NEOBIOTA 2018

10th International Conference on Biological Invasions
New Directions in Invasion Biology   www.neobiota2018.org
3rd – 7th September 2018, Dún Laoghaire, Dublin, Ireland

Programme & Book of Abstracts

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DUBLIN

Contents

Welcome from the Chairman of NEOBIOTA 2018

10th International Conference on Biological Invasions

I would like to extend a warm welcome to all of you attending the 10th NEOBIOTA conference on Biological Invasions. It seems difficult to believe that it has been 2 years since the last conference in Vianden, Luxembourg and even more difficult to believe it has been 18 years since the first NEOBIOTA conference in Berlin in 2000. In terms of the numbers of contributions and scientific content and quality the meeting has gone from strength to strength and is now arguably one of the more significant conferences on biological invasions.

Clearly, our understanding of biological invasions has also increased dramatically over the past 18 years and yet some of the same old questions still arise. What are the real impacts of biological invasions on ecosystems? How do biological invasions alter mutualistic and trophic interactions? Do biological invasions always have a negative impact? What are the best ways to control biological invasions with the minimum of environmental effects? These are long standing questions that come up time after time and will continue to be a major focus, not just of this conference, but also of future conferences. What we have also learnt over the last 18 years of research on biological invasions is that effects are a lot more complex than first envisaged and may, in some cases, not conform to the all-invasions-are-bad, idea that often pervades the popular press. Recent evidence also indicates that the magnitude of the impact of some common invaders may

be significantly less than once thought, thereby questioning the appropriateness and cost effectiveness of the widespread implementation of commonly used control measures. One of the difficulties here is the surprising paucity of rigorous long term experimentally-focussed assessments of biological invasions that can provide a more critical measure of their impacts and interactions. Yet, this is essential for decision making and the identification of appropriate strategies for implementing the recently introduced EU legislation on biological invasions.

I would like to take this opportunity to thank all of the invited speakers for agreeing to contribute to this meeting, as well as also thanking all of those who are contributing whether oral or poster presentations. Deciding on the final allocation of poster versus oral presentations proved to be a thankless task and there are many high quality poster presentations that, given more space in the programme, would have made equally excellent talks.

Finally, I would like to thank the local organising committee for their efforts, particularly the assessment of the abstracts for oral and poster presentations, as well as the session chairs and the workshop leaders for their contributions. Special thanks also go to the funders and funding agencies that provided generous support for this meeting, particularly Science Foundation Ireland (SFI) and the Environmental Protection Agency (EPA).

Bruce Osborne

Organisation

NEOBIOTA 2018 Local Organising Committee

Bruce Osborne

Jan Robert Bars

Yvonne Buckley

Joe Caffrey

Jaime Dick

Franz Essl

Mark Fennell

Dario Fornara

Margherita Gioria

Frances Lucy

Dan Minchin

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Wolfgang Nentwig

Wolfgang Rabitsch

Montserrat Vilá

Thank You to our Supporters

General Conference Information

Date
Monday, 3rd September to Friday, 7th September

Venue
NEOBIOTA 2018 will be held at The Royal Marine Hotel, Marine Road, Dun Laoghaire, Dublin. The Royal Marine Hotel is situated on an elevated site overlooking Dublin Bay in the coastal town of Dun Laoghaire. The hotel is ideally situated between the bustling city of Dublin and County Wicklow, the Garden of Ireland.

How to get to the Royal Marine Hotel
The hotel is just fifteen minutes' drive from Dublin City Centre by car & twenty minutes by DART train line to Dublin City Centre.

Taxi
There are a large number of taxi services available in Dun Laoghaire. Taxis from the Airport to Dun Laoghaire are readily available outside the Arrivals Hall.

Aircoach (from/to Dublin Airport)
Route 703: Dublin Airport to Killiney/Dalkey. Hourly Aircoach service to and from hotel front door to Dublin Airport. For more information including timetables and fares please go to www.aircoach.ie

Dublin Bus offers a high-frequency, accessible and easy to use service all over Dublin. A number of services operate close to the Royal Marine Hotel. Bus Routes that serve Dun Laoghaire and the Royal Marine Hotel: 7, 7a, 45a, 46a, 59, 63 and 75

DART and Rail: Both the DART and mainline train provide an excellent service from many parts of Dublin to the city centre. The Dun Laoghaire DART station is a 4 minute walk to the Royal Marine Hotel.

Parking: The Hotel has over 300 car parking spaces available and is delighted to offer all delegates attending a conference complimentary car-parking.

Registration Desk Hours:
Monday, 3rd September, 15:00 – 20:00
Tuesday, 4th September, 07:30 – 18:00
Wednesday, 5th September, 08:00 – 18:00
Thursday, 6th September, 08:00 – 17:00

Name Badge
Delegates must wear their name badge at all times to gain access to conference activities, including the Exhibition and Posters Hall. If you lose your badge, please visit the Registration Desk on the ground floor Pavillion Bar outside the main conference room (Carlisle Suite).

You will be required to show photo ID to have a new badge printed. €5 charge will apply.

Oral Presentations:

Plenary Presentations: 30min (25min and 5min Q&A)
Oral Presentations: 15 min (10min and 5min Q&A)
Flash Presentations: 5min (no Q&A, presenters can be asked questions at their poster)

- All speakers are requested to have their presentation loaded to the conference laptop located in the conference room at the very latest by the coffee break before their presentation.
- Please note that no personal computers will be allowed at the podium.
- There will be a laptop provided in the session room.
- Please have your presentation on USB stick, individual laptops cannot be linked to the in-house AV.
- Presentations should be formatted to fit a widescreen with the size of 16:9 for all presentations.
- Please liaise with the room technician before each session for pre-loading of presentations.
- Please load and quickly test all presentations during coffee/lunch breaks and before sessions begin – this is to ensure that if there are any difficulties, there is time for the AV technicians to rectify the issues before sessions begin.
- Speakers are asked to strictly adhere to the presentation timings listed above out of courtesy for other speakers.
- Each session will have a chairperson to monitor timekeeping. Should your presentation run over, the chairperson will inform you of this and ask you to finish your presentation, please comply with chairperson's requests.
- All speakers must be in the session room at least 10 minutes before the start of session. Please identify yourself to the session chairperson so that they are aware that all speakers are present before they start the session.
- All speakers are asked to remain in the room until the entire session is finished, if there is time at the end of the sessions further Q&A sessions may take place.

Poster Presentations

Posters will be on display each day (Tuesday, Wednesday & Thursday) and rotated daily, in The Carlisle Suite on the Ground Floor. Poster presenters have access to the Carlisle Suite from 8am each morning and posters should be in place by the first coffee break. Posters should be removed by 18:30 each day.

For a Poster Presentation Schedule,
please see page 19.

Catering

During the week, morning and afternoon Tea/Coffee breaks will be served in the poster area, The Carlisle Suite. Lunch will be served daily in the Restaurant.

Internet Access

WIFI access is available throughout the Hotel.

General Conference Information

Banking and Currency
The Euro (€) is the currency in use in Ireland. Visa and Master Card are all widely accepted in pubs, shops and restaurants throughout the country. Traveller's cheques can be cashed at most hotels and banks. *Bank Opening Hours: Mon, Tues & Fri 10.00 - 16.00; Wed 10.30 - 16.00; Thurs 10.00 - 17.00.*

Clothing
Delegates are reminded of Ireland's variable weather (it is why the countryside looks so lush and green!) During the conference we would recommend standard neat attire. Jeans and casual wear are appropriate.

Electricity
Electric Current: 240 Volts AV Plug type: 3 large flat prong British type plug. BS1363 system.

Emergency Contact Details
During the conference, in case of an emergency of any kind, please contact the conference registration. If you require medical services while residing in your hotel/accommodation, please contact your hotel/accommodation front desk who will be able to arrange a doctor on call. Please ensure to pay attention to any hotel alarms and announcements. *Fire/Ambulance and Emergency Number in Ireland is 999.*

Facilities
The venue is fully accessible for delegates. If you have any particular requirements, please advise any of the staff who will be able to make appropriate arrangements should they be required.

Liability and Insurance
All conference attendees are advised to arrange private travel insurance. The conference organisers and committee accept no liability for personal accidents or damage to property while in attendance at the conference. The organising committee of the NEOBIOTA 2018 reserves the right to amend and alter the conference programme and events without prior notice and accepts no liability as a result of such actions.

Lost and Found
During the conference any lost property should be turned in to the registration desk. All unclaimed items at the end of the week will be turned over to The Royal Marine Hotel's Security.

Parking
Car parking is available in the hotel car park.

Photography and Recording
No photography, videotaping or recording is allowed in oral sessions or in the Poster/Exhibition Hall except by the official conference photographer or conference approved Audio Visual vendor. This includes cameras, cell phones and all other devices. All conference attendees acknowledge and consent that pictures will be taken by the official conference photographer and may be used by NEOBIOTA for purposes such as marketing.

Smoking
Ireland has a strict ban on smoking. Smoking is prohibited in public areas within Ireland including all bars, nightclubs and restaurants. If required you should enquire whether your accommodation bedroom is a smoking or non-smoking room. Please use the smoking areas designated outside venues.

Shopping
General opening hours are Monday-Saturday, 09.00-18.00 with later opening hours on Thursday evenings. Most major stores/shops open on Sunday – some with reduced opening times, 10.30 to 18.00.

Tipping
Tipping is a generally accepted practice in restaurants, bars, taxis and hotel porters. A service charge may be included in some restaurants and should be stated on the menu, but otherwise this is a discretionary item.

Social Events & Conference Tour

Welcome Reception

The welcome reception will take place in The Royal Marine Hotel. Delegates will enjoy some light refreshments as they network with both new and existing colleagues.

Location: The Royal Marine Hotel
Date: Monday, 3rd September 2018
Time: 18:30
Ticket Price: Included in the NEOBIOTA Conference Registration Fee
Guest tickets: €35

Conference Dinner

The conference dinner will take place in Taylors Three Rock, the largest and highest thatched roof building in Ireland. Sample some of the traditional Irish elements that make up a good celebration - music, dance, food and a sampling of Guinness!

Location: Taylor's Three Rock
Departure Location: Royal Marine Hotel
Bus Departure Time: 18:45
Date: Wednesday, 5th September 2018
Time: 19:00 to late
Ticket Price: Full/Student NEOBIOTA Conference Attendee €65
Additional Guest Tickets €80

Half Day Tours

Coastal Scenic Tour including Bull Island and Malahide Castle: Delegates will be brought along the North shore of Dublin, where a view of Howth Head, Bull Island Bird Sanctuary and other sights can be seen. Malahide Castle and Gardens is one of the oldest castles in Ireland, set on 260 acres, this magnificent & historic 12th century castle has been home to the Talbot family for over 800 years. The castle is steeped in history and has many fascinating stories of the descendants who lived here.

The ornamental gardens adjoining the castle cover an area of about 22 acres and were largely created by Lord Milo Talbot. He was an enthusiastic plant collector who brought specimens from around the world to create the gardens here.

Delegates will go on to Visit Bull Island, which lies on the doorstep of Dublin city centre and is one of Ireland's key biodiversity sites. The 5km long sand bank created following the construction of the Bull Wall in 1825, and the extensive salt marsh combine to provide a refuge for thousands of wildfowl and waders in winter, and specialised plant and insect communities in summer. Bull Island is afforded more environmental designations than any other site in Ireland, and has been extensively studied. Having such an important biodiversity site on the doorstep of the capital city, makes this a very, very special site.

During your visit of the North Bull Island Interpretative Centre you will find out all about the Island's history and formation, the wildlife which live and visit there and the ecology of Dublin Bay.

Date: Friday, 7th September 2018
Departure Time: 09:30
Departure Location: Royal Marine Hotel
Return Time: ~15:00
Ticket Price: €50

Glendalough and Powerscourt Gardens Tour: Guests on this tour will enjoy stunning scenery and a glimpse of Ireland's monastic past at Glendalough in Co. Wicklow (pictured), one of Ireland's most popular tourist attractions.

Founded in the 6th century by St Kevin, Glendalough (meaning glen of two lakes) is a former glacial valley renowned for its early medieval monastic settlement. For thousands of years people have been drawn to Glendalough for its spectacular scenery, rich history, archaeology and abundant wildlife.

The Glendalough Valley is located in the Wicklow Mountains National Park and has many attractions to entice, entertain and enthral visitors, from its world famous Monastic Site with Round Tower to its scenic lakes and valleys.

From the gentle wilds of Glendalough, guests are then taken to the beautiful grounds of Powerscourt House & Gardens. Powerscourt House and Gardens is one of Europe's great treasures and Ireland's most famous estate.

Gracing the foothills of the Wicklow mountains, the 18th century mansion was partially destroyed by fire in 1974. A long restoration project ensued and an exhibition now brings its rich history to life.

Also onsite is Ireland's premier shopping emporium, Avoca Handweavers.

Begun in the 1740s, 47 acres of gardens are remarkable for their grandeur of scale and comprise a sublime blend of formal gardens, sweeping terraces, splendid statuary and ornamental lakes together with secret hollows, rambling walks, walled gardens and an extensive variety of trees and shrubs.

Date: Friday, 7th September 2018
Departure Time: 09:30
Departure Location: Royal Marine Hotel
Return Time: ~15:00
Ticket Price: €55

Conference Programme

Monday, 3rd September

15:00 - 20:00   **Conference Registration**

18:30 - 20:00   **Welcome Reception**

Tuesday, 4th September

08:00 - 09:00   **Conference Registration**

08:30 - 09:00   **Conference Opening**

	Positive and negative effects of biological invasions *Chair: Bruce Osborne*
09:00 - 09:30	**Keynote Speaker** Changing biological assemblages of the Anthropocene *Chris Thomas*

09:30 - 09:45   **O01:** Incorporating indirect interactions into invasion ecology: facilitation of exotic legumes by Scotch broom (Cytisus scoparius) in New Zealand
Warwick Allen

09:45 - 10:00   **O02:** Attractiveness of alien vs. native plants for pollinators in cities: Does urbanisation modulate plant-pollinator interactions?
Sascha Buchholz

10:00 - 10:15   **O03:** Nature-lovers and city-dwellers: Differential response of native and exotic species to human impact and habitat structure
Jacintha Ellers

10:15 - 10:30   **O04:** Himalayan balsam interacts with river restoration to modify macro-invertebrate community diversity across ecosystems
Ffion Davies

10:30 - 11:00   **Refreshments & Poster Display**

11:00 - 11:15   **O05:** Invasive Giant rhubarb (Gunnera tinctoria) has positive effects on earthworms and contributes carbon to soil food webs
Olaf Schmidt

11:15 - 11:30   **O06:** Defying a traditional assumption: Non-native plants species seem to have positive effects on native biodiversity in grasslands located in several Mediterranean-climate regions
Irene Martín-Forés

11:30 - 11:45   **O07:** A Quaternary perspective on synanthropic insect introductions
Eva Panagiotakopulu

11:45 - 12:00   **O08:** Quantifying and monitoring pine invasions impacts and their legacies: Pinus contorta in Patagonia. *Aníbal Pauchard*

12:00 - 12:15   **O09:** Leapfrogging to the Galapagos Islands: the introduced Fowler's Snouted treefrog
Heinke Jäger

12:15 - 12:30   **O10:** Contrasting long-term impacts of two large invasive alien plants
Margherita Gioria

12:30 - 12:35   **FP01:** What dimensions of biodiversity do we wish to preserve?
Martin A. Schlaepfer

12:35 - 12:40   **FP02:** Do alien plant invasions promote criminal activity?
Luke Potgieter

12:40 - 12:45   **FP03:** Allergens in the city: Effects of novel plant communities on seasonal pollen allergies in urban areas *Maud Bernard-Verdier*

12:45 - 13:15   **NEOBIOTA Council meeting and NEOBIOTA Board election**

12:45 - 14:00   **Lunch & Poster Display**

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14:00 - 14:30	**Keynote Speaker** Invasion into ecological networks: the integration and influence of novel interactions *Katriona Shea*
14:30 - 14:45	**O11:** The impact of the timing/duration and intensity of disturbance on network structure: how species invasion shapes network structure in a plant-pollinator community *Laura Russo*
14:45 - 15:00	**O12:** Variation in the role of microbial networks and fitness of common wasps in their native and invaded range *Monica Gruber*
15:00 - 15:15	**O13:** Roles of biotic resistance and disturbance in the establishment of an invasive invertebrate *Pauline Lenancker*
15:15 - 15:30	**O14:** Strong fitness differences impede coexistence between an alien water fern (Azolla pinnata R. Br.) and its native congener (Azolla rubra R. Br.) in New Zealand *William Godsoe*
15:30 - 15:45	**O15:** Carpobrotus edulis: what doesn't kill it makes it stronger *Jonatan Rodríguez*
15:45 - 15:50	**FP04:** Phylogeography of the invasive amphipod (Crustacea) Pontogammarus robustoides in native and colonized range *Tomasz Rewicz*
15:50 - 15:55	**FP05:** Quantifying and categorising the environmental impacts of alien birds *Tom Evans*
15:55 - 16:00	**FP06:** Biotic resistance, range size and residence time: invader performance decreases over millennia *Christine S. Sheppard*
16:00 - 16:30	**Refreshments & Poster Display**
16:30 - 16:45	**O16:** Enhancing Natural Biocontrol: Could a Generalist Snail Control an Invasive Herb? *Marju Prass*
16:45 - 17:00	**O17:** Species origin determines importance of traits for riparian plants abundance in response to environmental drivers in Central Europe *Agnieszka Sendek*
17:00 - 17:15	**O18:** Who is the winner? – the demon vs killer shrimp under mesocosm conditions *Karolina Bacela-Spychalska*
17:15 - 17:30	**O19:** The Alien Games: are facilitative and competitive interactions among invasive species a pathway to Invasional Meltdown? *Kate Crane*
17:30 - 17:45	**O20:** Free-roaming dogs alter interactions between two endemic carnivores (the kodkod Leopardus guigna and the Darwin's fox Lycalopex fulvipes) in temperate forests of Southern Chile *Ariel A. Farías*
	Workshop Chair - Sergej Olenin
17:45 - 17:55	**W01:** Tracking the Global Spread of the Invasive Chytrid Batrachochytrium dendrobatidis *Federico Castro Monzon*
17:55 - 18:05	**W02:** Prioritising species, pathways of introduction and sites of risk: the eThekwini (Durban) municipality, South Africa as a case study *Ashlyn Levadia Padayachee*
18:05 - 18:15	**W03:** Wild Spotter: Citizen scientists reporting invasives to aid USDA Forest Service restoration programs *Joseph LaForest*
18:15 - 18:25	**W04:** Towards a global database of alien plants in protected areas: effects of regional naturalized species richness *Desika Moodley*
18:25 - 18:45	**Workshop Discussion**
18:45 - 19:15	**O21:** The Age of Plastics meets the Age of Invasions?: How tsunamigenic Megarafting, coastal Development, and climate Change may all relate to a new ocean Vector *James Carlton*

