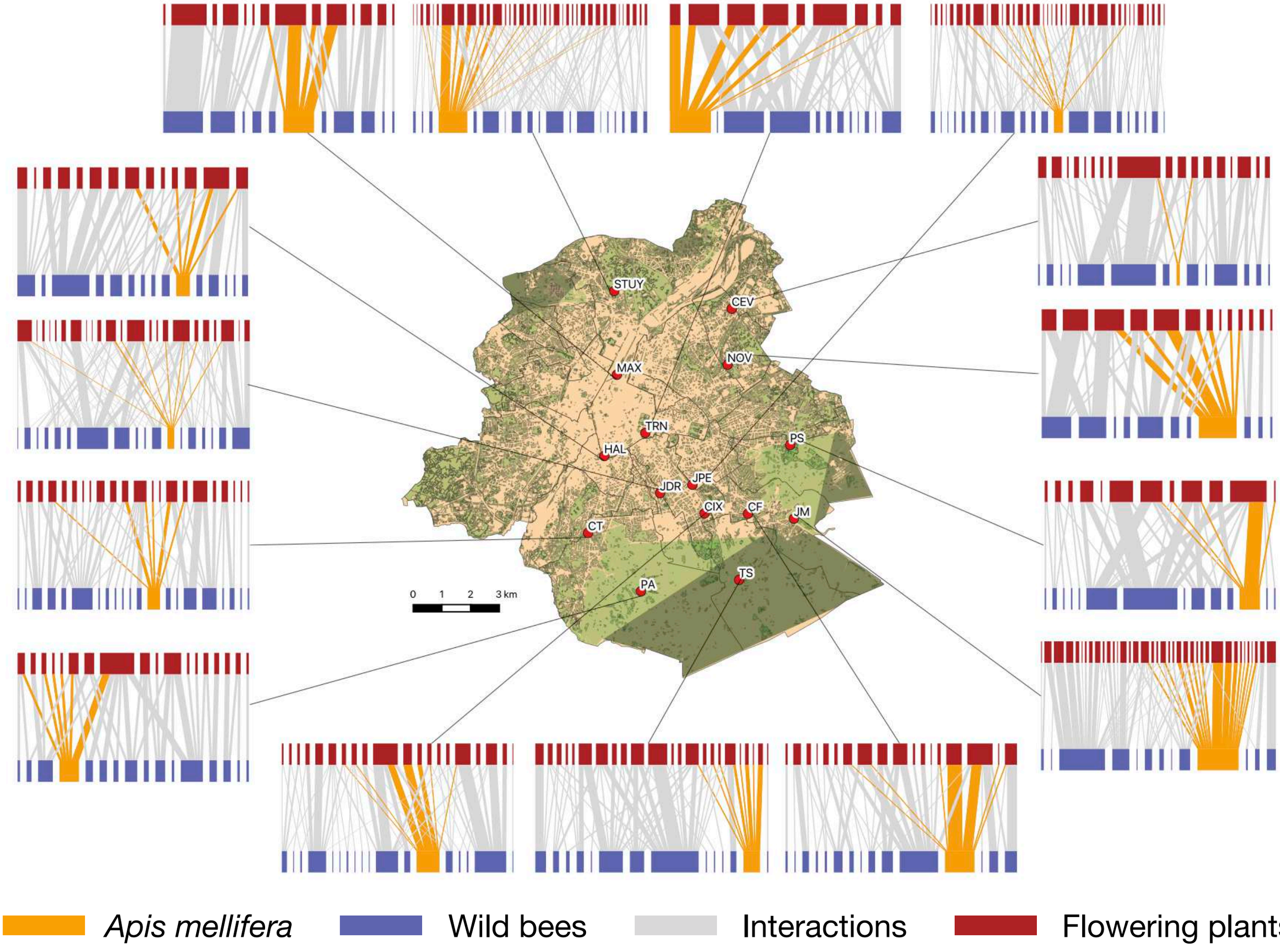
Using data from the COLOSS project (van der Zee et al. 2012, 2014; Brodschneider et al. 2016, 2018, Table I), we found that the average rate of honey bee colony winter mortality (Figure 4a) was not significantly correlated with the number of wild bee species assessed as threatened by national Red Lists as a percentage of the national fauna (GLM, $t_{20} = 0.986$, $p = 0.337$, $R^2 = 0.049$)

Impact of honey bees on wild bees





Geslin et al. 2017 AER


STUY
CEV
NOV
MAX
TRN
PS
HAL
JPE
JDR
CIX
CF
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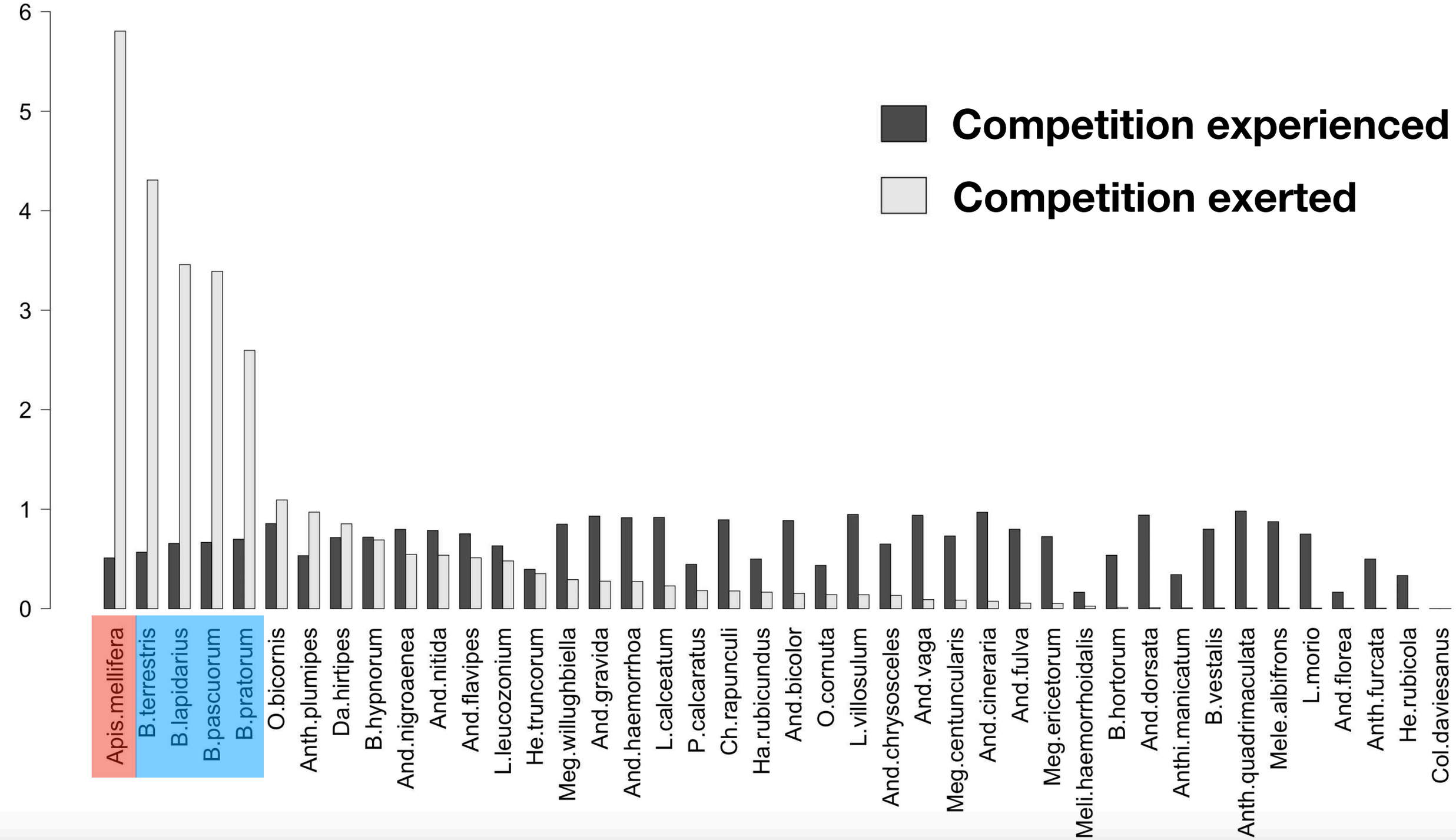
0 1 2 3 km
Apis mellifera
Wild bees
Interactions
Flowering plants

Potential apparent competition (PAC) in Brussels



- All bee species are subject to a certain level of intra- and inter-specific competition

Urban bees: just a few species or a bounty of species?

Urban green spaces and biodiversity: Are they synonyms?

http://images.trvl-media.com/media/content/shared/images/travelguides/Brussels-and-vicinity-178241-smallTabletRetina.jpg

Taxonomic and functional trait diversity of wild bees in different urban settings

Étienne Normandin[1,*], Nicolas J. Vereecken[2,*], Christopher M. Buddle[3] and Valérie Fournier[1]

[1] Centre de Recherche en Innovation sur les Végétaux, Université Laval, Québec, Canada
[2] Landscape Ecology & Plant Production Systems Unit, Université Libre de Bruxelles, Bruxelles, Belgique
[3] Department of Natural Resource Sciences, McGill University, Ste-Anne-de-Bellevue, Canada
[*] These authors contributed equally to this work.

ABSTRACT

Urbanization is one of the major anthropogenic processes contributing to local habitat loss and extirpation of numerous species, including wild bees, the most widespread pollinators. Little is known about the mechanisms through which urbanization impacts wild bee communities, or the types of urban green spaces that best promote their conservation in cities. The main objective of this study was to describe and compare wild bee community diversity, structure, and dynamics in two Canadian cities, Montreal and Quebec City. A second objective was to compare functional trait diversity among three habitat types (cemeteries, community gardens and urban parks) within each city. Bees were collected using pan traps and netting on the same 46 sites, multiple times, over the active season in 2012 and 2013. A total of 32,237 specimens were identified, representing 200 species and 6 families, including two new continental records, *Hylaeus communis* Nylander (1852) and *Anthidium florentinum* (Fabricius, 1775). Despite high community evenness, we found significant abundance of diverse species, including exotic ones. Spatio-temporal analysis showed higher stability in the most urbanized city (Montreal) but low nestedness of species assemblages among the three urban habitats in both cities. Our study demonstrates that cities are home to diverse communities of wild bees, but in turn affect bee community structure and dynamics. We also found that community gardens harbour high levels of functional trait diversity. Urban agriculture therefore contributes substantially to the provision of functionally diverse bee communities and possibly to urban pollination services.

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Academic editor
Sean Brady

Additional Information and Declarations can be found on page 26

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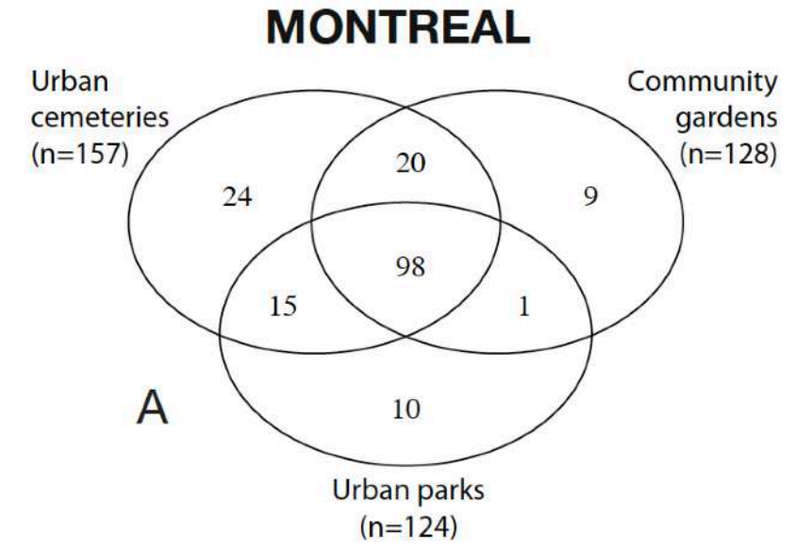
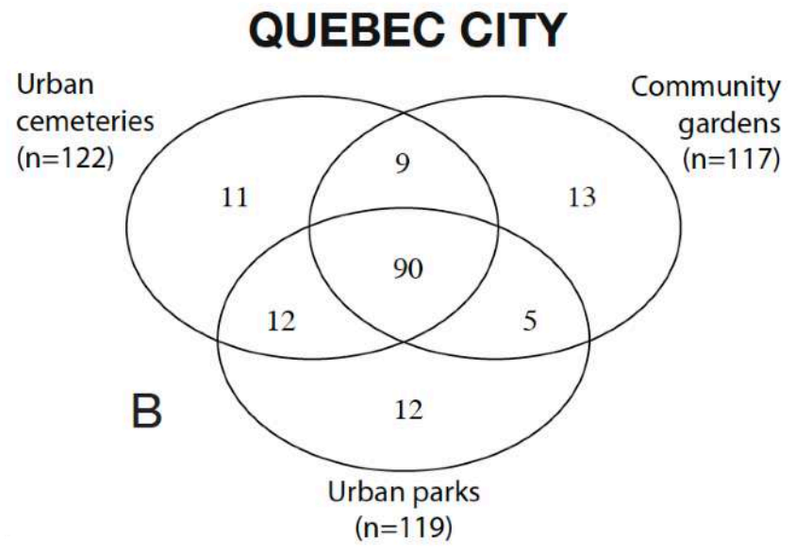
Subjects Biodiversity, Conservation Biology, Ecology, Entomology, Taxonomy
Keywords Urban ecology, Urban agriculture, Exotic species, Dominant species, Urbanization, Synanthropic species, Community ecology, Bee survey, Pollinator conservation, Biodiversity