Wednesday, 5th September

	Are there any universal traits associated with biological invasions *Chair: Franz Essl*
08:30 - 09:00	**Keynote Speaker** Predicting the ecological impacts of invasive species under context-dependencies *Jaimie Dick*
09:00 - 09:15	**O22:** Adaptation and Plasticity in Biological Invasions - Eco-Evolutionary Experience and Behavioural Innovation *Florian Ruland*
09:15 - 09:30	**O23:** European anthropogenic, semi-natural and natural habitats as donors of naturalized plant species worldwide *Veronika Kalusová*
09:30 - 09:45	**O24:** Predicting past and future biological invasions: challenges and opportunities of emerging alien species *Hanno Seebens*
09:45 - 10:00	**O25:** Invasion syndromes – moving towards meaninful generalisations in invasion science Ana Novoa
10:00 - 10:15	**O26:** Prosopis invasions in East Africa: Species identity, ploidy and increased invasive potential *Maria L. Castillo*
10:15 - 10:20	**FP07:** nvasive alien pests threaten the carbon stored in Europe's forests *Franz Essl*
10:20 - 10:25	**FP08:** Investigating the consistency of global niche shifts in invasive weeds *Thomas Carlin*
10:25 - 10:30	**FP09:** Rafting Communities of anthropogenic marine Litter in the South Pacific Gyre *Sabine Rech*
10:30 - 11:00	**Refreshments & Poster Display**
11:00 - 11:15	**O27:** Can we link successful exotic reptile establishment to rapid climatic niche evolution? *Wendy A.M. Jesse*
11:15 - 11:30	**O28:** Behavior and the invasion success of different clones of the New Zealand mud snail in North America *Edward Levri*
11:30 - 11:45	**O29:** Global meta-analysis of native and nonindigenous trophic traits in aquatic ecosystems *Marc Rius*
11:45 - 12:00	**O30:** A global attempt to unravel the context-dependence of the role of traits in plant naturalization *Noëlie Maurel*
12:00 - 12:15	**O31:** Environmental drivers of establishment and adaptation in the globally invasive Plantago lanceolata *Annabel Smith*
12:15 - 12:30	**O32:** Colonization pressure: a second null model for biological invasions *Tim Blackburn*
12:30 - 12:45	**O33:** Propagules are not all equal: traits of vegetative fragments and disturbance regulate invasion success *Marc Uyà*
12:45 - 14:00	**Lunch & Poster Display**

	Biological invasions, mutualisms and biotic interactions *Chair: Yvonne Buckley*
14:00 - 14:30	**Keynote Speaker** Mutualisms: drivers, and in turn victims, of biological invasions *Anna Travasett*
14:30 -14:45	**O34:** Biogeographical comparison of invaded insect-flower interaction networks: conserved structural role but shifts in mutualist-antagonist ratios *Jane Stout*
14:45 - 15:00	**O35:** Contrasting patterns of managed and native bumblebees in natural habitats *Montserrat Vilà*
15:00 - 15:15	**O36:** Phylogenetic distance and floral trait dissimilarity between alien and native plant species as drivers of novel pollination mutualisms *Mialy Razanajatovo*
15:15 - 15:30	**O37:** Examining the spread of non-indigenous species across marine ecoregions using environmental DNA *Luke Holman*
15:30 - 15:45	**O38:** Reduced impacts of natural enemies of invasive plants at high latitudes *Peter Kotanen*
15:45 - 15:50	**FP10:** Monitoring ballast water mediated introduction of Non-Indigenous Species through metabarcoding *Anaïs Rey*
15:50 - 15:55	**FP11:** Addressing uncertainty in S/EICAT assessments *Lara Volery*
15:55 - 16:00	**FP12:** Invasive small mammals: trophic dynamism and modified food webs in Irish hedgerows *Ian Montgomery*
16:00 - 16:30	**Refreshments & Poster Display**
16:30 - 16:45	**O39:** Invasive alliance: the presence of zebra mussel can facilitate the survival and dispersal of killer shrimp *Matteo Rolla*
16:45 - 17:00	**O40:** Enhanced attractiveness in the invasive Impatiens glandulifera? *Stephanie Coakley*
17:00 - 17:15	**O41:** Reconstructing the spread of a global invader: a genetic study of red swamp crayfish, Procambarus clarkii *Francisco Javier Oficialdegui*
17:15 - 17:30	**O42:** Extrafloral néctar in phyllodes from invasive Acacia longifolia: why, how, when *Manuela Giovanetti*
17:30 - 17:45	**O43:** Lineage overwhelms environmental conditions in determining rhizosphere bacterial community structure in a cosmopolitan invasive plant *Laura Meyerson*
	Workshop Chair - Giuseppe Brundu
17:45 - 17:55	**W05:** Developing risk assessments for invasive alien plants within the remit of the IAS Regulation: outcomes and issues *Rob Tanner*
17:55 - 18:05	**W06:** Preliminary results of negative impact risk assessment for selected invasive and potentially invasive alien species in Polan+C80:C81d *Barbara Tokarska-Guzik*
18:05 - 18:15	**W07:** First Experiences from the Implementation of the EU Regulation on Invasive Alien Species *Spyridon Flevaris*
18:15 - 18:25	**W08:** International Health Regulations, national biodefense policies, and threats from invasive disease vectors, hosts, and pathogens: a One Health analysis and call for action *David Bruce Conn*
18:25 - 18:45	**Workshop Discussion**
19:00	**Conference Dinner – Bus Departure at 19:00**

Thursday, 6th September

	Impacts of invasions on ecosystems and ecosystem processes *Chair: Jane Stout*
08:30 - 09:00	**Keynote Speaker** Ecosystem responses to exotic earthworm invasion *Nico Eisenhauer*
09:00 - 09:15	**O44:** Regional forest carbon loss resulting from insect and disease invasions *Andrew Liebhold*
09:15 - 09:30	**O45:** Functional responses reveal temperature-dependent predatory impacts of highly invasive fishes *Dumisani Khosa*
09:30 - 09:45	**O46:** Horizon scanning for invasive alien species likely to threaten biodiversity in the European Union *Helen Roy*
09:45 - 10:00	**O47:** Effects of experimental drought and invasion on fuel loads and fire intensity *S. Luke Flory*
10:00 - 10:15	**O48:** Socio-Economic Impact Classification of Alien Taxa (SEICAT) *Sven Bacher*
10:15 - 10:20	**FP13:** Integrating the impacts of non-native species on ecosystem services into environmental policy *Philip Hulme*
10:20 -10:25	**FP14:** Impacts of Gunnera tinctoria on soil carbon and nitrogen and its reduction effect on greenhouse gas emissions in Ireland *Mauricio Mantoani*
10:25 - 10:30	**FP15:** How does restoration impact native ant communities? The case of Acacia saligna invasions in South Africa's fynbos *Wolf-Christian Saul*
10:30 - 11:00	**Refreshments & Poster Display**
11:00 - 11:15	**O49:** Impact assessment of invasive fishes using the Relative Impact Potential (RIP) metric under a seasonal temperature gradient *Lubabalo Mofu*
11:15 - 11:30	**O50:** The impact of invasive plants relates to geography and characteristics of native communities: Eurasian invaders outcompete clonal perennials in North America *Martin Hejda*
11:30 - 11:45	**O51:** Disentangling direct and indirect effects of Prosopis on Eastern African dryland ecosystems *Theo Linders*
11:45 - 12:00	**O52:** The effect of invasive hybrid taxa on the ecological succession of coastal marshes *Blanca Gallego-Tévar*
12:00 - 12:15	**O53:** Soil legacy effects of Acacia invasions and their implications for restoration in South Africa's Cape Floristic Region *Florencia A. Yannelli*
12:15 - 12:30	**O54:** Direct and indirect effects of the invasive signal crayfish Pacifastacus leniusculus on leaf decomposition and invertebrate communities *Francisco Carvalho*
12:30 - 12:45	**O55:** Impacts of global change on freshwater plant species *Guyo Gufu*
12:45 - 14:00	**Lunch & Poster Display**

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14:00 - 14:30	**Keynote Speaker** Integrating local knowledge and science to assess the impacts of an invasive plant species and develop locally meaningful control strategies *Jennifer Firn*
14:30 -14:45	**O56:** The European pine marten's role in reversing native red squirrel replacement by invasive grey squirrels: differential predation and landscape of fear *Joshua Twining*
14:45 - 15:00	**O57:** The harmonic radar to track the invasive hornet Vespa velutina: a tool to improve the Early Warning and Rapid Response System for the species *Simone Lioy*
15:00 - 15:15	**O58:** Soil solarization as a tool for restoration of invaded habitat: advantages and limitations *Oded Cohen*
15:15 - 15:30	**O59:** Experimenting with remote sensing techniques to monitor and manage invasive alien species *Eithne Davis*
15:30 - 15:45	**O60:** Effects of River Engineering and Restoration Measures on Invasive Fish Species in the Main Stem of a Free-Flowing Section of the River Danube, Austria. *David Ramler*
15:45 - 15:50	**FP16:** Field validation of a novel method for marine salt selective application as environmentally friendly herbicide for *Baccharis halimifolia* mature infestations elimination in estuarine habitats *Diego Cicero-Fernández*
15:50 - 15:55	**FP17:** Cold as Ice: a novel eradication and control method for invasive Asian clam, Corbicula fluminea, using pelleted dry ice *Neil Coughlan*
15:55 - 16:00	**FP18:** Remote sensing approach to study the spread of invasive species *Jana Müllerová*
16:00 - 16:30	**Refreshments & Poster Display**
16:30 - 16:45	**O62:** Management options for IAS of Union concern: what's feasible? *Tim Adriaens*
16:45 - 17:00	**O61:** Can we make use of remote sensing data to manage invasive species? - The potential of detecting invasive species in Germany from above *Sandra Skowronek*
17:00 - 17:15	**O63:** Reconstructing biological invasions using public surveys: a new approach to retrospectively assess spatio-temporal changes in invasive spread *Nitya Prakash Mohanty*
17:15 - 17:30	**O64:** The Centre for Invasion Biology: An experiment in research, capability building, and service provision for invasion science and management *David Richardson*
17:30 - 17:45	**O65:** Mortality and regrowth of the invasive exotic fern Lygodium microphyllum in response to prescribed fire in southern Florida, USA *Nicole Sebesta*
17:45 - 18:00	**Closing Ceremony**

Poster Presentations Schedule

Best Poster Award will be presented at the Closing Ceremony.

Tuesday, 4th September
P001 – P040 & FP01 – FP12

Best Posted Award is kindly supported by the Journal of Plant Ecology

Wednesday, 5th September
P101 – P160 & FP13 – FP18

Journal of **Plant Ecology**
OXFORD

Thursday, 6th September
P201 - P272

Keynote Speakers

Chris Thomas *University of York, UK*

Tuesday, 4th
September
09:00 – 09:30
*Changing
biological
assemblages of the
Anthropocene*

Chris Thomas works on the ecological and evolutionary responses of species to Anthropocene change. He has particularly contributed towards understanding how the distributions of species are responding to climate change, and to habitat change. He has authored influential articles on extinction, and has recently written a major book on biodiversity gains in the Anthropocene: Inheritors of the Earth: How Nature Is Thriving in an Age of Extinction. This has highlighted conflicting conservation perspectives for the Anthropocene. He argues that traditional 'stem the losses' and 'keep things as they are' approaches to conservation are in the process of failing, and that many species will only survive the current period of rapid environmental change by moving to new locations (with and without our help). However, they risk being treated as 'non-native' species when they do so. He suggests that we should not presume that the only 'correct place' for species to live on the Earth is where we first recorded them, and he even advocates deliberately moving species to new locations if it will reduce their likelihood of extinction. Chris is a Professor at the University of York in England, a Fellow of the Royal Society and President-elect of the Royal Entomological Society.

Katriona Shea *Penn State University, USA*

Katriona Shea is Professor of Ecology and the Alumni Professor in the Biological Sciences at the Pennsylvania State University in the USA. She also holds an Adjunct Professor position at the Arctic University of Norway in Tromsø. She received her BA (Hons) in Physics from Oxford in 1990 and her PhD in theoretical population ecology from Imperial College, London University in 1994. Following postdoctoral positions in California and Australia, she joined the faculty at Penn State in 2001. Professor Shea uses a wide range of empirical and quantitative methods to study the ecology and management of invasive and outbreaking species in perturbed environments. Much of her work focuses on the applied ecology of invasive plants, addressing the demography, dispersal and spread of plant invaders, but she also studies a variety of insects, marine organisms, bacteria and mammals as well as epidemiological systems such as measles and Ebola. More information can be found at https://kshealab.wordpress.com/. She serves as an editorial board member for the journals Biological Invasions, Ecology Letters and Population Ecology. Professor Shea was named a Fellow of the Ecological Society of America in 2016.

Tuesday, 4th
September
14:00 – 14:30
*Invasion into
ecological
networks: the
integration and
influence of novel
interactions*

Keynote Speakers

Jaimie Dick *Queen's University of Belfast, Northern Ireland*

Jaimie T.A. Dick is Professor of Invasion Ecology at Queen's University Belfast and Director of Queen's Marine Laboratory in Portaferry. Jaimie is former Director of Research (Ecology) and Director of the Quercus Biodiversity and Conservation Centre. Jaimie was Senior Investigator on Invasive Species Ireland and currently Principal Investigator on several invasions projects with, for example, EPA, IFI, WWI, British Council and NSERC. Jaimie's interests are in the science and managmnent of the impacts of invasive species in freshwater, marine and terrestrial settings. In particular, Jaimie applies individual, population and community concepts to understand and predict the ecological impacts of invasive species. Current projects include applying individual per capita effects and population abundances to develop metrics to better predict invader impacts, development of methods to eradicate/control Asian clams and Chinese muntjac deer, measuring biotic resistance of fish communities in Africa, improving mosquito biocontrol using native and invasive predators and prey, and lionfish behaviour and invasion ecology. Jaimie has given several recent invitation/keynote talks in China, Argentina, Canada, South Africa, Australia and across Europe. His post-docs/PhD students are currenlty involved in fish, mammal, invertebrate and plant invasions across the globe and Jaimie engages BSc/MSc students in such ventures with lectures, fieldcourses and projects. Jaimie has published over 160 papers in the area and likes beer.

**Wednesday,
5th September
08:30 – 09:00**
Predicting the ecological impacts of invasive species under context-dependencies

Anna Traveset *IMEDEA, Spain*

Anna Traveset is a Research Professor of the Spanish Research Council at the Mediterranean Institute of Advanced Studies (IMEDEA, CSIC-UIB), based on Mallorca (Balearic Islands). Her research focuses on island systems, exploring how biotic interactions influence the regeneration and distribution of island plants. A major focus of her current work is the role of invasive species in natural communities, and how they influence mutualisms, especially on islands. She is currently coordinating projects in the Balearics Islands, Canary Islands, Galapagos, and the Seychelles. Prof. Traveset received her BS in Biology from the University of Barcelona. Her PhD work was conducted at the University of Pennsylvania, where she studied plant-insect interactions in Costa Rica under the supervision of Daniel Janzen. She then conducted postdoctoral research with Carlos Herrera and Pedro Jordano at the Doñana Biological Station in Seville, Spain. She has c. 200 publications in scientific journals and leads the Department of Terrestrial Ecology at IMEDEA. She has supervised numerous students and serves on the editorial board of several journals including Oikos, AoB Plants, Diversity & Distributions, Journal of Pollination Ecology, and PeerJ. In 2017 she received the prestigious award King Jaume I given to Spanisch scientists in the category of Protection of the Environment.

**Wednesday, 5th September
14:00 – 14:30**
Mutualisms: drivers, and in turn victims, of biological invasions

Keynote Speakers

Nico Eisenhauer *University of Leipzig, Germany*

Environmental change is altering the composition and functioning of the earth's ecosystems. My lab group aims to embrace the complexity of terrestrial ecosystems by considering interactions among organisms above and below the ground as well as within and across trophic levels. Our main questions are: How does environmental change affect the composition and biodiversity of ecosystems? How are shifts in community composition and biodiversity related to the functioning and service provisioning of ecosystems? We answer these questions in biodiversity and climate change experiments as well as in observation studies. We focus on the taxonomic and functional composition of food webs and the processes they drive. The ecological consequences of biological invasions are studied using exotic earthworms – a process we call 'global worming'. He is Full Professor for Experimental Interaction Ecology at the German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, and Leipzig University since 2014; born in Lindenfels, Germany in 1980. Diploma in Biology at Technical University of Darmstadt (2005), PhD in Ecology at Technical University of Darmstadt (2008), Habilitation in Ecology and Zoology at University of Göttingen (2012). Postdoc positions at Technical University of Darmstadt, Germany (2008-09), University of Göttingen, Germany (2009-10), University of Minnesota, MN, USA (2010-2012), Technische Universität München, Germany (2012). He was Associate Professor for Terrestrial Ecology at FSU Jena, Germany (2012-2014) before starting his current position. He has received the Emmy Noether group leader fellowship by the German Research Foundation (2012), the Heinz Maier-Leibnitz-Prize by the German Research Foundation (2014), and the ERC Starting Grant by the European Research Council (2015). He is the speaker of the Research Unit of the Jena Experiment (since 2015), Head of the iDiv Ecotron (since 2014), and Editor-in-Chief of Pedobiologia (since 2014). He has published ~180 papers in international peer-reviewed journals, has an H-index of 39 and >5,000 citations (GS).

Thursday, 6th September 08:30 – 09:00
Ecosystem responses to exotic earthworm invasion

Jennifer Firn *Queensland University of Technology*

Associate Professor Jennifer Firn is a theoretical and applied ecologist who specializes in studying ecological theory, then linking these theoretical constructs to the practical management of grasslands and tropical forests. The driving motivation throughout her career has been to find smarter, cheaper and more sustainable ways of restoring degraded plant communities including understanding and managing invasive plant species. Dr. Firn works in native grasslands in temperate, semi-arid and arid regions of Australia; and her research has focused on invasive grasses and shrubs across these regions including projects that were empirically, mathematical modeling and expert elicitation based. Dr. Firn is an Editor in Chief for the Journal Ecology and Evolution and works for the Queensland University of Technology in Brisbane, Australia.

Thursday, 6th September 14:00 – 14:30
Integrating local knowledge and science to assess the impacts of an invasive plant species and develop locally meaningful control strategies

Plenary Abstracts

Plen01

Changing biological assemblages of the Anthropocene

Chris D Thomas

University of York, York, United Kingdom

All ecological and evolutionary processes are dynamic: the birth, death and movement of individuals, the changing distributions of species and composition of biological assemblages in space and time, through to evolutionary adaptation and diversification. These dynamic events have always generated a kaleidoscope of biological diversity across our planet, particularly during periods when the physical environment was changing. Then humans evolved, a natural event for sure, but one with surprising consequences. The resultant changes to the world's vegetation, the distributions of species, the atmosphere, and the climate could not have been imagined. In this talk, I will discuss how two processes are generating changing biological assemblages, climate change and biological invasions. Whilst both are clearly negative in some situations, the perhaps surprising result is that local and regional diversity are increasing in many parts of the world. Human-altered ecosystems contain different sets of species, but not always fewer. Even more surprising, new hybrid and other species are coming into existence because of humans. This Anthropocene realisation – that humans are generators as well as destroyers of diversity – requires a reappraisal of the relationship between humans and nature. Humans are part of nature and it is as legitimate for us to facilitate novel biological diversity as it is for us to try to save the old.

Plen02

Invasion into ecological networks: the integration and influence of novel interactions

Katriona Shea[1], Laura Russo[2]

[1]The Pennsylvania State University, University Park, USA. [2]Trinity College Dublin, Dublin, Ireland

The integration of an invasive species into a new community is a complex process that may involve the formation of multiple new network interactions at different trophic levels. These interactions in turn will affect the structure and function of the invaded community. To study the formation, persistence (or not), and dynamics of these complex novel interaction structures is immensely challenging, and would be prohibitive even we limited ourselves to just a few important invader case studies. To what extent can we focus on studying simpler community modules to understand the success and impacts of invasions? We initially consider a single invasive species, and illustrate the insights that arise as its invasion success, and its impacts on the invaded community, are addressed through the lens of increasingly complex community networks. As we move from a focus on the invader alone to also considering one or more other network components (i.e. species in the invaded community) important ecological and applied insights arise. For example, ignoring invasional interference may lead to underestimation of required management efforts. Furthermore, the way in which novel interactions form, particularly the degree of generality of interactions displayed by an invader, affects the invaded community and its dynamics, and the prognosis for coexistence, stability or community collapse. Importantly, invaders may themselves become an integral component of the network structure; subsequent removal of an invader during restoration efforts may further perturb the community, with additional negative consequences. Finally, we address exciting new research directions, such as: approaches to examine the invasion of whole communities into new ecosystems; the importance of the resolution with which networks are studied; and the effects of external perturbations and climate change on invaded networks.

Plen03

Predicting the ecological impacts of invasive species under context-dependencies

Jaimie Dick

Queen's University Belfast, Belfast, United Kingdom

Invasive species impacts are notoriously unpredictable and highly context-dependent, making predictions of invader ecological impact extremely difficult; indeed, some would say impossible. Invasion history is useful in this respect, but obviously only for invaders that are established and spreading, and context-dependencies can still frustrate predictions of such invader impacts. In addtion, no individual or group of species traits have emerged as reliable predictors of ecological impact. Our new metric, "Relative Impact Potential" (RIP), blends the classic Functional Response (FR; consumer *per capita* effect) and Numerical Response (NR; consumer population response) with the "Parker-Lonsdale equation" (Impact=Range × Abundance × Effect), to give RIP=FR × Abundance. The RIP metric is an invader/native ratio, values >1 predicting that invader ecological impact will occur, and increasing values above 1 indicating increasing ecological impact. Across a diverse range of trophic and taxonomic groups, including predators, herbivores, animals and plants (22 invader/native systems, 47 individual comparisons), high impact invaders were significantly associated with higher FRs compared to native trophic analogues. However, the RIP metric substantially improves this association, with 100% predictive power of high impact invaders. Further, RIP scores were significantly and positively correlated with two independent ecological impact scores for invaders, allowing prediction of the degree of impact of invasive species with the RIP metric. Since both *per capita* effects and abundances of invaders can be measured across abiotic and biotic contexts, the RIP metric could substantially improve invader impact prediction. For example, FRs are sensitive to temperature, oxygen, salinity, parasitic infection and multiple predator effects (MPEs). RIP thus provides an explanatory and predictive tool for scientists, managers, practitioners and legislators in a changing world with increasing invasion threats. In particular, the RIP metric, for the first time, could predict the likely ecological impacts of potential new invasive species lacking prior invasion history.

Plen04

Mutualisms: drivers, and in turn victims, of biological invasions

Anna Traveset

IMEDEA (CSIC-UIB), Illes Balears, Spain

Mutualistic interactions play an important role maintainig biodiversity, structuring ecosystems and mediating their functioning. Such positive interations, however, have begun to receive much attention relative to negative ones (e.g. competition, predation) only in the last decade. The persistence of many mutualisms is increasingly threatened by different drivers of global change, with still unknown ecological and evolutionary consequences. Particularly, the impacts of alien invasive species on native mutualisms are still poorly documented, although the data available so far indicate that they may be highly relevant, often leading to population declines, reduced biodiversity, and altered ecosystem functioning. In turn, positive interactions enhance the invasion of many alien species. In my talk, I will go through the different mechanisms whereby mutualisms mediate invasions and are in turn influenced by invasions. I will focus on two main types of mutualisms (pollination and seed dispersal) and draw on examples mostly from Mediterranean ecosystems, and from both species and community-level studies, that show the possible demographic and genetic impacts of alien invasive species on native ones as well as the relevance of incorporating positive interactions in the study of biological invasions. I will also show how ecological networks provide a useful framework for predicting tipping points for community collapse in response to invasions and other synergistic drivers of global change.

Plen05

Ecosystem responses to exotic earthworm invasion

Nico Eisenhauer

German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, Germany

Biological invasions threaten biodiversity and ecosystem functioning across ecosystems. Invasions by ecosystem engineers, in particular, have been shown to have dramatic effects in recipient ecosystems. For instance, invasion by exotic earthworms, a belowground invertebrate ecosystem engineer, may exert strong effects on soil chemical and physical properties in previously earthworm-free ecosystems with potential far-reaching impacts on above- and belowground biodiversity. Here, I present the results of three independent meta-analyses of invasive earthworm effects on soil biogeochemical characteristics, plant communities, and soil communities.

Exotic earthworms increased soil pH but decreased soil water content, suggesting that removal of organic material by earthworms lowered water holding capacity and increased evapotranspiration from soil. Earthworms increased different carbon pools, carbon leaching, and inorganic nitrogen content. Effects depended on soil depth, indicating that earthworms mobilize and redistribute nutrients to lower soil layers and increase overall nutrient loss.

Plant diversity significantly declined with increasing richness of earthworm ecological groups. Moreover, cover of graminoids and non-native plant species significantly increased, while cover of native plant species tended to decrease, with increasing earthworm biomass, indicating pronounced changes in plant community composition.

Exotic earthworms significantly decreased the diversity and density of soil invertebrates. Earthworm effects on soil microorganisms depended on functional group richness of invasive earthworms and soil depth, indicating that the mixing of soil layers by earthworms (bioturbation) may homogenize microbial communities across soil layers.

The present meta-analyses provide compelling evidence for negative effects of invasive earthworms on plant and soil biodiversity and pronounced alterations in ecological communities of recipient ecosystems, which could potentially alter the functioning of these ecosystems. These results provide a comprehensive picture of invasive earthworm effects on recipient ecosystems and contribute to the mechanistic understanding of aboveground and belowground community changes in areas of ongoing earthworm invasion.

Plen06

Working together better: changing how we research invasive plant species to assist control efforts

Jennifer Firn

Queensland University of Technology (QUT), School of Earth, Environmental and Biological Sciences, Brisbane, Australia

Globally the prevalence and impact of invasive non-native species is increasing rapidly; while, experimentally based research aimed at adequately responding and supporting management is limited in its ability to keep up with this pace, given the complex drivers associated with successful invasion and control strategies. In contrast landholders are in unique positions to witness biodiversity turnover in grasslands, adapt management practices in response, and learn from successes and failures. This local knowledge could be crucial for identifying feasible solutions to land degradation, and ecological restoration, but local knowledge is rarely explicitly embedded in ecological research. In this talk, I will discuss three projects where we have or are collaborating with local farmers, Traditional Owners and local governments in three vastly different ecosystems across Australia. I will demonstrate how local knowledge coupled with scientific methods can act in tandem as a highly efficient method for developing management recommendations. This approach effectively identifies local perceptions that are not substantiated by scientific data to halt potentially harmful practices, and observations that are insightful predictions about the dynamics and impacts of introduced species that require long-term experiments to corroborate scientifically.

Oral Abstracts

O01

Incorporating indirect interactions into invasion ecology: facilitation of exotic legumes by Scotch broom (*Cytisus scoparius*) in New Zealand

Warwick Allen[1], Ralph Wainer[2], Jason Tylianakis[2,3], Barbara Barratt[4], Marcus Shadbolt[2], Ian Dickie[2,1]

[1]Lincoln University, Lincoln, New Zealand. [2]University of Canterbury, Christchurch, New Zealand. [3]Imperial College London, London, United Kingdom. [4]AgResearch, Dunedin, New Zealand

Direct species interactions have received copious attention from invasion ecologists, yet relatively little research has explored how indirect interactions contribute to the success and impacts of invasive plants. For example, invasive plants may serve as a reservoir for harmful herbivores and pathogens or beneficial mycorrhizal fungi and other mutualists, which spill over to hinder or help neighbouring plants (i.e., apparent competition/mutualism). No studies to date have compared the relative strength of these different interactions or their impact between closely related native and exotic taxa. Thus, we conducted a fully crossed multi-factor field experiment to measure the indirect effects of soil fungi and arthropod herbivores associated with Scotch broom (*Cytisus scoparius*) on the biomass of 10 native and 11 exotic legume species. Pots were constructed with nylon mesh windows of differing porosity to allow (38 μm) or prevent (1 μm) colonisation of fungi from neighbouring plants and positioned adjacent to broom or 50 m away in a location uninvaded by broom, so that differences in herbivore or fungal effects between locations could be attributed to indirect interactions with broom. To exclude arthropod herbivores, plants were regularly sprayed with pyrethrum pesticide or a water control. We found that the direct effect of broom (i.e., pot location treatment) increased biomass of both native and exotic species, likely through providing shelter from the environment and mammalian herbivores, whereas arthropod herbivore effects were negligible. Interestingly, exotic plants that could connect to the fungal network exhibited increased growth beside broom only, whereas native plants had higher biomass when allowed to connect to the fungal network in the uninvaded location. These results suggest that broom disproportionately facilitates exotic over native legumes, potentially contributing to exotic dominance in New Zealand. We also explore how these indirect interactions relate to each species' functional and phylogenetic similarity to broom.

O02

Attractiveness of alien vs. native plants for pollinators in cities: Does urbanisation modulate plant-pollinator interactions?

Sascha Buchholz[1,2], Ingo Kowarik[1,2]

[1]TU Berlin, Berlin, Germany. [2]Berlin-Brandenburg Institute of Advanced Biodiversity Research (BBIB), Berlin, Germany

Cities are hotspots of alien plant species, with a range of ecological consequences. Among these, alien dominance could severely affect plant-pollinator interactions since alien plants are often expected to be less attractive for pollinators than native plants. Previous urban studies yielded ambiguous results and are difficult to compare since the effect of urbanisation on plant-pollinator systems have not been systematically analysed. We thus performed an experiment along an urbanisation gradient in Berlin to test for (i) differences in the attractiveness of alien vs. native floral resources for pollinators, and (ii) whether urbanisation affects plant-pollinator interactions. We exposed flowering branches of a major plant invader (*Robinia pseudacacia*, black locust) and a native plant species with the same flower morphology (*Sarothamnus scoparius*, Scots broom) and observed different plant-pollinator-interactions (direct visits, hovering, hovering and visit). Surprisingly, a broad range of pollinator taxa visited flowers of both native and alien plant species, without significant differences between numbers of direct visits. In contrast, significantly more pollinators hovered only around flowers of the alien plants without visiting them later. Urbanisation was significantly related to plant-pollinator interactions since the decision to directly visit flowers of the alien plant after hovering decreased with increasing urbanisation. Results thus show that: (i) in contrast to previous findings, blossoms of *Robinia pseudoacacia* do not only attract honey bees but also a broad range of other pollinators; (ii) urbanisation significantly affected plant-pollinator interactions as decisions to visit flowers after hovering decreased with increasing urbanisation. Our study has important practical implications as it demonstrates the attractiveness of a frequently planted and invading, alien tree species for pollinators. A better understanding of mechanisms that underlie the detected urbanisation effects can support urban conservation policies and the conflicting debate on using alien plant species in urban greening.

O03

Nature-lovers and city-dwellers: Differential response of native and exotic species to human impact and habitat structure.

Wendy Jesse[1], Matt Helmus[2], Jocelyn Behm[2], Jacintha Ellers[1]

[1]Vrije Universiteit Amsterdam, Amsterdam, Netherlands. [2]Temple University, Philadelphia, USA

Exotic species cause major ecological and economic damage, and islands are particularly vulnerable to their impacts. The introduction and establishment of exotic species has increased rapidly over recent decades, due largely to the synergistic effects of human activities such as global trade and urban development. Exotic species often colonize and establish in urban areas and may thus depend on human land use before they can successfully spread into natural habitats. In this study we investigate how human land use affects local taxonomic and functional diversity, specifically contrasting native and exotic species. We extensively surveyed the reptile communities on two Caribbean islands for diversity and environmental data across habitats that varied in structure and human impact level. Of the composite environmental variation among 113 sample plots, 48% could be reduced onto two PCA axes, resulting in a habitat structure axis (29%) as well as a human land use axis (19%). These axes were subsequently regressed against various diversity indices and functional trait values. The effects of human land use and habitat structure differed significantly between exotic and native species. Exotic abundance and species numbers were found only in dry, shrub-covered and human-impacted environments, whereas native abundances reached their maximum in the tropical forest. Interestingly, the habitats occupied by exotics were dominated by large-bodied, large- headed, thermotolerant and sexually dimorphic species; the same traits that were previously associated to exotic establishment and likely beneficial for living in dry areas of low food availability. On the economically more developed island, recent extirpations have led to an extinction debt. Here, we found that exotic reptiles occupy the empty functional niche space left unoccupied by the extant native community. This suggests that eradication of exotic reptiles will quickly be followed by establishment of new exotic species as long as extinction debt exists.

Himalayan balsam interacts with river restoration to modify macro-invertebrate community diversity across ecosystems

Ffion Davies, Mike Fowler, Dan Forman

Swansea University, Swansea, United Kingdom

Himalayan balsam (*Impatiens glandulifera*) is an extremely invasive plant species, quickly colonising and dominating numerous habitats including woodlands, fens, mesotrophic grasslands and riparian zones. Balsam's impact on river systems and intra-riverine organisms is not fully understood and could have cascading impacts on local biodiversity that completely alters species assemblages. Anticipated impacts include reduced diversity and quality of allochthonous vegetation, and increased sedimentation of the river bed, which could directly reduce water quality and ecological health, counteracting the Water Framework Directive 2020 targets. We recorded benthic macro-invertebrate and riparian vegetation community diversity for two post-industrial rivers in South Wales (U.K.), investigating the effects of balsam coverage, physical river features and water quality on species diversity and multivariate community measures. Over 13,000 macro-invertebrate individuals revealed large overlap in species composition between the two rivers. However, the overall macro-invertebrate diversity at one river (Ogmore) was significantly lower than the other (Garw) and each river showed different responses to balsam cover. When balsam was present, increases in river width, water velocity, depth and total organic nitrogen had no effect on macro-invertebrate diversity at the Garw, but increases in these environmental variables increased macro-invertebrate diversity when balsam was absent. In the Ogmore, increases in the environmental variables positively influenced macro-invertebrate diversity when balsam was present, but had no effect on macro-invertebrate diversity when balsam was absent. The river Garw has undergone extensive restorative work following the cessation of mining in the mid-1980s to redeem it from its nickname "the Black River". On the contrary, the Ogmore remains subjected to greater levels of urbanisation, agricultural and industrial practices than the Garw. This work demonstrates the important interactions that can arise between habitat restoration efforts, local environmental variables and non-native invasive species in determining biodiversity changes across ecosystems.

Invasive Giant rhubarb (*Gunnera tinctoria*) has positive effects on earthworms and contributes carbon to soil food webs

Olaf Schmidt, Mauricio C. Mantoani, Hannah Fearon, Darragh Furey, Fawzah Al Hakami, Bruce Osborne

University College Dublin, Dublin, Ireland

Using an existing, replicated field experiment on Achill Island, County Mayo, Ireland, we compared earthworm populations in fields with long-term *Gunnara* invasion and in grassland (un-invaded control). We also included invaded sub-plots from which *Gunnera* had been removed mechanically or chemically about 6 months previously. Earthwom abundance under *Gunnera* was more than two times larger and earthworm biomass more than three times larger than under native grass. Earthworm populations in the two *Gunnera* removal treatments were smaller than those under *Gunnera*, but still larger than under grass. Natural abundance measurements of carbon and nitrogen stable isotope ratios in *Gunnera* tissues, in bulk soil and two earthworm species suggested strongly that *Gunnera* contributes substantial amounts of carbon to soil and soil food webs. In spite of presumed N_2 fixation in *Gunnera*, nitrogen isotope ratios in mature plants were not different from those in grass. It was therefore not possible to distinguish nitrogen contributions to soil pools from *Gunnera*. We conclude that *Gunnera* can have positive effects on soil fauna and soil food webs in invaded habitats.

Defying a traditional assumption: Non-native plants species seem to have positive effects on native biodiversity in grasslands located in several Mediterranean-climate regions

Irene Martín-Forés[1,2,3], Belén Acosta-Gallo[2], Greg Guerin[3], Andrew Lowe[3], Isabel Castro[4], José M. De Miguel[2], Miguel A. Casado[2]

[1]The National Museum of Natural Sciences (MNCN-CSIC), Madrid, Spain. [2]Complutense University of Madrid, Madrid, Spain. [3]The University of Adelaide, Adelaide, Australia. [4]Autonomous University of Madrid, Madrid, Spain

The presence, diversity and abundance of non-native plant species in natural vegetation are common condition indicators used to determine conservation status, with consequences for management strategies and investment. The rationale behind this is the assumption that non-natives have negative consequences on native biodiversity. But this assumption is not so clear-cut, especially when studying human-managed systems such as grasslands. Associated with the European colonisation and the expansion of the agrarian culture, non-native species originated in the Mediterranean Basin were introduced in the other Mediterranean climate regions worldwide. We carried out several studies focusing on relationships between non-native and native species in grasslands from central Chile and South Australia. Long-term patterns of these relationships in Chilean grasslands showed that community dynamics over time constitute a net gain in biodiversity, increasing natives and maintaining a general non-native pool, allowing the coexistence of both. In Australian grasslands, we found no negative relationships between non-natives and native biodiversity in terms of emergent diversity metrics and occupation of space, indeed, many positive relationships were revealed although differences were found along a disturbance gradient. In high-moderately disturbed grasslands such as crops and modified pastures, positive associations were enhanced. Thus, tolerance and facilitation mechanisms may be involved, such as complementary roles through different life history strategies (e.g. in Australian grasslands the non-native flora was dominated by annual grasses and herbs whereas the native flora represented more diverse growth-forms with a higher proportion of perennials). Non-native species present in Mediterranean-climate grasslands, that mostly originated in the Mediterranean Basin have co-evolved with human agrarian practices over millennia; thus they have developed a key role in other agroecosystems along the Mediterranean biome. Consequently, although particular non-native species may negatively impact biodiversity, this cannot be generalised and management focusing on general non-natives eradication in Mediterranean-climate grasslands might be ineffective

A Quaternary perspective on synanthropic insect introductions

Eva Panagiotakopulu

School of GeoSciences, University of Edinburgh, Edinburgh, United Kingdom

Research on fossil insect faunas from the beginnings of human settlements provide an understanding for both the spread of species of pests and the pathways which led to their current global distributions. This paper will provide a summary of introductions linked with the beginnings of farming, which started with storage pests such as *Sitophilus granarius*, *Oryzaephilus surinamensis* and *Tribolium castaneum*, the house fly *Musca domestica* and the human flea *Pulex irritans* spreading in Europe with the first farmers. These first introductions map the spread of farming utilising centralised storage in the Rhine valley with the earliest agriculturalists of the Linear Band Keramik, and its replacement by a more pastoral-based economy during the late Neolithic of northwest Europe. Another wave of introductions arrived with the expansion of the Roman Empire and its support systems, particularly grain supply for the army. In the British Isles the granary weevil follows step by step Roman expansion, but surprisingly fails to cascade down from forts, towns and villas to lesser, 'peasant' settlements. There is some evidence for its survival in South-east England after the collapse of centralised control. Norse colonisation saw the geographic expansion of several synanthropic species to Norway and additional introductions arrived on ballast. Trade during the medieval and the post-medieval period led to the wide spread of synanthropic faunas. With the changes in shipping vessels and transatlantic journeys the introductions become cosmopolitan and from the late 16th century onwards there is evidence for the progressive homogenisation of the biota and a different landscape arising.