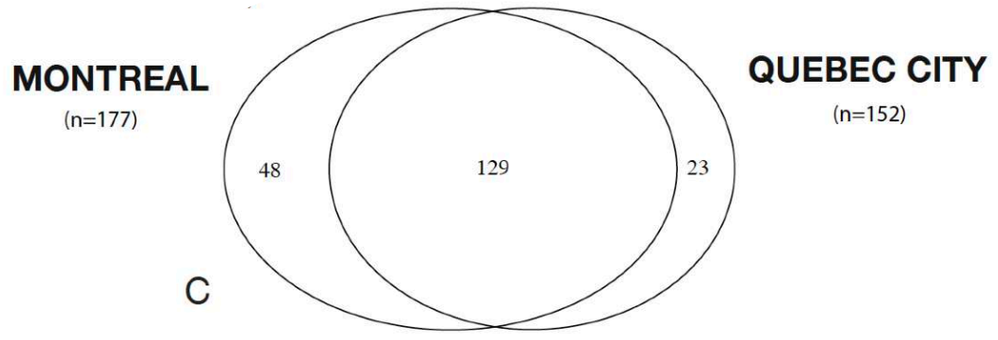
INTRODUCTION

Urbanization is pervasive worldwide, and dramatically modifies environments (*Aronson et al., 2014*; *Shochat et al., 2010*; *McDonnell & Hahs, 2008*; *McKinney, 2002*). Global urban sprawl and infrastructure development has increased considerably in the past 100 years, and this trend will continue well in the 21st century, with an estimated 66% of the world's population living in cities by 2050 (*United Nations Department of Economic, Social Affairs Population Division, 2014*). The ongoing expansion of paved surfaces, buildings, devegetated lands and human activities will amplify habitat loss, a leading cause of species extinction and

How to cite this article Normandin et al. (2017), Taxonomic and functional trait diversity of wild bees in different urban settings. **PeerJ 5:e3051; DOI 10.7717/peerj.3051**