Quantifying and monitoring pine invasions impacts and their legacies: *Pinus contorta* in Patagonia

Aníbal Pauchard[1,2], Rafael García[1,2]

[1]University of Concepción, Concepción, Chile. [2]Institute of Ecology and Biodiversity, Concepción, Chile

Pines are causing increasing impacts on the ecosystems they invade, but little is known on which are the main mechanisms by which those impacts occur and how long their legacy remains after the removal of pines. Here we report on the final results of a project aimed to quantify the ecological impacts of the invasion of *Pinus contorta* in two contrasting ecosystems (Araucaria araucana forest and Patagonian steppe). We found that the intensity of the pine invasion on several microenvironmental variables is highly associated to the pine biomass, as pine density increase water availability is reduced as well as light availability and temperature ranges (low and max To). Pinus contorta also reduces the diversity of vascular plants in the araucaria forest and in the Patagonian steppe, but this effect is more pronounced in the steppe. Regarding community changes in the history of life traits, environments with higher invasive biomass were positively correlated with higher community values of plant height, specific leaf area (SLA), and relative content of foliar chlorophyll. We found structural differences between the Malalcahuello and Coyhaique sites and through the invasion gradient. The richness and abundance of the invaded community changes significantly in the gradient of invasion and between sites. The removal of pines in the Araucaria forest and the steppe significantly reduced canopy and increase PAR, but there is a neighborhood effect in areas with a high pine biomass. For both sites, the maximum temperature of the soil and air increases when the pines are removed and remains so in the period. For soil moisture, there is no significant pattern of the effect of the removal or invasion legacy. This study provides new quantitative methods to test for long-term impacts of tree invasions. Funded by Fondecyt 1140485 and Conicyt PFB-23.

Leapfrogging to the Galapagos Islands: the introduced Fowler's Snouted treefrog

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Amphibians are not part of the native fauna of the Galapagos Archipielago. The only amphibian in the islands is the Fowler's Snouted treefrog *Scinax quinquefasciatus*, which was introduced from mainland Ecuador by means of cargo transfer, around 1997-1998. Frogs have since been reported as established in two of the five inhabited islands (Isabela and Santa Cruz), but there is little information available on its current impacts, distribution and dispersal mode.

Amphibians are known to be important elements in food webs, particularly in the tropics both as predator and prey. If they become invasive species, they can have severe impacts on the native biota. Therefore, we studied the distribution of the treefrog and assessed the invasion potential of the species across the archipelago. In addition, we conducted controlled predation experiments and gut contents analysis. Preliminary results showed that the frog is more abundant in the humid agricultural zones than in protected National Park areas, which could be an indication for human-mediated jump-dispersal. Most prey items encountered in the stomachs belonged to the arthropod orders Lepidoptera and Araneae. Predation experiments, in which tadpoles were exposed to different potential native aquatic predators, showed that the larvae of an endemic diving beetle caused a high mortality in the tadpole population.

Results obtained so far serve as baseline information about the trophic relationships and potential impact of this invasive frog. Currently, genetic analyses are carried out to determine the origin of the species' introduction (potential source populations) and its within and inter-island dispersal. In addition, a future Citizen Science project will advance the distribution maps by locals reporting frog sightings and calls through social media. This integrative approach will allow us to obtain results that are invaluable for an effective management of this species in the Galapagos National Park.

Contrasting long-term impacts of two large invasive alien plants

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Knowledge of the long-term impacts of plant invasions is the key to developing effective control and restoration measures, as well as for understanding the functional significance of invaded ecosystems. Recent evidence indicates that invasions by large herbaceous species often results in major changes to resident communities and ecosystems. Here, we assessed the legacy of two major invasive herbaceous species, *Gunnera tinctoria* and *Impatiens glandulifera*, on native plant communities (above- and below-ground vegetation) and ecosystem processes (pH and nutrient cycling), at three sites (per species) that had long been colonized by these invaders in Ireland. While both species are listed as species of Union concern in the EU Regulation on Invasive Alien Species, they differed substantially in their impacts on the standing vegetation, soil pH and nutrient availability. While both species were dominant in long-term invaded communities, *Gunnera tinctoria* promoted major changes in the diversity and composition of the invaded communities, and thus on their regeneration potential. In contrast, for *I. glandulifera*, only a few species disappeared from the invaded communities, suggesting that the removal of this invader could successfully promote restoration to pre-invasion conditions, although both invaded and non-invaded communities were relatively species-poor. *Gunnera tinctoria* also promoted significant changes in pH and nutrient cycling, while *I. glandulifera* did not appear to have major ecosystem-level effects. Additional examinations of the seed bank and soil parameters over the growing season will help improve our understanding of the long-term implications of these species in coastal (*G. tinctoria*) and riparian (*I. glandulifera*) communities. Besides confirming the high context-dependent nature of the impacts of plant invasions, these findings suggest that dominance in the above-ground vegetation is a poor indicator of the impacts of plant invasions or their reversibility or the efforts required to control invasive stands and restore native communities.

The impact of the timing/duration and intensity of disturbance on network structure: how species invasion shapes network structure in a plant-pollinator community

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For networks of ecological interactions, the addition of a novel species can act as a disturbance by perturbing the structure of existing interactions. A novel mutualist may act as a disturbance, for example, by competing for interactions or adding new interactions. When viewed as a disturbance, it seems likely that the impact of a novel species introduction on a mutualistic network will depend not only on the intensity of the disturbance (e.g. how many individuals invade), but also on the timing and duration of the disturbance. To empirically explore the effect of a species introduction into a mutualistic network, we designed a field experiment with a full cross of two levels of intensity and two of timing/duration of the invasion of a mutualist plant species into a background community of five native plant species. We used a well-known supergeneralist invasive plant species (*Carduus acanthoides*) because it was hypothesized to have a strong effect on network structure based on earlier theoretical work. We then monitored each plant species in this community for insect visitation across the flowering season and constructed replicated interaction networks. We found that the networks of interactions responded in predictable ways to the disturbance of the invader and that the number of interactions formed by the invader (its generality) with mutualists mediated the strength of its impact, in accordance with our hypothesis. Furthermore, the timing/duration of the disturbance did impact the network structure; invasions that occurred late in the flowering season and were of shorter duration had a lesser impact on network structure.

Variation in the role of microbial networks and fitness of common wasps in their native and invaded range

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All insects have a symbiotic microbial community, containing both pathogens and beneficial species. We asked how microbial communities in common wasps (*Vespula vulgaris*) have changed between their native and invaded range. Are microbial networks different between ranges and do these differences contribute to variation in fitness between areas? We estimated fitness in wasps by sampling populations from Belgium and New Zealand in autumn, when new queens have been produced. Microbial communities were examined by a combination of 16S, 18S, and micro-fluidic array sequencing. Wasp fitness indicators were higher in the native range, with Belgium nests typically producing more queens in autumn. Regularised Canonical Correspondence and network analyses revealed that the microbial communities were markedly different in the two ranges, with greater diversity and complexity in New Zealand. Neither of these results is consistent with the enemy release hypothesis. Moreover, we found no evidence of a reduction in harmful or beneficial microbes in the invaded range. Some microbial-fitness interactions were contrary to prior expectations. Release from microbial enemies or adoption of mutualists is not apparent in *V. vulgaris* wasps in New Zealand, and local factors are more likely to be associated with its ecological success.

Roles of biotic resistance and disturbance in the establishment of an invasive invertebrate

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Several studies have found that disturbance (any discrete event that disrupts community structure and changes available resources, substrate availability, or the physical environment) and the absence of biotic resistance drive biological invasions but most of these studies have focused on plant invasions. We performed a field experiment to determine the role of disturbance and biotic resistance on the establishment of the invasive tropical fire ant (*Solenopsis geminata*) into novel areas. We introduced 447 *S. geminata* queens within 40 hours of their nuptial flight in individual cages that either excluded or allowed access to native ants, into two pairs of uninvaded sites situated near Darwin, Australia. Each pair of sites comprised an undisturbed and a disturbed site. The undisturbed sites were unmaintained savannah woodland and the disturbed sites were maintained open grassland (historically cleared savannah woodland). We retrieved the cages after 7, 14 or 25 days and determined queen survival. We used 19±1 replicates per treatment combination (i.e. site, cage type and exposure time) at each site (112±3 cages per pair of sites). Overall, 48.3% of queens retrieved at 7 days survived, 38.1% at 14 days and 19.3% at 25 days. Queens were twice as likely to survive if they were isolated from native ants (GLM: binomial, F=6.94, P>0.01), but 29.6% of queens that were not isolated from native ants were found alive. In the first pair of sites, queens were twice as likely to survive in the disturbed site (GLM: binomial, post hoc test, P<0.05), but they were not affected by disturbance in the second pair (GLM: binomial, post hoc test, P>0.05). Queens are highly vulnerable during colony founding and we found that biotic resistance could hinder, but not prevent, the successful establishment of *S. geminata* queens.

Strong fitness differences impede coexistence between an alien water fern (*Azolla pinnata* R. Br.) and its native congener (*Azolla rubra* R. Br.) in New Zealand

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Despite considerable evidence that alien plants impact the fecundity, productivity and abundance of native plant species, support for alien plant species causing the widespread decline of native species is rare. Coexistence theory proposes that the outcome of competition between two species can be predicted through the invasion criterion, measured as a positive population-level growth rate of each competitor when that species is rare. Here we make use of coexistence theory to examine the likelihood of persistence of a native water fern (Azolla rubra) following invasion by an alien congener (Azolla pinnata) which has apparently displaced the native wherever their ranges overlap in New Zealand. We evaluate coexistence between the two water fern species using experimental measurements of population-level growth rates. We show that the alien A. pinnata has a higher fitness than A. rubra, which hinders coexistence between the two species. These experimental results match the rapid expansion of A. pinnata and the apparent decline of A. rubra observed in nature. Our study predicts that A. pinnata is capable of replacing its native congener, highlights the importance of fitness differences in invasion success, and demonstrates the value of experimental analyses of species coexistence for predicting longer-term invasion dynamics and impacts. Using experiments to test coexistence mechanisms between alien and native species is a valuable approach to predict invasion outcomes and one that can lead to insights on the long-term impacts of alien species, including extinction, on native species populations.

Carpobrotus edulis: what doesn't kill it makes it stronger.

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Carpobrotus edulis is considered as one of the most dangerous invasive species worldwide. It invades coastal habitats, such as cliffs and sand-dunes, salt marshes and coastal scrub. However, it can also be found on roadsides and railway lines inland. At present, both generalist and specialist herbivore species are known to feed on *C. edulis* in both its native and invaded ranges. Nevertheless, it is not known if *C. edulis* has a different response according to the type of herbivore that feeds on it. The aim of this study is to assess the performance response of *C. edulis* from different origins (native vs invaded) when it is being attacked by both generalist and specialist herbivores. To do this, we collected seeds of *C. edulis* in its native (South Africa) and invaded (Chile and Spain) ranges, and both a generalist (*Philaenus spumarius*) herbivore native to Europe and a specialist (*Pulvinariella mesembryanthemi*) herbivore native to South Africa as herbivore treatment (collected in areas invaded by C. edulis in NW Spain). In a greenhouse experiment in Spain, we grew a total of 90 individuals of *C. edulis* (30 individuals per origin) for 3 months, which were subsequently inoculated with the respective herbivory treatments for another 3 months. Our results showed that *C. edulis* (independently of its origin) presents an induced systemic resistance to herbivores, which was expressed by a compensatory growth response when exposed to the generalist herbivore. In contrast, we found the specialist herbivore to cause severe damage to *C. edulis*, even death. *Carpobrotus edulis* individuals from South Africa and Chile showed a higher resistance to the presence of herbivores, compared to individuals from Spain. This suggests that the response of *C. edulis* to both generalist and specialist herbivores varies depending on its origin.

Enhancing natural biocontrol: could a generalist snail control an invasive herb?

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The large-leaved lupine, *Lupinus polyphyllus*, has spread rapidly on road verges and disturbed grasslands in Finland. For instance, in the 1980's, this invasive perennial herb occupied ca. 5% of study squares across the city of Lahti, southern Finland, while today, lupines occupy more than 70% of these squares. Specialist herbivores are usually absent, but the generalist snail, *Arianta arbustorum*, is consuming the lupine vigorously. However, the impact of generalist invertebrates on plant communities has often been regarded negligible. Yet, long-term research on herbivory opposes this concept. Our aim is to enhance the natural biocontrol by snails with liming: high soil pH stunts lupine growth, and calcium carbonate could attract snails. In June 2017, we set up a field study at seven lupine-occupied disturbed grassland sites, each containing i) an exclosure cage (i.e. without snails), ii) a procedural control cage (i.e. snails present), iii) a control plot of the same size (i.e. snails present), iv) a limed exclosure cage, v) a limed procedural control cage, and vi) a limed plot. We monitored seedling emergence, plant growth and fecundity of lupines in these treatments. In addition, we conducted feeding trials, and run a common garden experiment with potted lupine plants (n = 40) that follows the field study set-up. Preliminary results from the feeding trials suggest that snails consume calcium-enriched plants at a higher rate than the control plants. Results from the first season also indicate that snails decreased the biomass and density of lupine populations. Yet, snail herbivory did not influence the growth of individual plants. However, we hypothesise that the negative effect of herbivory on lupines will increase with time, and that snail herbivory in combination with liming could be a promising biocontrol solution.

Species origin determines importance of traits for riparian plants abundance in response to environmental drivers in Central Europe.

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Whether abundances of native and introduced species are driven by different traits and whether the importance of traits differs across a range of environmental conditions are among the most important questions of invasion ecology. We address them by exploring relations between the origin, traits and abundances of riparian plant species co-occurring in sites along a climatic gradient.

We mapped the identity and abundance of native species, archaeophytes and neophytes in 36 sites established on banks of Central-European river systems, located along a gradient of temperature and precipitation. We used multivariate regression to explain abundances with environmental characteristics, species origin and traits relevant to growth and dispersal, obtained from BIOLFLOR and LEDA databases.

The observed relationships between traits and abundance depended on species origin. Although these relations were not affected by the climatic gradient, their strength and direction differed both across the riparian systems and along the rivers. Our findings indicate that while abundances of native species were mostly dependent on fitness- and growth-related traits (i.e. specific leaf area and heavier seeds), neophytes relied most often on dispersal-related traits such as hydrochory or vegetative reproduction in most of the river systems. Longer flowering period also increased abundances of neophytes, but only in the upper river course.

Our findings indicate that the realized abundances of native and introduced plants depend on distinct traits. Moreover, because the importance of species traits was strongly context-dependent, their relation to environmental conditions needs to be taken into account. Observed differences between particular river systems may further be related to river characteristics, disturbances and abundance of alien species in adjacent areas. These topics, however, would require further studies.

Who is the winner? – the demon vs killer shrimp under mesocosm conditions

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Two Ponto-Caspian gammarids *Dikerogammarus villosus* (the killer shrimp - Dv) and *D. haemobaphes* (the demon shrimp - Dh) (Amphipoda, Crustacea) belong to the most successful invaders in European rivers. Generally, Dh was the first colonizer, but a drastic diminishing of its population was observed after the introduction of Dv. The aim of our study was to test if Dv may negatively influence the population of Dh in a long term experiment and if the presence of a top predator – the racer goby (*Babka gymnotrachelus*) may influence this interaction. We conducted a six-month experiment in twelve 700L mesocosms in four treatments: 1. only Dh; 2. Dh and goby fish; 3. Dh and Dv; 4. Dh and Dv and goby fish. We also conducted short term experiments upon the selective predation of the goby on both gammarid species.

In short term experiments, we showed that both gammarids avoided the racer goby predation with a similar success utilizing available substrate. In the mesocosm study, we did not observe negative impact of the goby on Dh density, but we observed that the species avoided area inhabited by fish. The fish presence impacted Dv density only at the end of the experiment and it did not influenced its distribution in tank. Dv negatively influence the numer of Dh juveniles, but only when the goby was absent.

We may conclude that the dynamics between two closely related species of invasive gammarids leading to the dominance of the killer shrimp could be explained by a complex of biological features presented by both species. The avoidance of Dv and top predator exhibited by Dh together with effective outnumbering Dh juveniles by Dv may possibly best explain the low densities of Dh in the presence of Dv observed in nature.

The alien games: are facilitative and competitive interactions among invasive species a pathway to invasional meltdown?

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The Invasional Meltdown hypothesis posits that facilitation among invaders could increase invasion success and impacts, but there has been mixed support for this hypothesis. Here, we examine facilitative and competitive interactions among three invasive species, the macrophyte *Elodea canadensis*, the more recent congeneric invader *Elodea nuttallii*, and zebra mussel, *Dreissena polymorpha*, which have rapidly become widespread in Ireland. While all three species can negatively alter ecosystem dynamics, *D. polymorpha* is particularly problematic, having displaced native mussel species, increased water clarity and associated algae blooms, and may induce shifts in macrophyte communities. As incidental field observations suggested the *D. polymorpha* populations can change *E. canadensis* and *E. nuttallii* assemblages, it was hypothesized that *D. polymorpha* alter interactions between these invasive *Elodea* species, facilitating competitive replacement. Here, we assessed the effect of interspecific competition on the growth rates between *E. canadensis* and *E. nuttallii* in the presence and absence of *D. polymorpha*. *Elodea* species were placed within mesocosms with either two individual growing strands of a single species, or one strand of each, and with 1-3 individual live zebra mussels. Mussels absent and intact shells were used as controls. Overall, in the absence of live *D. polymorpha*, there was marginal interspecific competition between the *Elodea* species. However, the presence of *D. polymorpha* was associated with differential growth rates between theses macrophytes. While *D. polymorpha* significantly enhanced growth of monoculture *E. nuttallii* in comparison to all controls, monoculture *E. canadensis* appeared to be unaffected. Remarkably, despite apparent interspecific competition, increasing numbers of *D. polymorpha* incrementally enhanced the growth of both *Elodea* species being held in an *Elodea* polyculture. These results suggest that negative impacts associated with invasive *Elodea* species, especially those of *E. nuttallii*, will be further exacerbated by invasive *D. polymorpha*, supporting the Invasional Meltdown Hypothesis.

Free-roaming dogs alter interactions between two endemic carnivores (the kodkod *Leopardus guigna* and the Darwin's fox *Lycalopex fulvipes*) in temperate forests of Southern Chile.

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The close association between domestic dogs and humans turned the former the most widespread and abundant carnivore in the world. Poor management practices resulted in free-roaming dogs acting as an invasive species in rural and neighbouring natural habitats, affecting native animal populations either directly or through indirect effects by disrupting local interaction webs. The extent to which such effects modulate existing local interactions has been poorly explored. Here we assessed the effect of dogs on two interacting carnivores endemic from temperate forests of Southern South America (kodkod *Leopardus guigna* and Darwin's fox *Lycalopex fulvipes*), across three regions differing in the composition of the local carnivore assemblage and, thus, in the pre-existing interaction web structure. We used two-species single-season occupancy models to assess the co-occurrence of the two native forest endemics while accounting for habitat structure and the detection rates of dogs and two larger competitively-dominant fox species (*Lycalopex* spp.) as co-variables. Overall, we found negative values for the interaction parameter 'phi' between the forest-endemic species, suggesting a trend to co-occur less than expected by chance (i.e. negative interaction). Further, deforestation and activity of dogs and other foxes seem to have stronger negative effects on the Darwin's fox than on the kodkod. This suggest a possible indirect positive effect (release) of free roaming dogs (and likely other foxes) on kodkod by restricting Darwin's fox abundance and/or distribution, and could contribute to the apparent commonness of this forest endemic felid on highly fragmented rural landscapes of southern Chile.

The Age of Plastics meets the Age of Invasions?: How tsunamigenic megarafting, coastal development, and climate change may all relate to a new ocean vector

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The 2011 Great Japan Earthquake generated a massive tsunami that launched an extraordinary transoceanic biological rafting event with no known historical precedent. More than 400 living species of Japanese marine animals and plants were transported to North America and Hawai'i over a 7 year period on drifting objects that traveled many 1000s of kilometers across the North Pacific Ocean. As of April 2018 Japanese tsunami marine debris with living species continued to arrive in North America. We suggest that the astonishing multi-year survival of coastal species at sea, also never before documented, is sustained by the modern-day non-biodegradable nature of these rafts, which sets anthropogenic-based ocean dispersal in clear contrast to historical processes. Plastic availability and use increased vastly in the last half of the 20th century at the same time as growing shoreline infrastructure poised these plastics at the land-sea interface. In turn, amplified storm activity due to human-mediated climate change will serve to sweep these plastics in unprecedented quantity into the sea. This expanded plastisphere may provide greater rafting opportunities for invasive species.

Adaptation and plasticity in biological invasions - eco-evolutionary experience and behavioural innovation

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Animal behaviour has been recognized as an important factor in biological invasions, either as facilitating invasions or coping with new ecosystems and species associations. The behavioural flexibility of taxa can render them apt invaders, and naive natives enter evolutionary traps or may be sufficiently plastic to cope with invaders. We aimed at synthesizing available data and information to predict and understand behavioural changes in the context of biological invasions. Based on a systematic review of the literature, we identified 195 studies documenting a total of 300 cases of behavioural change due to biological invasions in native (196 cases) and non-native species (104 cases). This global cross-taxonomic dataset contains information on the speed and the type of behaviour that changed in each case plus the underlying mechanism. We found that the types of behaviour that change differ between invaders and natives. In particular, native species changed their anti-predator behaviour more frequently than non-native species which is in line with the enemy release hypothesis. As expected, pre-disposition sets off instant behavioural changes, whereas genetic adaptation takes longer than learning. Interestingly, these mechanisms were quite evenly distributed among the taxa in our dataset. Furthermore, we developed and applied two classification schemes to measure eco-evolutionary experience (EEE) and the innovation in a behavioural change, both using an ordinal scale. We found that species with a low EEE in interacting with an invader show a negative population trend since the invader's introduction. This result was particularly strong for birds and suggests that the proposed classification scheme for EEE might be useful for predicting impacts of invasive species.

European anthropogenic, semi-natural and natural habitats as donors of naturalized plant species worldwide

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Long-lasting association of European plants with humans in their native range is frequently thought to be behind their success as aliens worldwide. We combined two available databases, the European Vegetation Checklist and the Global Naturalized Alien Flora (GloNAF) to compare human-made, semi-natural and natural habitats of Europe as donors of naturalized species to the rest of the globe. We also examined how these habitat categories based on level of human-induced disturbances affect the probability of naturalization of their plant species outside of the native ranges. Our data set contained 9,875 native European vascular plant species assigned to 37 European habitats, 2,550 of these species have become naturalized outside native range. Therefore, our study provides the most comprehensive analysis of the role of native-range habitats on naturalization probability available. Generalized linear models showed that European species with broad habitat range, i.e. those able to occur in human-made and semi-natural or natural habitats at the same time, and species confined to human-made and semi-natural habitats only had a significantly higher probability of becoming naturalized than species of natural habitats. From species linked to human-made habitats or combining the occurrence in them and other habitats, 64.7% ⎯41.7% have naturalized elsewhere. In contrast, 19.4% of species confined to natural habitats were identified as naturalized. Species associated with arable land and human settlements have naturalized in the largest number of regions (82.5% of all world regions recognized). Our findings highlighted broad habitat range and European plant species' association with highly or moderately human-disturbed habitats in the native range as factors significantly contributing to the global invasion patterns.

Predicting past and future biological invasions: challenges and opportunities of emerging alien species

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The predictions of new biological invasions is one of the most challenging and pressing questions in invasion ecology. Answering this question requires good data and a thorough understanding of invasion dynamics, which are often incomplete. Data availability considerably improved recently particularly for spatial distributions of alien species, but for predicting new invasions temporal data are needed, which are still scarce. We recently established the first record database encompassing >50,000 first records of >17,000 alien species worldwide. First analyses of this data set shows that even after centuries of introducing alien species, there is still a large proportion (26%) of species, which have never been recorded as alien species before worldwide. These so-called emerging alien species have no invasion history elsewhere and thus emerging alien species challenge horizon scanning studies and risk assessments, which often rely on known invasion histories. Using the information of the temporal development of alien species accumulations during the last 500 years, we developed an invasion model predicting past dynamics of the accumulation of emerging alien species for different taxonomic groups. Our study revealed that past dynamics of emerging alien species can only be understood by considering a source pool of alien species, which increased in time likely as a consequence of expanding trade networks and habitat modification. We used this knowledge about past invasion dynamics to project trajectories of emerging alien species until 2050 for various combinations of taxa and continents. This shows that we can expect distinct increases in alien species numbers throughout the world with particular strong increases in Europe, but also in regions with emerging economies such as South America.

Invasion syndromes – moving towards meaningful generalisations in invasion science

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The generalizable species traits, processes, and abiotic conditions that underlie successful invasions by alien species are often highly context-specific and have many exceptions. It is therefore challenging to gain insights into general invasion dynamics needed to make predictions and effectively manage ecosystems. In this presentation we will discuss an approach to identify the conditions under which certain generalisations hold based on the identification of "invasion syndromes". We define invasion syndromes as a three-way combination of a specific invasion pathway, alien species traits, and characteristics of the recipient ecosystem that results in predictable outcomes (regarding invasion or impact), and which in turn can be best managed by using a specific approach. We will present a conceptual model based on this tripartite scheme that aims to facilitate the procedure of identifying invasion syndromes. Finally, we will discuss how identifying invasion syndromes will allow us to account for the context dependency of biological invasions and move towards a predictive framework for invasion science and syndrome-specific management practice.

Prosopis invasions in East Africa: Species identity, ploidy and increased invasive potential

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Trees within the genus *Prosopis* (Fabaceae) are recognized as some of the world's worst invasive species. In Kenya and Ethiopia, the original founder plantations of several *Prosopis* species are still present, providing a unique opportunity to examine the original genotypes that acted as sources of invasive populations. These *Prosopis* species vary in their ability to spread, and intermediate morphotypes of the pure parental species, i.e. possible hybrids, seem to dominate the invasion in some areas in Kenya. Here, we studied the genetic variation and population genetic differentiation of original plantations and invasive populations in both Kenya and Ethiopia using microsatellite DNA markers. We also performed reciprocal transplant and common garden experiments to compare plant traits associated directly or indirectly with invasiveness. *Prosopis juliflora* appears to be the dominant invasive species in both Kenya and Ethiopia, consisting of mostly polyploid individuals with low genetic differentiation. Overall, differences in growth-related traits were greatest among individual *Prosopis* species. *Prosopis juliflora* genotypes that dominate the invasive populations do not display differential performance in growth-related traits when compared to genotypes from the original plantations. However, we found a higher rate of germination in seeds taken from invasive populations than those taken from plantations, and invasive genotypes reached reproductive maturity at an earlier age than genotypes from plantations. Our results indicate increased invasive potential in *P. juliflora* that may have facilitated its successful expansion in East Africa.

Can we link successful exotic reptile establishment to rapid climatic niche evolution?

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Introductions of exotic species cause major ecological and economic damage worldwide. Much research effort has gone into predicting exotic establishment based on the climate match between a species' native and exotic range, under the premise that if a species is adapted to a certain climate in its native range, it has a high probability of persisting in an exotic range with similar climate. However, an exceptionally high percentage of exotic populations demonstrate post-colonization climatic niche shifts, suggesting that species that can quickly adapt to novel climatic circumstances may be more likely to establish exotic populations elsewhere. High adaptability to novel climates has previously been linked to high speciation rates and historic range expansions of birds, amphibians, and plants. In this study, we assessed whether species from speciose clades, with large and variable climatic ranges and high rates of climatic niche evolution have a higher chance of becoming exotic (i.e., modern range expansions) than species from other clades. To test this, we performed phylogenetic analyses on 3400 lizard and snake species of the Western Hemisphere of which a subset has established at least one exotic population elsewhere in the world. Preliminary analyses on this dataset already showed that exotic species are phylogenetically clustered, indicating that exotic propensity might be conserved through evolution. We obtained climatic variables from the native geographic ranges of all species and calculated niche evolutionary rate, climate variation and native species richness per monophyletic clade. We subsequently regressed these variables against exotic species richness per clade. This study is to our knowledge the first to include an evolutionary component of ecological adaptability to explain exotic establishment success.

Behavior and the invasion success of different clones of the New Zealand mud snail in North America

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The traits responsible for invasion success appear to vary between species, but there is increasing evidence that behavior may be an important factor in the invasion process for animals. The world-wide invader, the New Zealand mud snail (Potamopyrgus antipodarum) has established populations in the American west and in the Great Lakes region of North America. In North America, the species appears to be composed of three genetically distinct clonal genotypes: US1, US2, and US3. US1 and US2 appear to be highly invasive as both have wide geographic distributions. However, US3 is found in only one location, and it seems that it has not spread since its introduction. The purpose of these experiments was to determine if P. antipodarum exhibits clone specific differences in behavior that may influence invasion success and how the detection of potential predators affects these behaviors. The snail in New Zealand is known to respond with avoidance behaviors to the detection of common piscine predators. Here we compare various behavioral traits between US and New Zealand native clonal genotypes in the presence of and absence of chemical cues from different potential North American predators. These behaviors include a floating behavior that may be important in dispersal, geotaxis, photokinesis, and emergence behavior. The results demonstrate that behavior does vary significantly between different clonal genotypes and that, in general, the most invasive North American genotypes respond to fish and crayfish odor more than other genotypes. We also found some evidence of behavioral differences between populations of the same clonal genotype suggesting that evolution of these traits has occurred since the species arrived in North America. These results also suggest that the ability to detect and/or respond to novel predators may have played a role in the invasion success of this species.

Global meta-analysis of native and nonindigenous trophic traits in aquatic ecosystems

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Ecologists have recently devoted their attention to the study of species traits and their role in the establishment and spread of non-indigenous species (NIS). However, research efforts have mostly focused on studies of terrestrial taxa, with lesser attention being dedicated to aquatic species. Aquatic habitats comprise of interconnected waterways, as well as exclusive introduction vectors that allow unparalleled artificial transport of species. Consequently, species traits that commonly facilitate biological invasions in terrestrial systems may not be as represented in aquatic environments. We provide a global meta-analysis of studies conducted in both marine and freshwater habitats. We selected studies that conducted experiments with native and NIS under common environmental conditions to allow detailed comparisons among species traits. In addition, we explored whether different factors such as species relatedness, functional feeding groups, latitude, climate, and experimental conditions could be linked to predictive traits. Our results show that species with traits that enhance consumption and growth have a substantially increased probability of establishing and spreading when entering novel ecosystems. Moreover, traits associated with predatory avoidance were more prevalent in NIS and therefore favour invasive species in aquatic habitats. When we analysed NIS interacting with taxonomically distinctive native taxa, we found that consumption and growth were particularly important traits. This suggests that particular attention should be paid to newly NIS for which there are no close relatives in the local biota. Finally, we found a bias towards studies conducted in temperate regions, and thus, more studies in other climatic regions are needed. We conclude that studies aiming at predicting future range shifts should consider trophic traits of aquatic NIS as these traits are indicative of multiple interacting mechanisms involved in promoting species invasions.

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A global attempt to unravel the context-dependence of the role of traits in plant naturalization

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About 4% of all plant species have successfully naturalized somewhere in the world outside of their native range. Yet, even larger numbers of species have failed to do so, and those that did so have not been successful in all non-native regions. An important body of research has thus aimed to understand the drivers of naturalization success, in particular with respect to the characteristics of the species. A consensus view is that these drivers are context-dependent, however to a large extent this context-dependence remains a black box. A recent database on the Global Naturalized Alien Flora (GloNAF) provides information on which of > 13,000 plant species have naturalized, in each of > 800 terrestrial world regions. We took advantage of this database to assess which species characteristics promote or impair naturalization in what type of environment. To do so, we collected data on species characteristics as well as data on region attributes. The three matrices thus obtained (species *vs* regions, species *vs* characteristics, regions *vs* attributes) were analysed jointly by means of RLQ and fourth-corner analyses. By highlighting positive and negative associations between particular species and region features, the results of our analyses help understand what context-dependence is, after all.

Environmental drivers of establishment and adaptation in the globally invasive *Plantago lanceolata*

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Invasive plant species are renowned for their ability to rapidly adapt to new environments. It is likely that different environmental features act on different traits to drive establishment and adaptation, but we still lack a clear framework for understanding such trait-environment relationships and their underlying genetic basis. Quantifying relationships between traits, genotypes and the environment can provide insights into the drivers of plant invasion and help manage invaded ecosystems.

We studied global patterns of spatial genetic diversity in the forb *Plantago lanceolata* and asked: how does variation in temperature, precipitation and moisture availability affect fecundity, population density and genetic diversity? We sampled DNA from 238 individuals in 28 populations of *P. lanceolata* across its native European range and its non-native range in North America and Australasia. A panel of > 19,000 single-nucleotide polymorphism markers was used to assess population genomic structure and genetic diversity.

We found substantial levels of spatial genomic structure across the native range (F_{ST} = 0.017–0.309; four genomic clusters) while all non-native populations (F_{ST} = 0.022–0.230) formed a single genomic cluster of Mediterranean origin. Genomic differences among native populations were structured by geographic distance alone (isolation-by-distance), indicating a strong dispersal effect on population structure. In the global population, variability in temperature was the predominant driver of spatial genomic structure, indicating environmental filtering of warm climate-adapted genotypes in the non-native regions (which were overall warmer than the native range). Non-native populations had higher genetic diversity, reflecting either their Mediterranean origin or increased genetic diversity through hybridisation. Genetic diversity among native populations increased with warm, dry climatic conditions and was also related to increasing fecundity. Our data from *P. lanceolata* suggest that traits affecting reproduction are sensitive to environmental variation and might be important for driving adaptation to hotter, dryer climatic conditions.

Colonization pressure: a second null model for biological invasions

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Colonization pressure was defined by Lockwood et al. (2009; *Diversity & Distributions*) as the number of species introduced or released to a single location, some of which will go on to establish a self-sustaining population and some of which will not. Here, we show that the number of alien species established in an area is a function of colonization pressure, combined with propagule pressure (the combination of propagule size and propagule number) and the probability that an introduced individual leaves

a surviving lineage. Changes in propagule pressure and the probability that an introduced individual leaves a surviving lineage affect alien species richness through their effects on population establishment probability, but only up to a limit set by colonization pressure. The influence of propagule pressure has already been argued to be a 'null model for biological invasions' (Colautti *et al.* 2006; *Biological Invasions*), yet we show that colonization pressure is the key primary of the number of alien species at a location. Therefore, we propose that colonization pressure should be considered as the second null model for biological invasions. We give examples of how ignoring colonisation pressure leads to incorrect conclusions about the invasion process.

Propagules are not all equal: traits of vegetative fragments and disturbance regulate invasion success

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Invasion success is regulated by multiple factors. While the roles of disturbance and propagule pressure in regulating the establishment of non-native species are widely acknowledged, that of propagule morphology (a proxy for quality) is poorly known. By means of a multi-factorial field experiment, we tested how the number (5 vs. 10) and quality (intact, without fronds or without rhizoids) of fragments of the clonal invasive seaweed, *Caulerpa cylindracea*, influenced its ability to establish in patches of the native seagrass, *Posidonia oceanica*, exposed to different intensities of disturbance (0, 50, or 100% reduction in canopy cover). We hypothesized that the ability of fragments to establish would be greater for intact fragments (high quality) and reduced more by frond removal (low quality) than rhizoid removal (intermediate quality). At low propagule pressure or quality, fragment establishment was predicted to increase with

increasing disturbance, whereas, at high propagule pressure or quality, it was predicted to be high regardless of disturbance intensity. Disturbance intensity, fragment number and quality had independent effects on *C. cylindracea* establishment success. Disturbance always facilitated fragment establishment. However, fragments retaining fronds, either intact or deprived of rhizoids, had higher establishment success than fragments deprived of fronds. Increasing propagule number had weak effects on the cover of *C. cylindracea*. Our results demonstrate that propagule traits enabling the acquisition of resources made available by disturbance can be more important than propagule number in determining the establishment and spread of clonal non-native plants. More generally, our study suggests that propagule quality is a key, yet underexplored, determinant of invasion success.

Key words: biological invasion; biotic resistance; *Caulerpa cylindracea*; clonal seaweeds; disturbance; propagule pressure; propagule quality.

Biogeographical comparison of invaded insect-flower interaction networks: conserved structural role but shifts in mutualist-antagonist ratios

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Most ecological studies on invasive species are carried out in the introduced range; however, comparative studies of communities and species interactions in both the introduced and native ranges are key for understanding how invasive species affect community structure. We tested whether an invasive plant with attractive and generalist floral displays dominates insect-flower interaction networks in native and introduced ranges, and assessed the occurrence of mutualistic and antagonistic flower visitors in both places. Using *Rhododendron ponticum* as a model species, we present the first comparison of field replicated, quantitative, insect-flower interaction networks in the native and introduced range of an invasive plant species.

Insect-flower interaction network structure, as measured by five commonly used network level descriptors, was similar for communities in both the native and introduced range.

Furthermore *R. ponticum* acted as a "super-generalist" in networks in both ranges. It had the highest species strength (i.e. the sum of dependencies of each species) of any plant, and was strongly connected to most insect visitors in all networks. Interestingly, visitation from nectar and pollen thieves and evidence of nectar robbing was more frequent on *R. ponticum* individuals in the native range.

Our findings indicate that the structural role of the invasive plant in insect-flower interaction networks is conserved across the native and alien range. They further suggest that invasive plants may alter insect-flower interaction network structure in invaded communities not just because they are novel introductions to the community, but because of the attractive and generalist nature of their floral displays. However, we found evidence for increased mutualist-antagonist ratios in the flower visitor communities of the invasive plant and thus "enemy release" from floral larcenists in the introduced range. Our study demonstrates that a comparative biogeographical approach is valuable in interpreting the impacts of invasive species on native plant-pollinator communities.

Contrasting patterns of managed and native bumblebees in natural habitats

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During recent decades, there has been a remarkable expansion of pollinator-dependent crops. An increase in colony numbers of managed pollinators associated with these crops might promote their spillover into nearby natural habitats. There, these managed pollinators might exploit resources similar to that of wild pollinators, and thus increase competition for local resources. In SW Spain, we investigated the presence, density and exploitation of flower resources of managed (Bombus terrestris ssp.) and native bumblebees (B. terrestris lusitanicus) in 19 Mediterranean pinewood understories across a landscape gradient of strawberry greenhouse cover. Sampling was performed over two consecutive years in two seasons: winter, when strawberries start flowering and farmers use many colonies; and spring, when there is greater

availability of wild flower resources and more wild pollinators across the landscape.

The presence of managed and native bumblebees in pinewoods showed opposite patterns in relation to greenhouse cover: the presence of managed bumblebees increased with greenhouse cover, whereas that of native bumblebees decreased. The density of managed bumblebees in pinewoods also responded positively to greenhouse cover and was higher in winter than in spring, while that of the native bumblebees did not show a pattern. The two bumblebee groups had similar wild flowering plant preferences particularly in winter, although strawberry pollen was only found on managed bumblebees. We conclude that although managed bumblebees are introduced in agroecosystems for crop pollination, their occurrence and density in nearby natural habitats demonstrates that the role of these domesticated animals extends beyond greenhouses. The opposing pattern in the presence of native bumblebees suggests detrimental impacts of habitat loss and managed pollinators on local pollinator fauna. Thus, an optimization of the required pollination services should be addressed in pollinator-dependent crops.