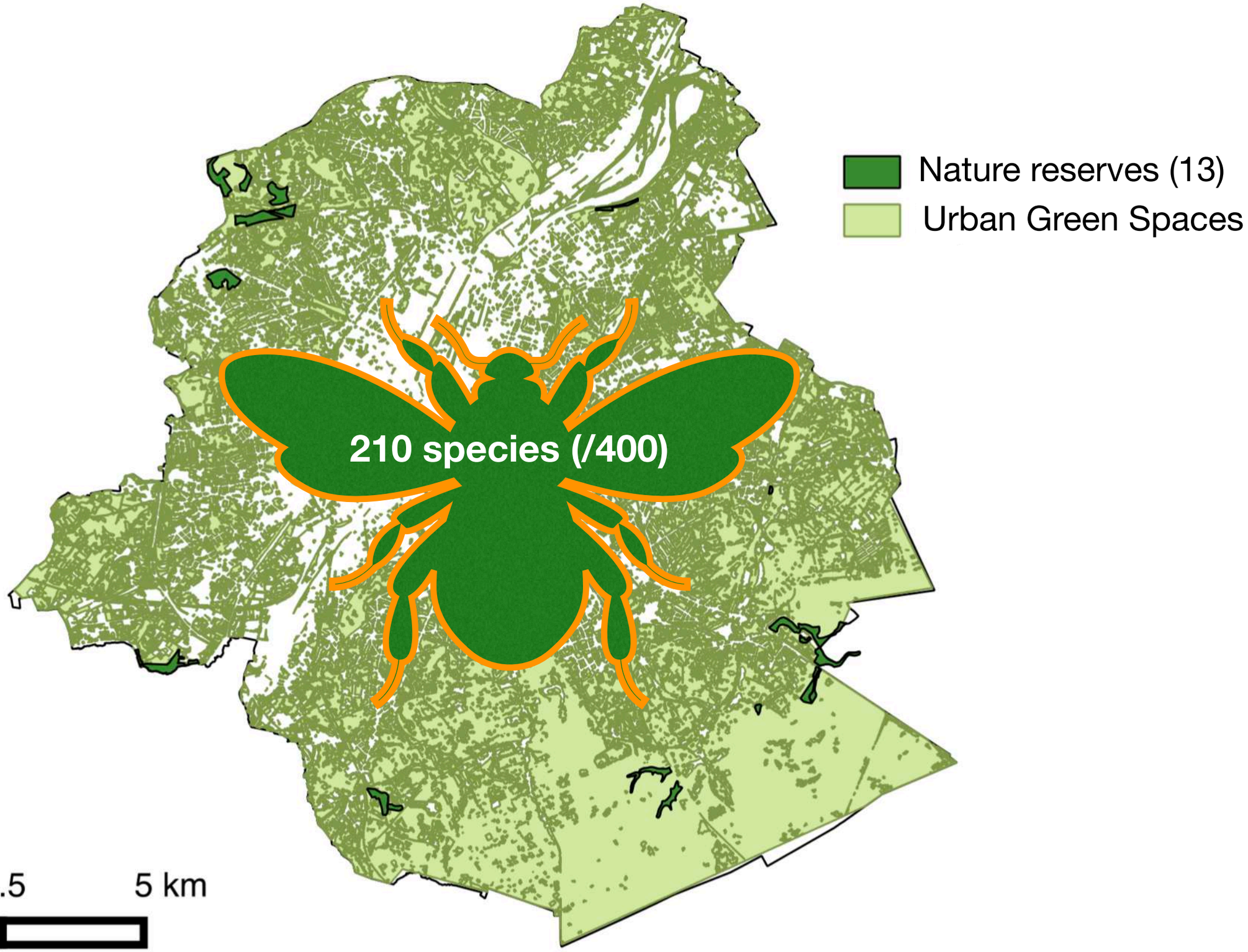






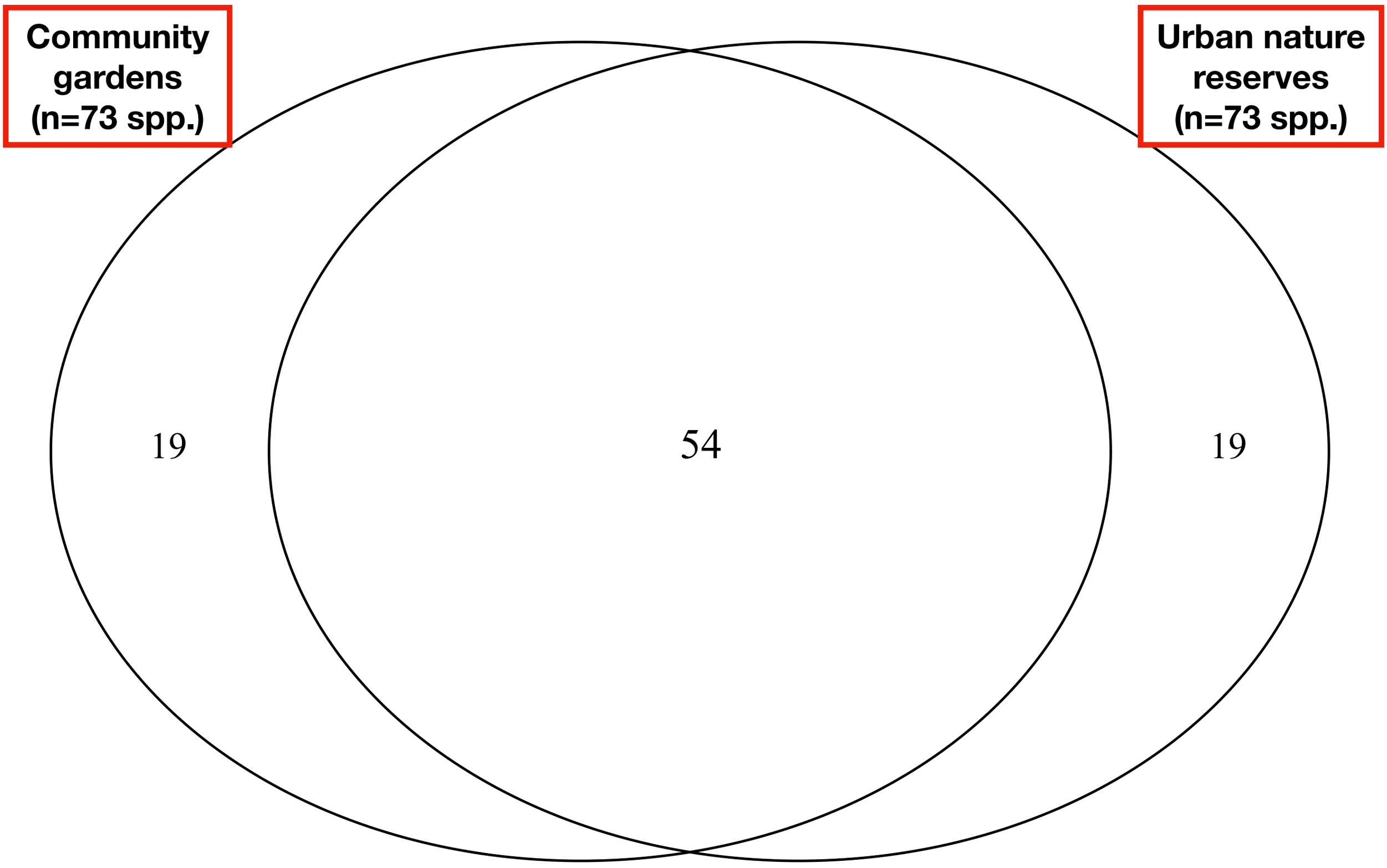
Brussels (Belgium)

A « garden city » at the heart of Europe



Could community gardens be the next generation of urban nature reserves?

Are urban agriculture plots a new form of nature reserves in cities?



Macropis fulvipes Photo © NJ Vereecken

Wild bees as « environmental detectives »

***Osmia cornuta* mating pair (Hym. Megachilidae)**
Photo © NJ Vereecken

Osmia cornuta

* New to the UK in 2017

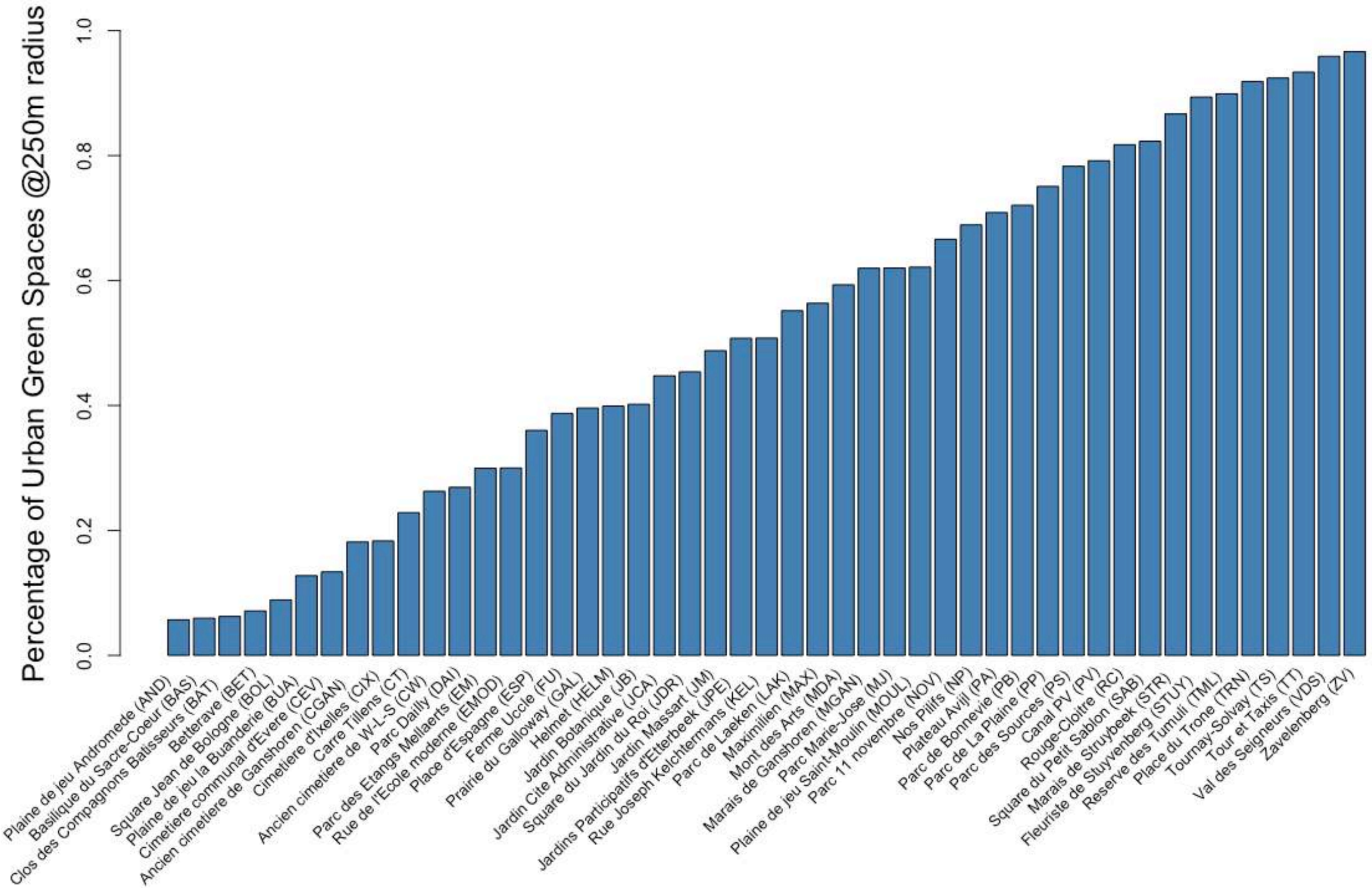
Source: Nieto *et al.* (2015) IUCN Red List of EU bees