Phylogenetic distance and floral trait dissimilarity between alien and native plant species as drivers of novel pollination mutualisms

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Biological invasions offer real-time opportunities to study the assembly of communities, as many alien organisms have integrated into native communities, and novel biotic interactions are established. There are two major concepts on the roles of novel plant-pollinator interactions in the assembly of invaded communities. Due to pollinator facilitation, alien plants that can use the same pollinators as the natives should more readily attract pollinators, because they have more similar floral traits to the natives. Alternatively, due to pollinator-mediated competition, alien plants that can use different pollinators from the natives should more readily attract new pollinators in the local community. In both cases, the formation of novel interactions may depend on the plant traits that influence pollination. In a field experiment, we test whether novel plant-pollinator interactions involving alien plants

and native pollinators are influenced by phylogenetic distance and floral trait dissimilarity between the alien and the native plant species. In multiple sites in Southern Germany, we simulate invaded plant communities and manipulate the phylogenetic distance and floral trait dissimilarity between the alien and the native species within the communities by placing pots with flowering alien plants in communities of co-flowering natives. To disentangle the effects of phylogenetic distance and floral trait dissimilarity, we include six factorial combinations of phylogenetic distance and flower color similarity between the added alien species and the dominant native species in the community. We record flower visitation by native insect pollinators to the alien plants, and collect floral trait data on the added alien species and on all the native species. We expect that frequency of flower visits and reproductive success of the added alien species will decrease with increasing phylogenetic distance and floral trait dissimilarity between the alien and the native plant species in the case of facilitation, and increase in the case of competition.

O37

Examining the spread of non-indigenous species across marine ecoregions using environmental DNA

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The successful establishment and spread of non-indigenous species in new ranges partly depends on the composition of the recipient community and abiotic conditions such as temperature. However, little is known about how these factors influence the spread of non-indigenous species post-establishment. Genetic tools reveal historical range shifts and provide insights into how these factors may interact. Biodiversity monitoring using environmental DNA (eDNA) metabarcoding is becoming increasingly common and has the potential to contribute to our understanding of post-establishment spread. In eDNA studies, DNA from organisms found in environmental samples is sequenced to infer presence or absence of the species. This approach has been shown to overcome challenges in sampling effort and species identification common in traditional survey methods. Here we compare traditional rapid assessment biodiversity surveys (RABS) and eDNA metabarcoding to analyse spatial and temporal patterns of recipient community species richness and non-indigenous species across the dramatic temperature gradient of the South African coastline. The cold easterly Benguela current dominates the west coast of South Africa, while the warm Agulhas current flows westerly along the south and east coasts, resulting in distinct eco-regions. These eco-regions have different patterns of introductions by sessile marine invasive species such as sea squirts (Class Ascidiacea, Phylum Chordata), with cold and warm water species restricted to certain regions. We first examine in detail nine non-indigenous sea squirt species by collecting samples along the entire coastline for population genetic analyses. We then compared the RABS data (both historical and current) with eDNA from seawater samples collected in the same sites. We found that eDNA biodiversity surveys provide reliable estimates of species richness in comparison to RABS. Additionally, we provide insights into post-colonisation spread of non-indigenous species at different time scales.

O38

Reduced impacts of natural enemies of invasive plants at high latitudes

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Invasions at high (northern) latitudes are an emerging problem that is likely to worsen with ongoing climate change. Understanding how non-native species interact with communities of natural enemies (herbivores and pathogens) near their upper latitudinal range limits may be crucial to understanding their future spread and impacts on native competitors. Evidence suggests that these interactions may differ significantly from those important at better-studied low-latitude sites. My lab has documented latitudinal trends in herbivore damage to the invasive European thistle *Cirsium arvense* by sampling plants over a 800 km transect from agricultural southern to boreal northern Ontario, Canada. We also have investigated soil feedback using inocula sampled at both local (inside/outside existing populations) and geographic scales. Results indicate that thistle populations host a diverse set of herbivores, many of which are shared with co-occurring natives; however, impacts of these enemies generally decline with increasing latitude. Plants inoculated with northern soils outperformed those inoculated with southern soils, also suggesting a reduction of pathogens at northern sites. These patterns resemble the decline in herbivore pressure with increasing latitude described for native species by the latitudinal herbivory-defense hypothesis (LHDH). Surveys of both native and non-native species at the northern port of Churchill, Manitoba, on Hudson Bay, are helping to put these results into perspective by indicating whether non-native plants are outliers, or are merely exhibiting a shared trend. In either case, escape from enemies by latitudinally marginal populations of invaders indicate that they experience a very different interaction network than more central populations, potentially contributing to future range expansion into previously invader-free regions.

O39

Invasive alliance: the presence of zebra mussel can facilitate the survival and dispersal of killer shrimp

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Synergies between invasive species are an important, but little investigated, aspect of invasion biology that can offer a better understanding of the impact and dispersal of invasive species. We carried out three experiments to investigate potential synergies between two of the most damaging freshwater invasive species: the zebra mussel (*Dreissena polymorpha*) and the killer shrimp (*Dikerogammarus villosus*). Previous studies had shown that killer shrimp could benefit from living in the substrate created by zebra mussel but the mechanisms remain obscure. We show that killer shrimp attraction to patches of zebra mussel is not related to zebra mussel density and that substrates with similar textures offer equally suitable refugia for killer shrimp. Using specimens from two different populations, one living in sympatry with zebra mussel and one living in isolation, we tested how killer shrimp react to the presence of zebra mussel. Our results indicate that killer shrimp can chemically recognise the presence of zebra mussel and are attracted to it. We argue that chemical attraction among invasive species should be taken in account when predicting future dispersal scenarios, as the presence of some invasive species could facilitate the establishment of others.

Killer shrimp behaviour has also been tested in the presence of a predator, aiming to understand which anti-predatory strategies allow this species to survive in a newly colonised environment. Our results show that when killer shrimp recognize the presence of a potential predator, it's preferred anti-predatory strategy is hiding behaviour rather than group protection with other killer shrimps. A substratum composed of zebra mussels, where the shrimp can hide, can play an important additional role in killer shrimp survival.

Enhanced attractiveness in the invasive *Impatiens glandulifera?*

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Impatiens glandulifera, also known as Himalayan balsam, is known for its prolific spread across Europe and Northern America. *I. glandulifera* is listed among the "100 of the Worst" list of invasive species by DAISIE (www.europe-aliens.org). *I. glandulifera* out-competes and replaces native flora, significantly reducing biodiversity. *I. glandulifera* is known to preferentially attract pollinators away from native flora, incurring a reduction in both the seed set and fitness of nearby flora, enabling *I. glandulifera* to conquer the invaded environment (Chittka & Schürkens, 2001). The nectar of *I. glandulifera* is rich in sugars (~50% sugar) and is produced in large volumes, facilitating the attraction of pollinators. Along the River Barrow in Carlow there is a population of *I. glandulifera* which is dominated by a typically rarer white morph.

White morphs have been observed to persist in populations in larger numbers where there is an ecological advantage (Dormant *et al.,* 2010). The nectar of the white morph and the wildtype are juxtaposed to investigate if this observed phenotypical change has affected the attractiveness or fecundity of the species, and consequently, its invasive status. The quantity of nectar produced and the nutritional composition of the nectar (sugar and amino acid composition) are compared to determine if the morphs differ in their attractiveness to pollinators.

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Reconstructing the spread of a global invader: a genetic study of red swamp crayfish, *Procambarus clarkii*

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Biological invasions are one of the biggest threats to global biodiversity. Understanding how introduced species succeed and become widely distributed within non-native areas is critical to reduce the threats posed by them. Propagule pressure (i.e. the size and number of introduction events) is thought to be one of the key elements driving invasion dynamics. Over the last 100 years, freshwater ecosystems have been widely invaded by the North American red swamp crayfish, *Procambarus clarkii*. In order to confirm the "official" history of the red swamp crayfish invasion process throughout globe, we aim to (1) determine whether there had been unrecorded introductions and (2) establish the genetic structure of native/invaded populations and (3) analyze the invasion dynamics. To do this, 1416 crayfish from 22 native and 100 invaded sites in the Northern Hemisphere were analyzed using mitochondrial gene sequences (COI) and 864 of them were analysed with 14 polymorphic microsatellites loci. A total of 65 haplotypes were found, 15 of which were shared between at least two populations. As expected, our results showed that the native area has the highest haplotype diversity (Hd: 0.902). However, diverse hotspots in some invaded areas, such as United States (Hd: 0.804) or South-western Spain (Hd: 0.663 and 0.716) were lower than native area, indicating possible bottlenecks due to the propagule pressure. Our results suggest a large and/or diverse population for initial introduction events and a spread involving several subsequent secondary introduction events thereafter with losses of genetic diversity, possibly due to the accumulation of population bottlenecks. However, the finding of new haplotypes also suggests that additional translocations of crayfish other than those initially introduced may have happened. Such additional introductions have so far not been well documented in the literature.

Extrafloral néctar in phyllodes from invasive Acacia longifolia: why, how, when

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Plants respond to the environment and to interactions with other biotic life around them thanks to a number of different kind of strategies. Nectar is one of them: at the base of mutualisms enhancing plant reproduction (flower nectar for pollinators) or defence (extrafloral nectar for ants), it is also thought to be an overproduction of the plant ('leaky phloem' hypothesis and/ or 'sugar excretion' hypothesis). However, it has not yet been addressed from the point of view of invasive species. *Acacia* is a genus that resulted especially aggressive out of its homerange, able to establish interactions with native generalist pollinators thanks to the abundance of its resources. Most acacia species produce extrafloral nectar, mainly thought to be related to plant defence. In few species (e.g. *A. pycnantha* and *A. longifolia*) it has been thought to be related to pollination. Yet its presentation may be puzzling: on which phyllodes? To what extent? What about the secretory structure? At what time of the year? We will present data on acacia phyllodes and nectar morphologies, nectar presentation during pollination on a daily basis, and discuss them in the light of role of nectar in other alien invasive species.

Lineage overwhelms environmental conditions in determining rhizosphere bacterial community structure in a cosmopolitan invasive plant

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Plant-microbe interactions play critical roles in species invasions but are rarely investigated at the intraspecific level. We studied these interactions in three lineages of a globally distributed model plant species, *Phragmites australis.* We used field surveys and a common garden experiment to analyze the total and active bacterial communities in the rhizosphere of *P. australis* stands from Native, Invasive, and Gulf lineages to determine whether there were lineage-specific controls on rhizosphere bacteria. We show that regardless of sampling location across the continental United States, within-lineage bacterial communities are similar, but are distinct among lineages, results that were reproduced in a complementary common garden experiment. Further, our results indicate that the rate of bacterial community turnover with distance is lineage-specific. Invasive *P. australis* rhizosphere bacterial communities had significantly lower abundances of pathways involved in antimicrobial biosynthesis and degradation, suggesting a lower exposure to enemy attack than for the Native and Gulf lineages. However, lineage and not rhizosphere bacterial communities influenced individual plant growth in our common garden experiment. We concluded that lineage is critical for determination of both rhizosphere bacterial communities and plant fitness in North America. The next steps in our research are to expand our study to the global scale and sample in South America, Austral-Asia, Europe, and Africa. We are including other species in the genus *Phragmites* and we will collect samples not only for rhizosphere soil but also leaf tissue for both fungi and bacteria. Because environmental change is likely to favor some plant genotypes over others, understanding bottom-up changes due to microbial communities is critical in predicting ecosystem responses and community reorganization.

Regional forest carbon loss resulting from insect and disease invasions

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Worldwide, forests are increasingly affected by non-native insects and diseases, many of which cause substantial tree mortality across large regions. North America has been invaded by a particularly large number of such pests; over 400 forest insect and pathogen species are known to be established and about 70 of these cause noticeable damage. While information exists about ecological impacts of certain individual species, a comprehensive analysis assessing the composite ecosystem impacts of these species is lacking. Here we analyze > 120,000 forest inventory plots distributed across the USA to estimate the composite impact of the 15 most damaging forest insects and diseases on total tree biomass and carbon loss. We determine that the most damaging agents, in terms of biomass and carbon loss, are *Ophiostoma novo ulmi* (causal pathogen of Dutch elm disease), *Agrilus planipennis* (emerald ash borer), *Cryptococcus fagisuga* (causal agent of beech bark disease), and *Adelges tsugae* (hemlock woolly adelgid). From 2009-2015, all non-native forest pest species combined induced an average annual mortality rate (above background mortality) of 4.7% of living tree biomass. This translates into 7.1 million tons of carbon lost per year, which comprises 2.9 % of the annual net carbon sequestration of forest ecosystems in the USA or an equivalent of emissions from 5.6 million automobiles annually. These results indicate that forest pest invasions, driven primarily by globalization, are contributing to the accumulation of atmospheric greenhouse gases. Additional non-native forest pest species are anticipated to establish in the future and currently established species will likely expand their ranges. These trends can be anticipated to result in increased carbon loss in forests. More research is needed to better understand the fate of these losses on global carbon cycles.

Functional responses reveal temperature-dependent predatory impacts of highly invasive fishes

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Comparative functional responses have proven robust in predicting the impact potential of non-native species. Damaging invasive species have recurrently demonstrated higher levels of prey resource utilisation when compared to tropically-analogous native species. However, emergent context-dependencies, such as those driven by climatic change, can profoundly modulate interaction strengths in consumer-resource systems, resulting accordingly in fluctuations in ecological impact. In this study, functional responses were used to predict and compare the impacts of the invasive largemouth bass Micropterus salmoides and Florida bass Micropterus floridanus across a temperature gradient. Mosquito larvae were used as focal prey. Both species displayed a potentially population-destabilising Type II functional response across the three employed temperatures, characterised by high levels of proportional consumption at low prey densities. There was no significant difference in attack rates between the two species across all temperature treatments. The handling times differed significantly at higher temperature, M. floridanus had shorter handling times compared to M. salmoides. This resulted with higher maximum feeding rates for M. floridanus at higher temperatures than M. salmoides. Overall, the increase in temperature significantly decreased the functional response of M. salmoides, however, the functional response of M. floridanus was significantly increased. The study highlights the importance of species level impact assessments for invasive species management, as ecological impacts can between species within a genus.

Key words: Micropterus spp., Functional responses, temperature, non-native, impact, predation

Horizon scanning for invasive alien species likely to threaten biodiversity in the European Union

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The European Union (EU) has recently published its first list of invasive alien species (IAS) of EU concern to which current legislation must apply. The list comprises species known to pose great threats to biodiversity and needs to be maintained and updated. Horizon scanning is seen as critical to identify the most threatening potential IAS that do not yet occur in Europe to be subsequently risk assessed for future listing. We undertook a systematic consensus horizon scanning procedure to derive a ranked list of potential IAS likely to arrive, establish, spread and have an impact on biodiversity in the region over the next decade. The approach is unique in the continental scale examined, the breadth of taxonomic groups and environments considered, and the methods and data sources used. From an initial working list of 329 species, a list of 66 species not yet established in the EU that were considered to be very high (8 species), high (40 species), medium (18 species) risk species was derived. Here we describe the approach and the resulting species list alongside information on functional group, native distribution, the most likely pathway of entering the EU, the potential negative impacts and the most likely biogeographic regions to be affected.

Effects of experimental drought and invasion on fuel loads and fire intensity

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Multiple stressors such as drought and plant invasions can interact to alter the diversity and composition of plant communities and may consequently affect fuel loads and fire intensities. These interactions may complicate predictions of fire severity and potential feedbacks that might further affect community dynamics. Here we used a long-term field experiment with a factorial combination of drought (simulated with rainout shelters) and invasion (by the perennial rhizomatous cogongrass, *Imperata cylindrica*) to evaluate the effects of these stressors on fuel loads and fire intensity. To improve our mechanistic understanding of invader effects on fire intensity, we also experimentally manipulated invader fuel load and structure while measuring fire temperatures and flame heights. Invasion reduced native diversity, altered community composition, and significantly affected fuel loads, but the invader was minimally affected by the drought treatment. Fire intensity was predictably enhanced by greater invader fuel loads but also was altered by fuel structure. For example, with equal fuel loads, fire rate of spread was over 5x faster in standing invader fuels than piled fuels. Standing fuels also had nearly 3x greater maximum fire temperature on average at 50 cm height than piled fuels, but piled fuels produced hotter temperatures for a longer duration at ground level. Our results demonstrate that plant invasions can significantly affect fuel loads and mediate the intensity of fires in invaded areas, especially when invader performance is unaffected by water stress, and that fuel structure can significantly affect fire behavior. Additional research is needed to determine how the long-term effects of invasions on fuel loads and fire behavior scale up to landscapes, but our results highlight the need to understand drought-fire-invasion interactions when developing management plans for invasion prone habitats.

Socio-Economic Impact Classification of Alien Taxa (SEICAT)

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Many alien taxa are known to cause socio-economic impacts by affecting the different constituents of human well-being (security; material and immaterial assets; health; social, spiritual and cultural relations; freedom of choice and action). Attempts to quantify socio-economic impacts in monetary terms are unlikely to provide a useful basis for evaluating and comparing impacts of alien taxa because they are notoriously difficult to measure and important aspects of human well-being are ignored. Here we propose a novel standardised method for classifying alien taxa in terms of the magnitude of their impacts on human well-being, based on the capability approach from welfare economics. The core characteristic of this approach is that it uses changes in peoples' activities as a common metric for evaluating impacts on well-being. Impacts are assigned to one of five levels, from Minimal Concern to Massive, according to semi-quantitative scenarios that describe the severity of the impacts. Taxa are then classified according to the highest level of deleterious impact that they have been recorded to cause on any constituent of human well-being. The scheme also includes categories for taxa that are Not Evaluated, have No Alien Population, or are Data Deficient, and a method for assigning uncertainty to all the classifications.

The classification provides a consistent procedure for translating the broad range of measures and types of impact into ranked levels of socio-economic impact, assigns alien taxa on the basis of the best available evidence of their documented deleterious impacts, and is applicable across taxa and at a range of spatial scales. The system was designed to align closely with the Environmental Impact Classification for Alien Taxa (EICAT) and the Red List, both of which have been adopted by the International Union of Nature Conservation (IUCN), and could therefore be readily integrated into international practices and policies.

Impact assessment of invasive fishes using the Relative Impact Potential (RIP) metric under a seasonal temperature gradient

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Developing methods to predict and understand the impacts of both existing and emerging invasive species is of critical importance for assessment of potentially damaging invaders. However, impacts may be highly variable due to ranging biotic and abiotic context-dependencies which affect interaction strengths between consumers and resources. The Relative Impact Potential (RIP) metric provides an approach to quantify the potential impact of invasive species through the coupling of *per capita* effects (i.e. functional responses; FRs) and proxies for consumer population-levels responses (i.e. numerical responses; NRs). The RIP of three freshwater fishes that co-occur in freshwater ponds in South Africa was assessed: a native Goby *Glossogobius callidus*, an extra-limital Tilapia *Oreochromis mossambicus* and the alien Mosquitofish *Gambusia affinis*, towards representative focal prey. RIP was calculated using seasonal numerical field data and FR data from temperatures comparable to seasonal gradients, to elucidate temporal impact fluctuations. All three species exhibited potentially population-destabilising Type II FRs towards chironomid prey, which increased in magnitude under higher temperatures due to increased attack rates and concurrently reduced handling times. The native goby displayed the lowest FR irrespective of temperature suggesting lower impacts on native biota. The Tilapia exhibited the highest magnitude FR under both temperatures, suggesting greater *per capita* impacts on native biota, followed by the alien Mosquitofish. When seasonal field abundances were integrated in the new RIP metric, impacts of the three species differed between seasons, with the native Gobies displaying the lowest impact irrespective of season but with Tilapia and Mosquitofish RIP being dependent on season. Changes in RIP with seasonal temperature fluctuations demonstrate how such context-dependencies can have an effect on the relative field impact capacities of introduced species.

Keywords: Seasonal abundance, impact assessment, functional response, introduced species

The impact of invasive plants relates to geography and characteristics of native communities: Eurasian invaders outcompete clonal perennials in North America

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Developing methods to predict and understand the impacts of both existing and emerging invasive species is of critical importance for assessment of potentially damaging invaders. However, impacts may be highly variable due to ranging biotic and abiotic context-dependencies which affect interaction strengths between consumers and resources. The Relative Impact Potential (RIP) metric provides an approach to quantify the potential impact of invasive species through the coupling of *per capita* effects (i.e. functional responses; FRs) and proxies for consumer population-levels responses (i.e. numerical responses; NRs). The RIP of three freshwater fishes that co-occur in freshwater ponds in South Africa was assessed: a native *Goby Glossogobius* callidus, an extra-limital Tilapia Oreochromis mossambicus and the alien Mosquitofish *Gambusia affinis*, towards representative focal prey. RIP was calculated using seasonal numerical field data and FR data from temperatures comparable to seasonal gradients, to elucidate temporal impact fluctuations. All three species exhibited potentially population-destabilising Type II FRs towards chironomid prey, which increased in magnitude under higher temperatures due to increased attack rates and concurrently reduced handling times. The native goby displayed the lowest FR irrespective of temperature suggesting lower impacts on native biota. The Tilapia exhibited the highest magnitude FR under both temperatures, suggesting greater per capita impacts on native biota, followed by the alien Mosquitofish. When seasonal field abundances were integrated in the new RIP metric, impacts of the three species differed between seasons, with the native Gobies displaying the lowest impact irrespective of season but with Tilapia and Mosquitofish RIP being dependent on season. Changes in RIP with seasonal temperature fluctuations demonstrate how such context-dependencies can have an effect on the relative field impact capacities of introduced species.

Disentangling direct and indirect effects of Prosopis on Eastern African dryland ecosystems

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Invasive alien plants (IAPs) may affect many environmental variables simultaneously and the effects may depend on the receiving environment and site history. Moreover, some IAP effects may be indirect and mediated by, e.g., changes to biodiversity or vegetation structure. Measuring few, individual responses in a single region may therefore lead to an incomplete or incorrect understanding of invasion effects. Structural equation models (SEM) integrate multiple variables and can reveal direct and indirect effects of IAPs. We assessed how and through which mechanisms biodiversity and multiple ecosystem parameters changed along cover gradients of *Prosopis juliflora*, a woody IAP, in two dryland regions in Eastern Africa: Afar, Ethiopia, and Baringo, Kenya. Prosopis was introduced in this region to improve rural livelihoods and though it is valuable for, e.g., wood, shading and fencing, it also reduces biodiversity, herbaceous biomass and ground water levels. We assessed up to fourteen vegetation, soil and invertebrate parameters in ca. 65 plots in each region. Direct and indirect Prosopis effects on biodiversity and ecosystem parameters in each study region were assessed using SEMs. Linear regressions showed negative relationships between Prosopis and plant species richness and cover. Most effects of Prosopis in Afar on soil and invertebrate parameters were indirect and mediated through direct effects on plant species richness or plant cover. Prosopis caused an indirect decline in invertebrate abundance, soil carbon and soil stability. In Baringo no cascading effects were found, which may be due to the more severe ecosystem degradation there. Our results confirm that Prosopis can affect different aspects of ecosystems simultaneously, but suggest that effects on vegetation drive other ecosystem changes. Hence, plant species richness and cover are key variables to assess Prosopis effects on ecosystems. This study illustrates the value of SEMs to better understand the drivers of seemingly simultaneous ecosystem effects of IAPs.

The effect of invasive hybrid taxa on the ecological succession of coastal marshes

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Hybridization following colonization of invasive species in novel environments frequently results in offspring with improved biological and competitive functions referred to as heterosis or *hybrid vigor*. However, little is known about the effect of these invasive hybrids on the structuring and functioning of invaded ecosystems. Highly competitive, invasive hybrid taxa may play an important role in advanced stages of ecological succession in which competition becomes the dominant process determining the spatial distribution of plant taxa.

In the marshes of the Gulf of Cadiz (SW Iberian Peninsula) the invasive cordgrass with South American origin *Spartina densiflora* (2n = 70) has hybridized with the native *Spartina maritima* (2n = 60) giving rise to two different hybrids *Spartina maritima x densiflora* (2n = ca. 95) and *Spartina densiflora x martima* (2n = 65) with different ecological niches. To assess the role of these new genotypes in ecological succession, we recorded the size (diameter) of different tussocks of the *Spartina* hybrids and determined their annual lateral expansion growth rates in low and middle marshes in four invaded estuaries. The year of colonization for every tussock was estimated and the annual growth rates were compared to recorded meteorological with the aim to relate specific environmental conditions with colonization events of the invasive hybrids. Additionally, in a model invaded marsh in the Guadiana River Estuary, we recorded the cover of both *Spartina* hybrid taxa along the intertidal elevational gradient in January 2003 and 2016, and temporal changes in cover and distribution were analyzed.

Changes in meteorological conditions may increase hybridization risk and contribute to altering ecological succession within plant communities of coastal marsh ecosystems. In a scenario of climate change, results of this study are especially relevant to increase our knowledge about the effects of meteorological conditions on heterotic plant invasions.

Soil legacy effects of *Acacia* invasions and their implications for restoration in South Africa's Cape Floristic Region

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Invasive Australian acacias pose a major threat to the species-rich fynbos vegetation of the Cape Floristic Region (CFR) of South Africa. In these highly diverse ecosystems, the belowground soil microbial community is closely related to aboveground plant community diversity and structure. When invasive acacias become dominant in these habitats, they change both the aboveground plant and associated soil microbial communities. Such alterations could lead to plant-soil feedbacks, which likely persist even beyond the removal of the *Acacia* plants (so-called legacy effects) and can have a strong influence on the recovery of native plant communities. Here we evaluate the impact that invasive acacias have on mutualistic soil microbial communities in the CFR, and seek to disentangle the effects of soil conditions on their own performance and the recovery of native vegetation following clearing. We first evaluated whether acacia invasions change the nitrogen-fixing rhizobial community and how the availability of these rhizobia, along with overall invader-induced soil changes, influence acacias' performance. We also examined whether the legacy of *Acacia* invasions would influence the reestablishment success of native plants under field conditions. For this, we conducted vegetation surveys, sampled chemical composition and overall bacterial communities in soils from neighboring areas where pristine fynbos, *Acacia*-invaded and cleared sites are present. We found that invasive Australian acacias change the diversity and the structure of soil nitrogen-fixing microbial communities in the CFR. Although we did not find evidence of increased performance with rhizobia inoculation, our results indicate that interactions between soil abiotic and biotic conditions enhance invader performance through positive feedbacks. Our field study suggests that even when acacias are removed from the system, legacy effects driven by soil conditions hinder the full recovery of the native vegetation.

Direct and indirect effects of the invasive signal crayfish Pacifastacus leniusculus on leaf decomposition and invertebrate communities

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The crayfish Pacifastacus leniusculus is one of the most problematic invasive species in aquatic ecosystems in Europe. The crayfish may play an important role in plant-litter decomposition through direct consumption of plant litter or by changing the density and/or the behavior of native invertebrate detritivores. However, these effects remain poorly studied and may be context dependent. Therefore, we selected two rivers in Northern Portugal (Rabaçal and Tuela) subjected to very low human disturbance, but where P. leniusculus was recently introduced and is currently spreading. In each river, three different sites where selected according to records of the crayfish density (absent, low density high density). At each site, we measured direct and indirect effects of P. leniusculus on leaf decomposition using a set a four-treatments controlling the presence/absence of crayfish in rectangular baskets containing leaf litter and allowing or not the entry of other aquatic benthic invertebrates, by covering the baskets with fine (500 µm pore size) or coarse mesh (5 mm pore size). Results showed differences in both rivers regarding abiotic conditions, mainly conductivity. After 28 days, leaf mass loss was 18% higher in Tuela than in Rabaçal. In Tuela, leaf mass loss was affected by the crayfish presence and crayfish density in situ and by the interaction between factors. In Rabaçal, leaf mass loss was significantly affected by crayfish in situ density and interaction. Crayfish presence increased leaf mass loss in both rivers. Invertebrate abundance, richness, equitability and species composition were affected differently in both rivers. Further microbial analyses are being performed to better understand the different patterns between rivers. Overall, results indicate that P. leniusculus may directly alter plant-litter decomposition and affected associated invertebrate communities; however, effects are highly context dependent.

Impacts of global change on freshwater plant species

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Pervasive introductions of exotic plant species have resulted in naturalized species becoming a major component of floras of many countries. It is likely that many naturalized species will benefit from ongoing global climatic and environmental change and become problematic invaders. Freshwater systems are generally thought to be particularly vulnerable to exotic plant invasion, due to increased nutrient input from anthropogenic sources, but less is known on CO_2 effects or the interaction of nutrients and additional CO_2. Using published and herbarium records, we first conducted a descriptive analysis of the naturalized freshwater plant species in Australia. We found there are 63 naturalized exotic freshwater plant species comprising 13 nationally invasive and 14 that are invasive in at least one state or territory. The greatest numbers are in New South Wales (87%), Queensland (71%) and Victoria (63%) with the main introduction pathway being aquarium trade.

We then used an experimental glasshouse mesocosm approach to compare responses of selected native and exotic freshwater plant species to additional nutrients and elevated CO_2. In the first experiment, we compared trait responses of two native species (*Azolla filiculoides* and *Vallisneria spiralis*) and the exotic *Salvinia molesta* at ambient and elevated CO_2 concentrations. Elevated CO_2 resulted in increased biomass production and reduced specific leaf area (SLA) in the native *A. filiculoides*, while the other two species were unaffected. In a second experiment we investigated the effects of elevated CO_2 and nutrients on competition between *Azolla filiculoides* and *Salvinia molesta*. Additional nutrients and elevated CO_2 enhanced the relative growth rates (RGR) of both species, however there was no effect of competition on the RGR of either species. We conclude that exotic species are an important component of Australia's freshwater systems and that eutrophication is more important than elevated CO_2 in facilitating some exotic plant species in these ecosystems.

The European pine marten's role in reversing native red squirrel replacement by invasive grey squirrels: differential predation and landscape of fear

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1. Invasive species pose a serious ecological threat to the survival of native species and the functioning of entire ecosystems. In parts of Europe the increase of eastern grey squirrel (*Sciurus carolinensis*) populations has led to regional extinctions of the native red squirrel (*Sciurus vulgaris*). However, recent research suggests a negative, spatial correlation between an expanding population of European pine marten (*Martes martes)* and grey squirrels, reversing species replacement in squirrels as well as providing biological control of an invasive species. The mechanism whereby these effects occur is unclear but may entail differential predation rates and/or differences in response to the presence of a novel predator.

2. We investigated the occurrence of both squirrel species in scats of pine marten, and conducted an experimental investigation using camera traps to investigate behavioural responses of both squirrel species to chemical cues of pine martens at feeding points.

3. Grey squirrels occurred proportionally more frequently in the diet of pine martens than red squirrels, and could not be attributed to differences in the relative abundance of red and grey squirrels across the study area.

4. Red squirrels demonstrated a landscape of fear in response to pine marten scent at feeding stations. Grey squirrels did not demonstrate any such behavioural response to pine marten scent. This suggests that a landscape of fear is an adaptive behavioural response leading to reduced predation rates but is not yet evident in grey squirrels. The timing of pine marten predation on squirrels suggests that pine martens prey on juvenile grey squirrels. This could lead to reduced recruitment, population decline and reversal of red squirrel, grey squirrel species replacement.

5. This provides a plausible mechanism whereby interspecific differences in predation rate based on presence/absence of a landscape of fear, influences species interactions involving invasive alien species.

The harmonic radar to track the invasive hornet *Vespa velutina*: a tool to improve the Early Warning and Rapid Response System for the species

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The yellow-legged hornet *Vespa velutina* is an invasive alien species in Europe that preys honeybees and native insect species, thus producing serious impacts on beekeeping and biodiversity. Because of the issues posed by this hornet, Europe is considering *V. velutina* as an invasive species of union concern (Reg. EU 1143/2014), and member states should act to prevent, contain and limit its spread.

Many researchers are working on this topic, trying to develop innovative control methods. Currently, control strategies in Europe are based on hornet trapping and nest destruction. One of the main problems of the latter method is nest detection: despite of their great sizes, colonies remains hidden by leafs until late autumn or winter, when new queens have already spread into the surrounding environment.

To improve the efficiency of Early Warning and Rapid Response Systems (EWRRS) based on nest detection and destruction, the LIFE STOPVESPA project has developed a harmonic radar prototype able to track the hornets when flying back to their nests, to detect nests position before the reproductive period of the species. Advanced processing techniques allows to suppress clutter and improve target detection. The radar is capable to cover 360° in the horizontal plane and a large field of view in the vertical plane (20°). It allows following the tracks of the hornets tagged with a vertical 12.3 mm wire antenna and a diode (overall weight of 19.3 mg) in complex morphological environments, with a detection range up to 470 m.

This system has been used in Italy in autumn 2017, and allowed the detection of three nests that were immediately destroyed. In 2018, the harmonic radar will be used for the control of *V. velutina* diffusion in Italy, in particular in new invasion outbreaks to improve the efficiency of the EWRRS for the species.

Soil solarization as a tool for restoration of invaded habitat: advantages and limitations

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Soil solarization is an effective agricultural method for soil disinfestation eliminating various pests, pathogens, and weeds. Initial experimental applications in natural ecosystems were conducted in order to suppress *Acacia saligna* reinvasion after tree-clearing at Palmachim Nature Reserve. Seed bank removal was highly effective and resulted in almost zero seedling emergences two years after the treatment. However, the high costs and complexity associated with soil irrigation prior to mulching, as well as the small size of the experimental plots cast doubt on the feasibility of the method in large-scale areas. Two experiments have been conducted recently in order to adjust soil solarization to natural ecosystems. In the first experiment, soil was mulched immediately after the last winter rains to trap the natural soil moisture until the summer. The experiment was repeated in different years and in various habitats. In the second experiment, soil solarization was conducted on dry soil without prior irrigation at a large 0.4 Ha plot on the eastern shore of Lake Kinneret. Both experiments resulted in almost complete eradication of the *A. saligna* seed bank, followed by elimination of seedling emergence in the experimental plots, while in the control plots, the seed bank remained large and vital leading to thousands of seedlings per square meter. Recently, we found that the solarization process is effective against other woody invasive species such as *Acacia salicina, Leucaena leucocephala,* and *Parkinsonia aculeate*. Therefore, soil solarization may be effective against various invasive species in different habitats.

Experimenting with remote sensing techniques to monitor and manage invasive alien species.

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This series of experiments focuses on the treatment of a single problematic invasive alien species, *Petasites fragrans* (Winter heliotrope). Our aim is to inform best practice guidelines both for public bodies who require efficient, cost-effective, wide-scale management techniques, and private individuals who wish to engage in smaller-scale, domestic management of this plant.

Petasites fragrans is an invasive terrestrial plant that is becoming increasingly common on our roadsides and verges. It is notoriously difficult, if not impossible, to eradicate. It has an unusual biology, with its' principal growth season occurring between October and March. This gives it a strong competitive advantage over native flora when the principal growing season begins in spring.

There are two objectives to this work:

1. To identify the most appropriate treatment methods and their timing for maximum impact, thus minimizing the quantity of herbicides released into the environment.

2. To explore the value of using digital imagery and existing, freely-available software in an innovative way to analyse the results of ecological experiments and inform future management decisions.

Our experiments used carefully controlled treatment plots. The plots were monitored using both traditional methods of numerical data collection, as well as state-of-the-art imaging techniques, which minimize subjectivity in the interpretation of the results.

This presentation outlines the results so far, which show that readily-available herbicides, used correctly, can impact the growth and spread of *P. fragrans*. We describe the process by which the pilot project was monitored and analysed, and the usefulness of digital images and freely-available software in monitoring ecological experiments.

This work is part of a three-year research project (2016-2019) on the prevention, control and eradication of IAS. The project is a whole-island initiative involving the two separate political jurisdictions of Northern Ireland and the Republic of Ireland, and is funded by the Environmental Protection Agency (EPA).

Effects of river engineering and restoration measures on invasive fish species in the main stem of a free-flowing section of the river Danube, Austria

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Large rivers are not only natural habitats, but are also heavily used for energy production, transportation of goods, and recreation. As a result, major parts are modified by shore embankments, groynes, and other river engineering measures. These artificial structures, in combination with navigation, also facilitated the introduction of non-native fish species. To what extent invasive fish species actually pose a threat to native fishes is, however, in discussion.

One of the largest projects in Central Europe that aims at ameliorating conditions for the native fauna is the 'Integrated River Engineering Project' (IREP), currently carried out in a free-flowing stretch of the Danube east of Vienna (Austria). The IREP has an inter-disciplinary approach and tries to integrate improvements for navigation, to stop the ongoing incision of the river bed, and to conduct measures for ecological restoration. Detailed actions include sidearm reconnections, adaptation of groynes, and large-scale removal of bank stabilization measures, primarily aiming at improving conditions for the aquatic biota, including a characteristic fish assemblage.

In this study, we analysed to which extent the above mentioned habitat alterations may support or hinder the occurrence and abundance of invasive gobies, based on their spatio-temporal changes in a free-flowing, yet modified, section of the Austrian Danube. We present data from three full sampling years (before and after the measures) from a period of about 10 years, and three different sampling methods. Ten out of 51 fish species caught in the study area were non-native. Most of them were rare except for the invasive goby species (Neogobiinae). Although we found a drastic decrease in numbers since the last ten years, they are still among the most abundant species in the Danube. We further discuss the role of habitat type and response to different measures, as well as inter-specific interactions.

Can we make use of remote sensing data to manage invasive species? - The potential of detecting invasive species in Germany from above

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Combining remote sensing and field data allows for the detection of some invasive alien plant species with an adequate accuracy. Especially the use of satellite data for larger areas or UAS (unmanned aerial system) data for smaller sites may provide a useful addition to classical approaches. The feasibility of a remote sensing based detection, however, always depends on the respective study area and the available data.

This study discusses the possibilities and limitations of remote sensing to contribute to the detection of invasive alien plant species in Germany. We provide an overview of the available data types and explain the methodology for detecting invasive alien plants. Reviewing previous studies on the topic and taking into account the species characteristics (size, detectable traits, habitat) as well

as their similarity to other native species, we estimate the potential for a successful detection of relevant invasive plant species in Germany as including all species of the EU list of invasive alien species of union concern which are currently present in Germany.

For 19 of the 42 species examined, the use of remote sensing data may be successful, mainly for larger species and species with characteristic features such as colorful flowers or leaves, for another 10 species the detection might be feasible, and for about 13 species, especially hydrophytes living below the water surface and other species lacking any characteristic features, the detection is currently not possible. While for some species more research is needed to determine the detectability, for others remote sensing may offer efficient solutions for a small or large scale monitoring of the species spread or a control of management success.

Management options for IAS of Union concern: what's feasible?