***Osmia bicornis* mating pair (Hym. Megachilidae)**
Photo © NJ Vereecken

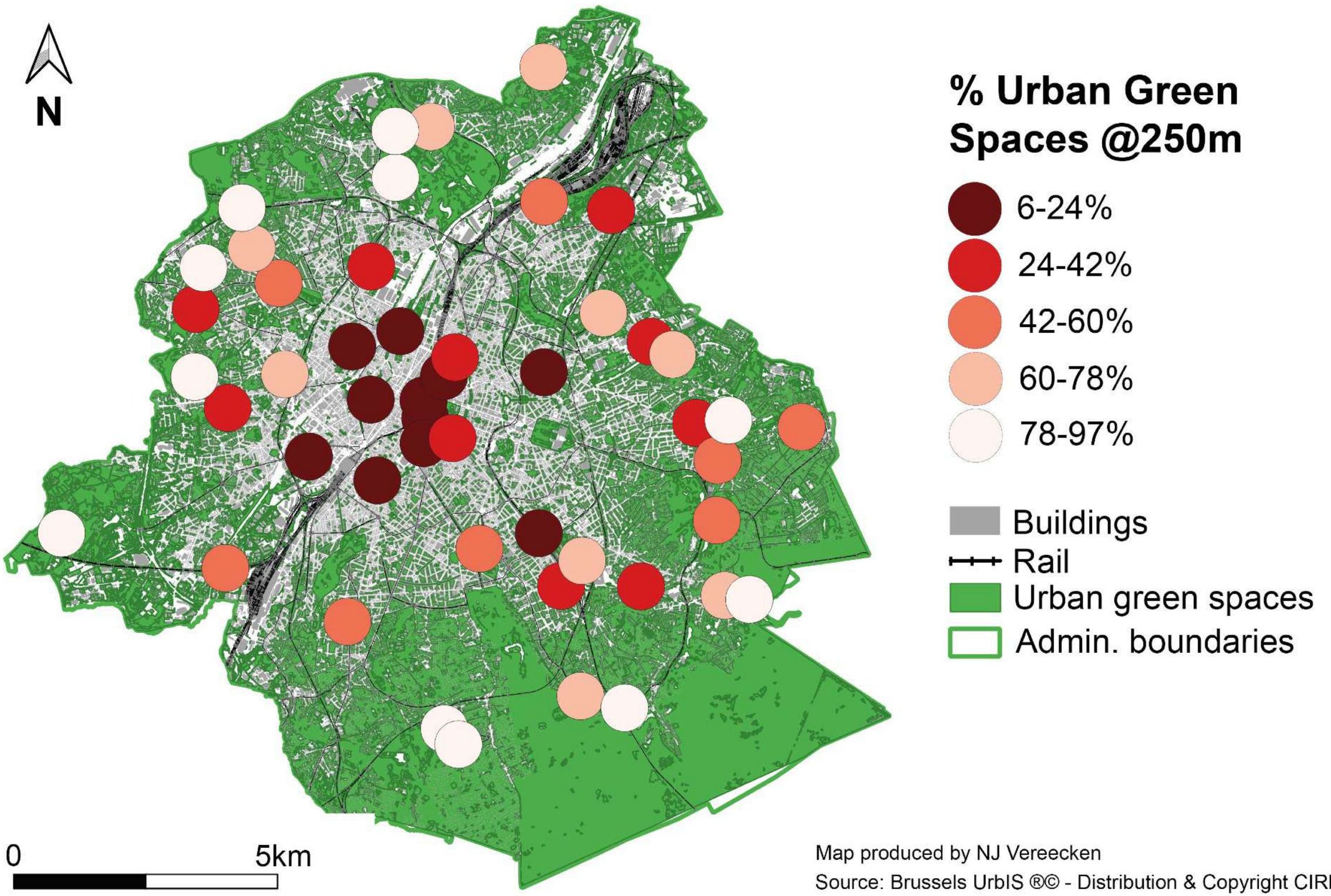
Osmia bicornis (syn. *O. rufa*)

Source: Nieto *et al.* (2015) IUCN Red List of EU bees

Experimental setup - UGS in Brussels



Experimental setup - UGS in Brussels (n=49)



***Osmia cornuta* egg (Hym. Megachilidae)**
Photo © NJ Vereecken

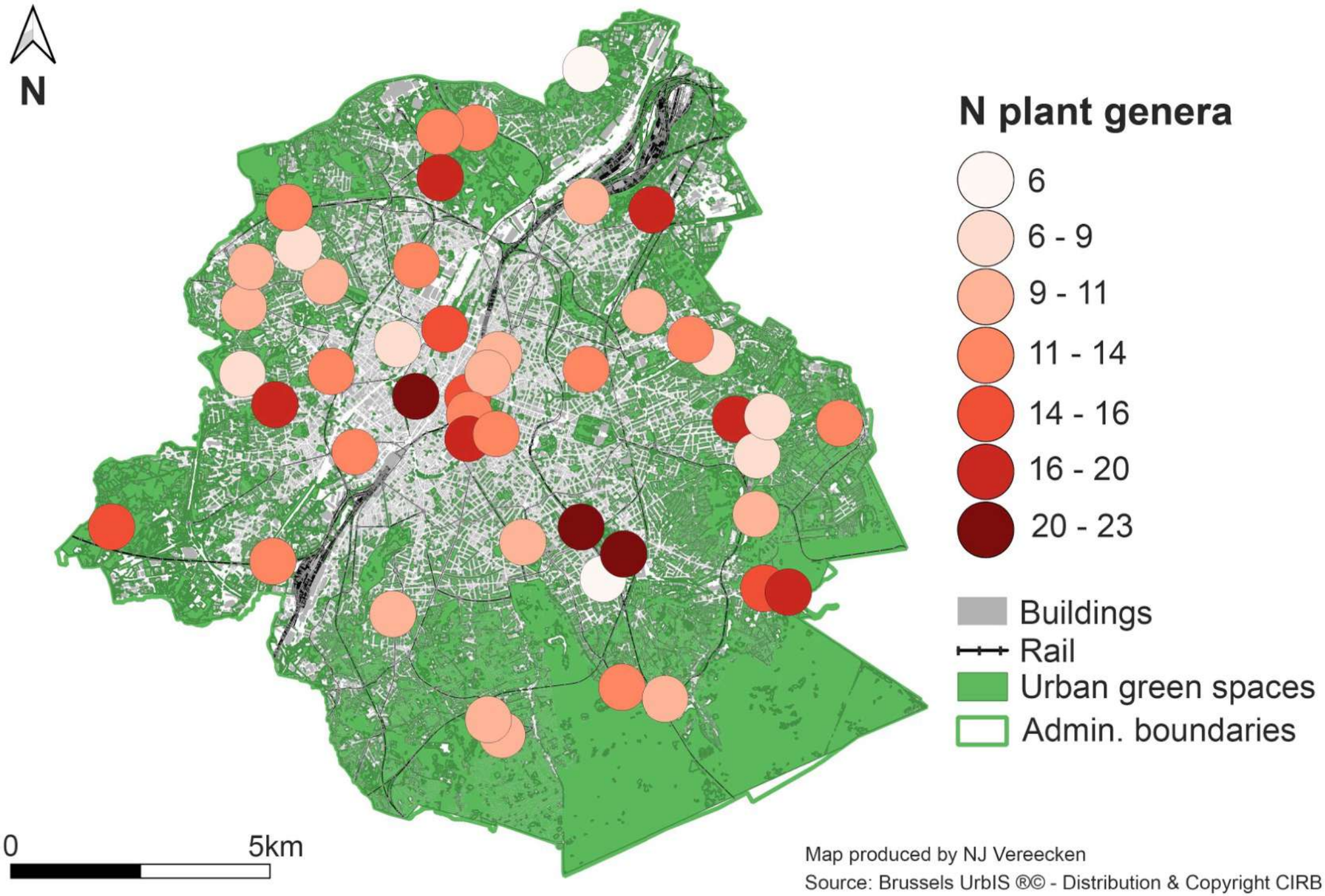
Osmia cornuta **larva on pollen ball (Hym. Megachilidae)**
Photo © NJ Vereecken

Sample collection for pollen metabarcoding analyses

Brood cells (pollen only) were collected from nests and pooled for each of the 49 study sites; the results of the pollen meta-barcoding analyses are available for 47 sites

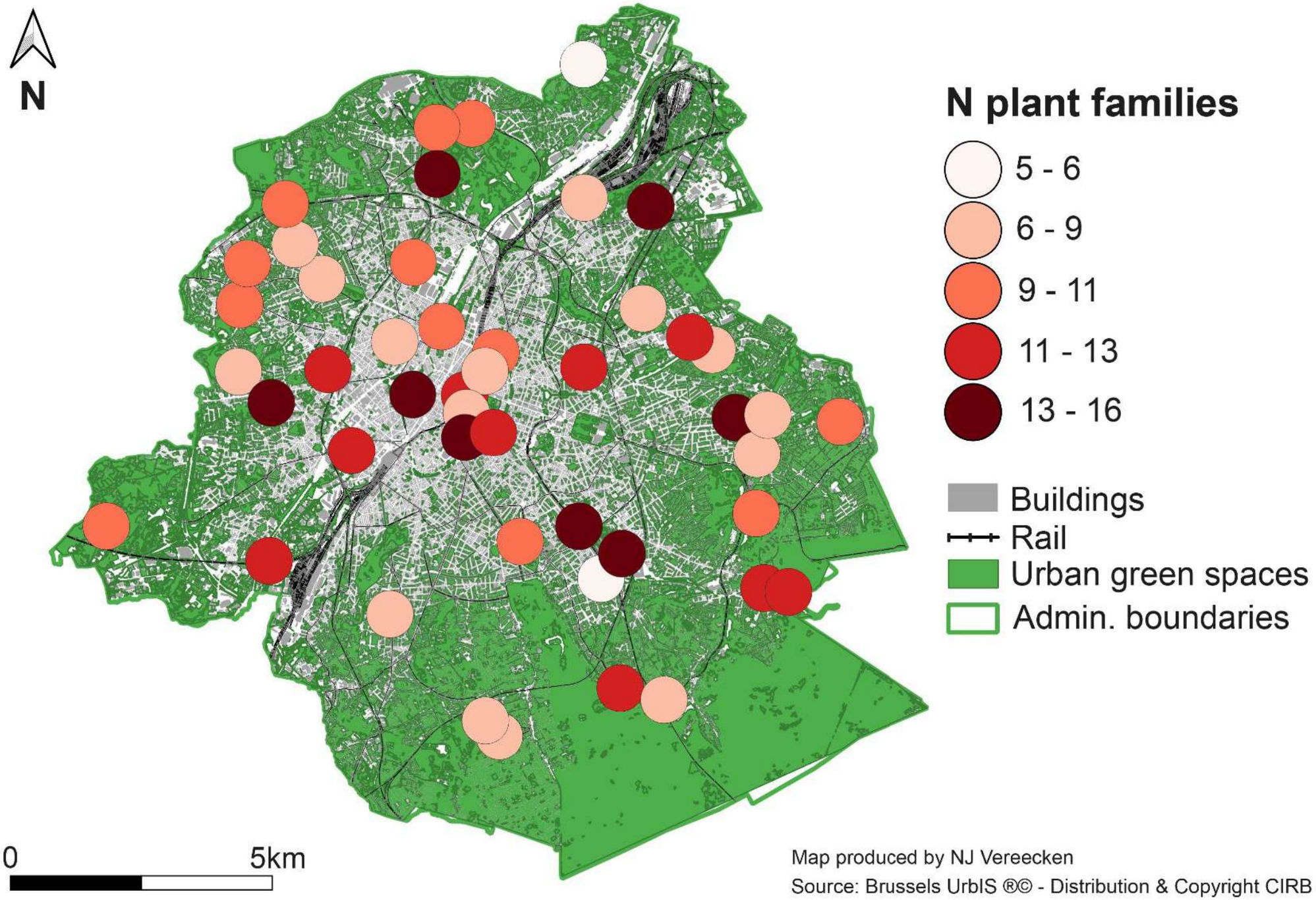
Results - Pollen meta-barcoding in BCR

- *Osmia* females collected pollen from a minimum of 6 genera and a maximum of 23 genera of flowering plants at a single site as shown below

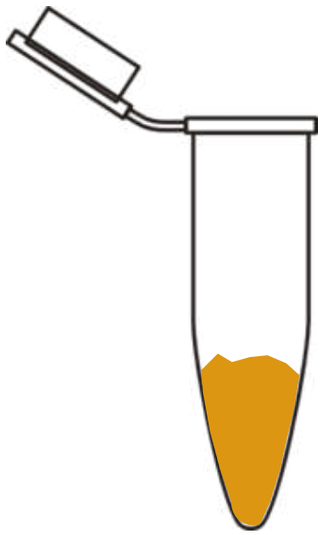
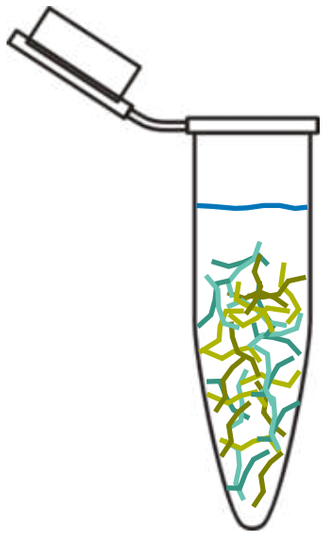
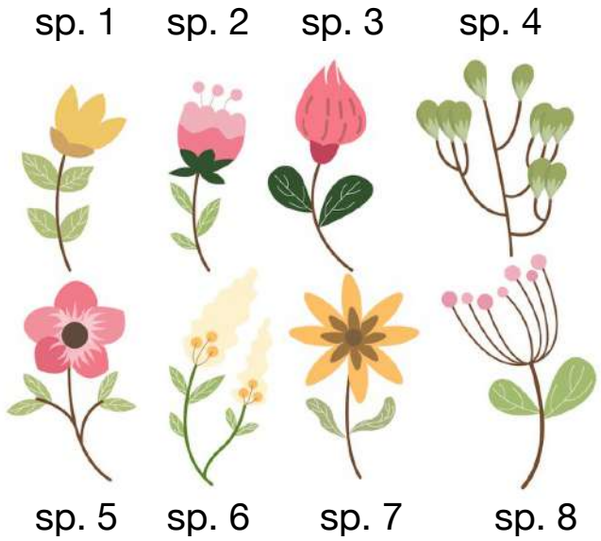


Results - Pollen meta-barcoding in BCR

- *Osmia* females collected pollen from a minimum of 5 families and a maximum of 16 families of flowering plants at a single site as shown below



Results - Pollen meta-barcoding in BCR

1.	2.	3.	4.	5.
			tttgagtatacaact ttcgagcatacgact aacgtccaaaggagt ttggagcatacgact aaggtccaaagagt ttcgagcatacgact atcgtccaatggagt aaggtccaaacgagt aacgtccaaaggagt tttgagtatacaact	

- Mason bees in the UGS of Brussels Capital Region visit a spectrum of plant species belonging to no less than 48 genera in 34 families
- The plant families with the highest number of genera visited are the Brassicaceae (7 genera), the Rosaceae (5 genera) and the Fabaceae (4 genera)
- **Major issue**: current methodologies do not allow a reliable and quantitative assessment of the relative abundance of each species using # sequence reads
- The urbanisation gradient has no significant effect on the number of plant genera visited (p=0.149)

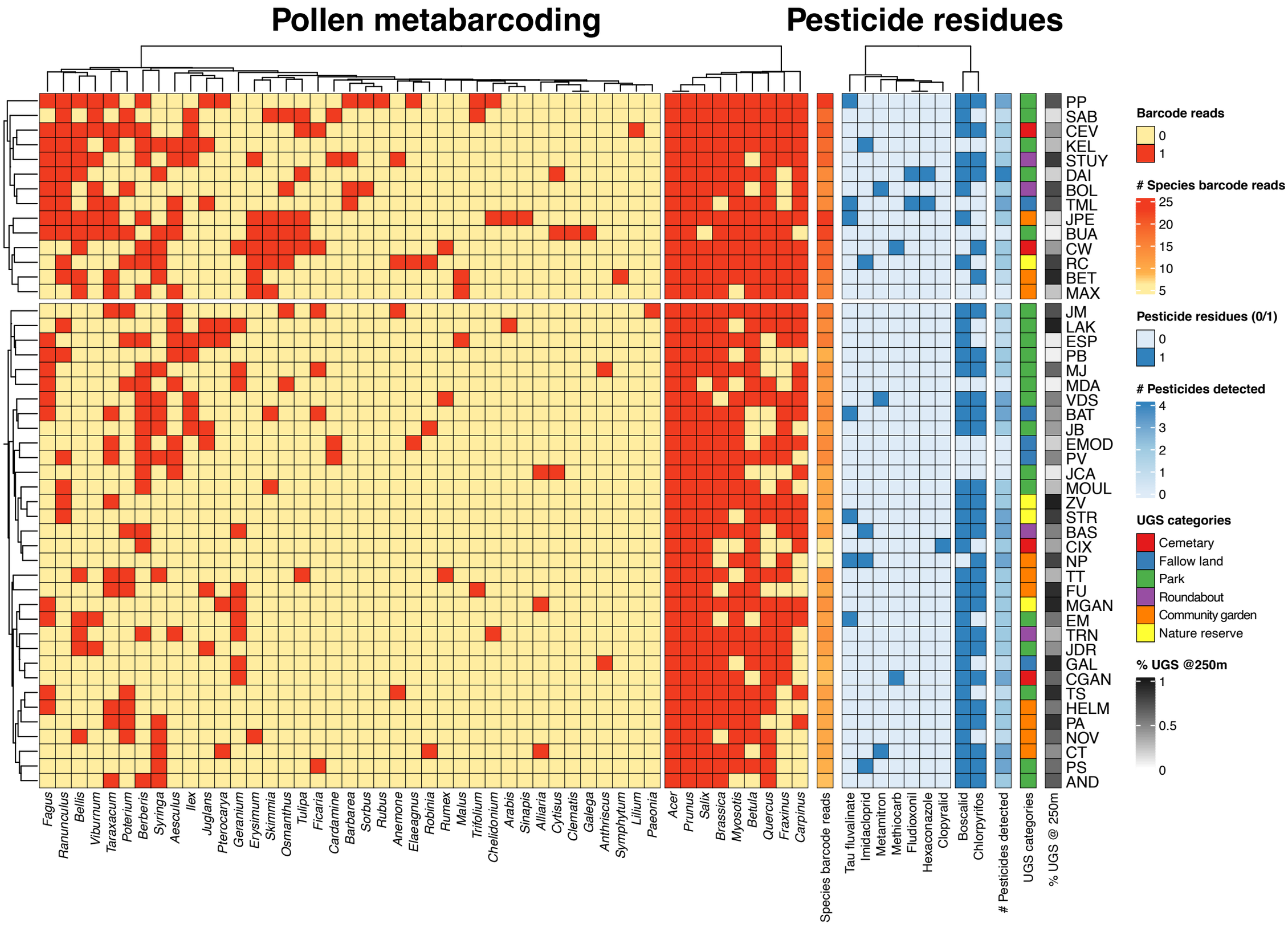
Experimental setup - UGS in Brussels

- Aliquots (sub-samples) of the brood cells pooled in the experiments carried out for Target #2 were used to track pesticide residues
- **Pesticide residues** have been characterised by Gregor Claus, PhD student under supervision of Prof. Pieter Spanoghe (UGent) for **all 49 samples**

O. bicornis

O. cornuta

Plants visited and pesticide residues analyses



Results - UGS in Brussels (n=49)

- **85.71% of the 49 samples** (i.e., 42 sites) analysed contained at least one active substance
- The only **significant co-occurrence** pattern found in pesticide residues was between the fungicides hexaconazole and fludioxonil; all other interactions were found to be random
- **Two pesticides**, namely the fungicide **boscalid** and the insecticide/acaricide **chlorpyrifos** make up for nearly 75% of pesticides recorded in the dataset

  - ★ ***Boscalid*** *is a widely used fungicide used to control major plant pathogens that is very persistent in soils; it has a low toxicity to honey bees* (Lewis et al. 2016)
  - ★ ***Chlorpyrifos*** *is a widely used organophosphate insecticide no longer approved for use in the EU; it is highly toxic to birds, fish, aquatic invertebrates and honey bees, and moderately toxic to aquatic plants, algae and earthworms* (Lewis et al. 2016)

- We found **no evidence for a significant impact of urbanisation** (defined here as % of UGS @250m radius) **on the number of pesticide molecules** detected in the *Osmia* brood cells (n=49)
- We found **no evidence for a significant impact of the number of flowering plant genera** or families **on the number of pesticide molecules** detected in the *Osmia* brood cells (n = 47), although a negative trend is observed between these two variables
- **Applying machine-learning analyses** to investigate the covariance of the pesticide and pollen meta-barcoding matrices (pending)

Lewis, K.A., Tzilivakis, J., Warner, D. and Green, A. (2016) An international database for pesticide risk assessments and management. *Human and Ecological Risk Assessment: An International Journal*, **22**(4), 1050-1064. DOI: 10.1080/10807039.2015.1133242; see https://sitem.herts.ac.uk/aeru/ppdb/en/search.htm

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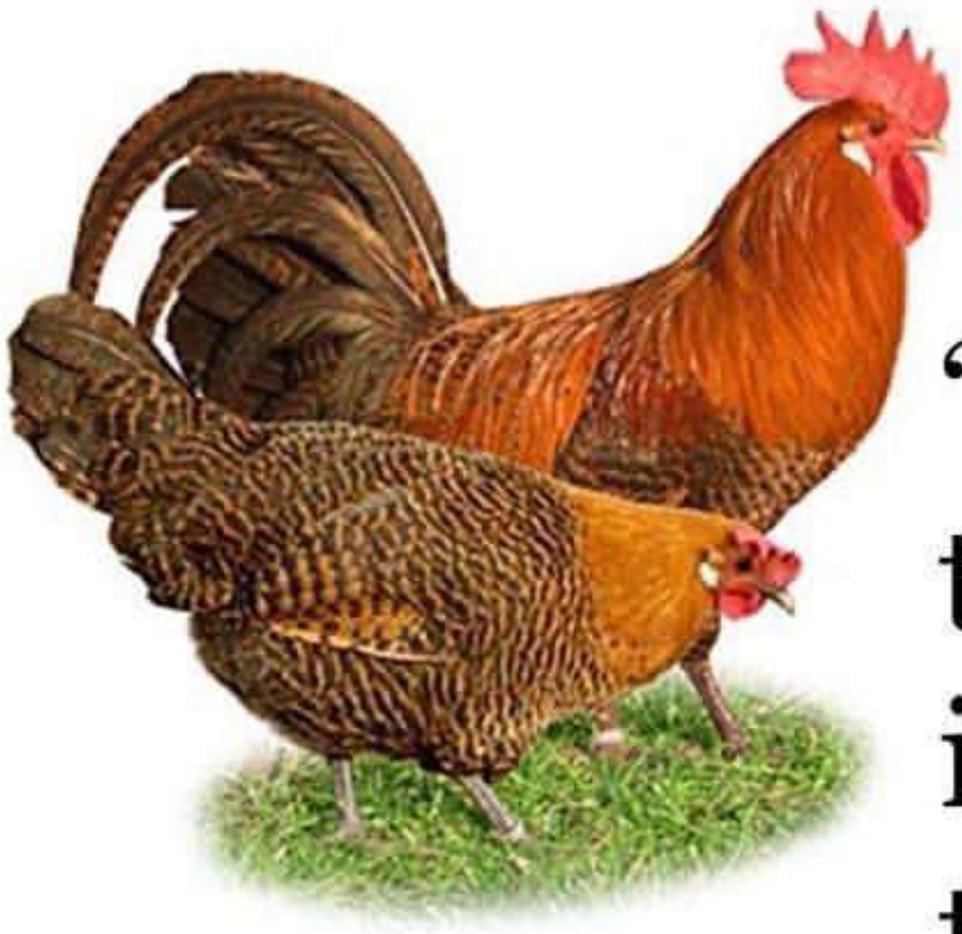
GWEN PEARSON SCIENCE 04.29.15 08:00 AM

YOU'RE WORRYING ABOUT THE WRONG BEES

Native bee (Andrena sp) on coneflower. ALEX WILD

https://www.wired.com/2015/04/youre-worrying-wrong-bees/


HONEY BEES
PUBLIC
SOLITARY BEES THAT ARE NATIVE



"Raising honeybees
to save pollinators
is like raising chickens
to help birds"

Before you can
#SaveTheBees
you need to get to
#KnowTheBees

Thank you for your attention

ULB ECOLE INTERFACULTAIRE DE BIOINGENIEURS

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Photo NJ Vereecken