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Robust evidence is needed to ensure management of IAS is feasible and resources are used cost-effectively. Risk assessments are of limited use to decide on species management because the feasibility of different options is not considered. Risk management provides a structured evaluation of management options including an assessment of practical, resource, societal, ethical and legal constraints. We used this approach in Belgium to assess the feasibility of management for 43 species of Union Concern sensu the EU IAS Regulation. We organized an online participatory process involving more than 40 experts with experience in species management using an adaptation of the UK Non-Native Risk Management scheme (NNRM) (Booy et al. 2017). NNRM uses semi-

quantitative response and confidence scores to assess key criteria linked with management feasibility: effectiveness, practicality, cost, impact, acceptability, window of opportunity and likelihood of re-invasion. We developed invasion scenarios and management strategies for Belgium, not only for assessing feasibility of species eradication but also their spread limitation. Spread limitation strategies were categorized based on species distribution extent: limiting species presence to a single or a few patches, containment of populations in core area(s), elimination of the most dispersive populations or maintenance of pest free areas. The outcome of the exercise supports the Regulation implementation in Belgium, notably for the identification of a cost-effective management goals and techniques as required by Article 17 and 19 on IAS eradication and management, respectively. It provides an evidence base for Belgian management decisions through a transparent, standardized and repeatable process. The structured decision making and the participatory approach involving the Belgian expert community has added value in terms of engagement and support for the implementation of management action plans deriving from the risk management evaluation.

Booy et al. (2017) *Biol Invasions* 19(8): 2401–2417.

Reconstructing biological invasions using public surveys: a new approach to retrospectively assess spatio-temporal changes in invasive spread

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Management of biological invasions increasingly relies on the knowledge of invasive species dispersal pathways that operate during introduction and post-introduction dispersal. However, the early stages of biological invasions (introduction, establishment, and initial spread) are usually poorly documented, limiting our understanding of post-introduction dispersal and the role of humans in invasive spread. We aim to assess a new approach to retrospectively understand spatio-temporal patterns of introduction, establishment, dispersal, and spread in biological invasions, using the case study of an ongoing invasion of the Indian bullfrog (*Hoplobatachus tigerinus*) on the Andaman archipelago, Bay of Bengal. We sampled 91 villages on eight human inhabited islands of the Andaman archipelago in 2015-2016. We assessed the occurrence of the bullfrog using visual encounter surveys and recorded the invasion history (year of establishment, source site, and dispersal pathway) for each site by surveying 892 key

informants (farmers, plantation workers, and aqua-culturists). We sought to corroborate the reconstructed invasion history with false positive occupancy modelling, using site specific covariates that corresponded to hypotheses on specific dispersal pathways. The bullfrog occurred in at least 62% of the sampled sites spread over five islands, a dramatic increase to the previously known invaded range. The bullfrog was most likely introduced in early 2000s, and its exponential expansion has occurred since 2009. 'Contaminants' of fish culture trade and intentional 'release' were reported to be the primary pathways of introduction and post-introduction dispersal, facilitating introductions from the Indian mainland and inter-island transfers. False-positive occupancy modelling confirmed that three sites on the archipelago influenced the invasion disproportionately by acting as dispersal hubs. The study elucidates the efficacy of using public surveys to identify dispersal pathways and to understand spatio-temporal changes in invasive spread, when such information is typically unavailable otherwise. The proposed approach is scalable to other systems and species.

The Centre for Invasion Biology: An experiment in research, capability building, and service provision for invasion science and management

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The DST-NRF Centre of Excellence for Invasion Biology (hereafter the "Centre for Invasion Biology" or C·I·B) was launched in 2004 as one of the first six national Centres of Excellence (CoE) in the South Africa's Department of Science and Technology's CoE Programme. Over 14 years the C·I·B has grown to become one of the largest and most productive university-based centres for research, training and associated activities relating to biological invasions globally.

The C·I·B has trained over 500 students, produced over 1500 peer-reviewed papers, numerous books and other research products, and has contributed to many national policy documents. Many of the Centre's alumni now hold key positions in partner organizations in South Africa and internationally. The C·I·B operates on multiple fronts to deliver cutting-edge science, top-grade students, and serves as an honest broker of globally benchmarked information and contributions to national policy to meet the requirements of South Africa's endeavours in the field of invasive species management.

This presentation reviews key developments, phases and trajectories in the history of the Centre for Invasion Biology, focussing on its five key performance areas: research; education and training; networking; information brokerage; and service provision. It draws lessons and insights that may be useful for other centres and institutes devoted to biodiversity science in other parts of the world.

Mortality and regrowth of the invasive exotic fern Lygodium microphyllum in response to prescribed fire in southern Florida, USA

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The Australian native fern, Lygodium microphyllum (Old World Climbing Fern), is invading a variety of habitats in southern Florida, USA. Lygodium microphyllum produces rachis mats that shade out native vegetation, inhibit native plant recruitment, impede animal movement, and alter fire behavior. In Everglades National Park (ENP), prescribed fire is used to maintain fire-dependent habitats and to manage Lygodium infestations, although effectiveness of the latter has not been documented in the field. Greenhouse experiments monitoring L. microphyllum growth after a single controlled burn indicated that small plants suffer higher mortality than large plants. To determine whether this pattern extends to heterogeneous field conditions, we monitored mortality and regrowth of individual plants after burning in the field. We selected 210 L. microphyllum plants in southern ENP that were distributed spatially and among three cover size classes (120 small [each <1/16m2], 60 medium [1/16 to ¼m2], and 30 large plants [>¼m2]). For each plant we documented height, extent (large only), reproductive status, and biocontrol presence. For small, medium, and large plants, respectively, average height was 66±26, 92±35, and 168±55 cm; extent for large plants was 1.8±1.5 m2 and percent of plants sporulating was 10, 58, 96%. One biocontrol, Floracarus perrepae, was found on 80% of the plants in all class sizes.ENP burned the experimental area in February 2017. Three months post-burn, plants were resurveyed to document regrowth and confirm mortality of burned plants: 80% of small, 52% of medium and 20% of large plants died. New growth on surviving plants reached average heights of 23±12, 29±11, and 47±17 cm and large plant extent of 0.53±0.4 m2. No plants were sporulating, and no biocontrol was present. Additional surveys will continue to monitor survivor regrowth.

Workshop Abstracts

W01

Tracking the global spread of the invasive chytrid *Batrachochytrium dendrobatidis*

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Batrachochytrium dendrobatidis, a chytrid parasite that has devastated amphibian populations, has spread with human help as infected hosts were translocated and used for food, as pets or for pregnancy tests. The parasite was only identified as one of the culprits of amphibian declines in the late nineties but by then it had already established globally. Great efforts have been undertaken to monitor and evaluate the spread and impact of this chytrid across the world given its expanding range and the threat it poses to amphibian populations.

For this study, we conducted a systematic literature review and assembled a global database with infection records. This database updates the list of amphibian species where infection has been detected, includes a list of first infection records (including museum specimens) and allows for identifying taxonomic, geographic and temporal patterns. Interestingly, there were regions that received little attention despite being hotspots of infection and centers of amphibian diversity. Equally interesting is the presence of a large number of species whose IUCN status has not been evaluated since infection was detected in them. Finally, infection was found more frequently than expected on invasive than non-invasive amphibian species.

W02

Prioritising species, pathways of introduction and sites of risk: the eThekwini (Durban) municipality, South Africa as a case study

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The exacerbation of modern trade and travel has resulted in the increased introduction of biological organisms to new regions. Urban environments, such as cities, are hubs for human activities (trade and travel) which facilitate the introduction of alien species. Additionally, cities are susceptible to invading organisms as a result of the highly altered and transformed nature of these environments. Preventing the introduction of all alien species may not be feasible; therefore, prioritising species for prevention strategies is essential. Pathways facilitating species introduction and the areas which are most at risk of invasion should also be prioritised. We aim to highlight the importance of prioritisation (species, pathways and areas at risk) for prevention strategies in the eThekwini (Durban) municipality. We used watchlists of alien species and environmental criteria to select species for which introduction should be prevented, and we identified whether pathways facilitating these species introductions were operational in eThekwini. We selected four species (*Alternathera philoxeroides* – alligator weed, *Cenchrus echinatus* - sandbur, *Lithobates catesbeianus* - bullfrog and *Solenopsis invicta* – red imported fire ant) based on these criteria, and developed predictive models using the maximum entropy modelling algorithm. Bullfrogs and sandbur have fairly high predicted suitability throughout the municipality. The predictive models for alligator weed and red imported fire ants showed substantial variation in predicted suitability across eThekwini. The highest predicted suitability for alligator weed was found along the coastline decreasing towards the interior regions of eThekwini. The pattern of suitability for red imported fire ants shows the highest predicted suitability in the north east region of the municipality. The use of predictive modelling in setting prevention targets for alien species introduction is potentially advantageous for decision makers and environmental managers.

W03

Wild Spotter: Citizen scientists reporting invasives to aid USDA Forest Service restoration programs

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The University of Georgia – Center for Invasive Species and Ecosystem Health and Wildlife Forever partnered with the USDA Forest Service to recruit, train, and empower volunteers to provide critical scientific support to better address the expanding threat of aquatic and terrestrial invasive species. "Wild Spotter" is a nationwide effort to complete a comprehensive survey, inventory, and mapping of a prioritized set of aquatic and terrestrial invasive species across the 193-million acre National Forest System (NFS) to help meet the Forest Service's restoration objectives and stewardship mission. This program's initial focus is in specific high-value NFS areas: Wilderness Areas and Wild and Scenic Rivers. Wild Spotter promotes a citizen science approach and creates partnerships to expand local capacity to gather accurate data on the location and spatial extent of high-risk populations of invasive species in remote areas. Wild Spotter aims to empower unique audiences, including individuals or groups, to have a diverse array of the visiting public and local communities mapping invasive species using a mobile application based data collection tool to provide resource managers a broad cross section of data. The information gathered will quantify the extent and impact of all targeted invasive species to improve effectiveness at preventing, controlling, and eradicating invasive species and ultimately aid in restoring invaded areas to desired conditions.

Towards a global database of alien plants in protected areas: effects of regional naturalized species richness

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Factors that determine the variation in plant invasions world-wide have recently become well understood, however, surprisingly little is known about processes and mechanisms of invasions into undisturbed ecosystems harboured in protected areas (PAs). Invasive species management is difficult and often very expensive and this is no exception for PAs. Estimating management costs requires an understanding of the relative invasion across PAs, however, available data on invasive species presence and distribution is often incomplete. The last global overview is from the 1980s and available data for many regions are surprisingly scarce. To close the knowledge gap on the presence and distribution of alien plants in protected areas globally, as well as examine how plant invasions differ between PA landscapes and those operating in non-protected landscapes, we aimed at (1) building a new global inventory of naturalized and invasive plant species in PAs, (2) measure the level to which PAs suffer from invasions, and (3) investigate the relationship between the overall level of invasion in the region and in PAs located within that region. A list of PAs was extracted from the World Database on Protected Areas and the invasion records are being collated using literature, local databases and unpublished accounts. The Global Naturalized Alien database (GloNAF) is used to measure the overall level of invasion in the region and investigate its effect on that recorded in PAs. We test the hypothesis that a large proportion of PAs will contain alien species, particularly PAs that occupy a large area with heterogeneous habitats, and that a higher number of naturalized and invasive alien plants will be recorded in PAs located within regions that comprise high alien plant richness.

Developing risk assessments for invasive alien plants within the remit of the IAS Regulation: outcomes and issues

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The core of the recent Regulation (EU) No. 1143/2014 is the List of Invasive Alien Species (IAS) of Union concern. For a species to be included in this list, a risk assessment is required to technically and objectively evaluate scientific and economic evidence to determine the level of risk associated with a species. Importantly, a risk assessment should demonstrate a species meets the criteria in Article 4 of the IAS Regulation where a species is non-native to the whole of the European Union (excluding the outermost territories), has the potential to establish and spread in the natural environment of one biogeographical region shared by two Member States, and has a demonstrable negative impact on biodiversity and ecosystem services. Here we present the results of 16 risk assessments (*Ambrosia confertiflora, Andropogon virginicus, Cardiospermum grandiflorum, Cinnamomum camphora, Cortaderia jubata, Ehrharta calycina, Gymnocoronis spilanthoides, Hakea sericea, Humulus scandens, Hygrophila polysperma, Lespedeza cuneata, Lygodium japonicum, Pistia stratiotes, Prosopis juliflora, Salvinia molesta* & *Sapium sebiferum*) which include species both present and absent from the region. Each of the 16 species had been prioritised and identified as a high priority for risk assessment using the EPPO EU prioritisation process for invasive alien plants and we compare the outcome of this process with the final results of the full risk assessments. We summarize the priority entry and spread pathways from these 16 risk assessments, and measures to mitigate the future influx of the species into and within the region. In addition, we compare the likelihood of establishment based on species traits and through species distribution modelling, thus highlighting biogeographical regions most at risk. Finally, we highlight the lack of information available for some sections of the risk assessment and how this can hinder the listing of emerging invasive alien plants in the future.

Preliminary results of negative impact risk assessment for selected invasive and potentially invasive alien species in Poland

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In response to European and national regulations on invasive alien species, the General Directorate for Environmental Protection in Poland commissioned a project aiming at supporting their implementation. The aim of this study was to provide the necessary information about invasive and potentially invasive alien species in Poland, to identify priority species threatening native flora and fauna, and to propose strategic actions to combat them.

A total of 118 species of alien plants and animals were analysed, including 49 species of European Union concern, included in the EU Regulation on IAS, 33 species listed in the national regulation on IAS, as well as 36 unlisted species, previously identified as invasive aliens in Poland.

The Belgian scheme Harmonia+ was adjusted to Polish circumstances and applied for the assessment of the species invasiveness. Its results were the basis for the first stage of choosing priority species. Apart from species invasiveness, this stage of the process considered the availability of effective control methods and the level of spread of these species in Poland. A list of 26 species was produced, for which the second stage of prioritization was conducted. It was based on the British Non-Native Risk Management scheme and used semi-quantitative scores, elicited by consensus-building methods, to assess effectiveness, practicality, cost, impact, acceptability, window of opportunity and likelihood of re-invasion. This method was adjusted to account not only for eradication but also for other control options. Control programmes for some of these species are to be implemented in Poland within the next few years.

First experiences from the implementation of the EU regulation on invasive alien species

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At the core of the EU Regulation on invasive alien species[1],[2] is a list of invasive alien species of Union concern (the Union list). Species are considered for inclusion on the Union list following a proposal of the Commission or the request by any of the EU Member States.

The EU Regulation foresees three types of intervention to be applied across the EU in relation to the species on the Union list: (1) prevention, (2) early detection and rapid eradication, and (3) management of invasive alien species that are already widely spread.

The Union list currently includes 49 species[3] and the EU Member States have been gradually implementing measures according to the deadlines set out by the EU Regulation. The first experiences will be presented but an overview of the situation across the EU will only be possible following the reports to be made by the Member States by 1 June 2019.

[1] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014R1143

[2] http://ec.europa.eu/environment/nature/invasivealien/index_en.htm

[3] http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1523285841564&uri=CELEX:02016R1141-20170802

***International Health Regulations*, national biodefense policies, and threats from invasive disease vectors, hosts, and pathogens: a One Health analysis and call for action**

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Bioinvasion science has much to offer emerging infectious diseases science, yet the two areas remain highly isolated, with the former being mostly based among environmental sciences while the latter is based mostly among biomedical sciences. On a practical level, international and national health and biodefense policies are informed and driven primarily by biomedical interests, with inadequate consideration of the essentially biological and bioinvasive nature of emerging infectious disease threats as primarily ecological rather than clinical phenomena. Some policies provide minimal guidance about the organisms that cause, carry, and maintain disease. The most extensive of these, the UN/World Health Organization's *International Health Regulations (IHRs)*, still falls short of recognizing the essentially bioinvasive nature of emerging diseases in ways that could be informed by the vast body of work on bioinvasion science. The IHRs mention "reservoir" 15 times, and "vector" 39 times in reference to disease, but the concept of biological invasion is not mentioned at all. More alarmingly, specific taxa essential for disease spread and maintenance are not mentioned at all, and the term "agent" is applied in a way that suggests little distinction between living and non-living disease etiologies. Most national-level policy documents are even more lacking in this regard. Unlike chemical, physical, or radiological agents, biological disease agents that colonize and disseminate within an invaded environment are constantly adapting in ways that require adaptive technologies and methodologies to control them. The conclusion from this analysis is that health policy makers often do not fully appreciate or emphasize the distinctions between living and non-living threats, and for the diverse epidemiological roles played by the pathogens or parasites, reservoir hosts, and living vectors. This is a severe problem that should be overcome by incorporating One-Health principles of bioinvasion science when drafting and implementing future international and national health policies.

Flash Poster Abstracts

FP01

What dimensions of biodiversity do we wish to preserve?

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A number of different value-systems co-exist within the field conservation biology. Historically, conservation efforts have focused on "intrinsic" values that aim to protect species and habitats from extirpation. More recently, the ecosystem service approach has emphasized the importance of dimensions of biodiversity that contribute to human well-being. These different value systems can occasionally lead to contradictions, and here, I explore the consequences of this shift in values on how we perceive and manage non-native species.

Non-native species have traditionally been viewed as potential invasive species, and thus of no conservation value. As a result, current biodiversity indicators based on species-richness exclude non-native species.

The role of biodiversity, however, is evolving. Several major international agreements (Sustainable Development Goals, Convention on Biological Diversity, IPBES) now emphasize the link between biodiversity and long-term human well-being. Both empirical and theoretical lines of reasoning suggest that some non-native species have both intrinsic and functional values. I argue that excluding all non-native species from biodiversity assessments and conservation targets represents a missed opportunity. The scientific community

FP02

Do alien plant invasions promote criminal activity?

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Invasive alien plants can have considerable negative impacts on ecosystems and humans. These impacts include effects on public safety and security such as increased fire risk, land invasion by vagrants and criminal activity. Vegetation has been associated with actual and perceived crime risk because it provides criminals a place to hide, yet the role of alien plant invasions in facilitating criminal activity remains poorly documented.

We analysed over 4300 court cases and conducted questionnaire-based surveys and face-to-face interviews with land managers to examine the relationship between vegetation and criminal activity using the Western Cape province of South Africa as a case study. We explore whether the composition of vegetation (dominated by native, alien, or invasive alien species) is a significant determinant of criminal activity. Anecdotal evidence suggests a strong link between invasive alien plants and criminal activity. Preliminary results revealed nine criminal cases associated with vegetation, five of which have been linked to invasive alien plants.

We hypothesise that habitat structure is the key factor facilitating criminal activity, while the invasion status may prove significant in areas where plant invasions have drastically altered the natural vegetation community structure. This study highlights the need for an integrated approach when managing plant invasions to enhance ecosystem service provision and can be useful for managers in all settings to guide the selection and prioritization of areas for vegetation management.

FP03

Allergens in the city: Effects of novel plant communities on seasonal pollen allergies in urban areas

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Pollen-related allergies affect over 20% of adults in Europe and have been on the rise in the past decades. This increase seems largely driven by global changes: warmer temperatures and increased atmospheric CO_2 increase yearly pollen production, while the introduction of plant species outside their native range spreads novel allergens – i.e. allergenic molecules previously absent from the resident flora. In this context, urbanization – where warmer temperatures, pollution and thriving neophyte invasions shape novel urban ecosystems– is a rapidly changing terrain of yet unknown allergenic potential.

We investigated how allergenic properties of grasslands change with urbanization in Berlin, Germany. We expected the more urban and neophyte-invaded grasslands to exhibit the highest allergy risk. In 2017, we recorded plant species abundance in 56 plots of grasslands covering a double gradient of urbanization and neophyte invasion. We collected publicly available data on flowering phenology and allergenic properties of 234 plant species, including specific allergenic pollen molecules. Borrowing from trait-based community ecology, we developed new methods to characterize the mean allergenic potential, diversity and seasonal spectrum for each community along the urban-rural gradient.

Contrary to expectations, urban grasslands of Berlin were less severely allergenic than rural ones. Non-native plants were not more frequently or severely allergenic than natives. Nevertheless, in invaded grasslands the flowering season tended to extend further into autumn, and the wider spectrum of molecules suggested that new allergies may be appearing in these areas. Increasing human population densities in cities imply that novel allergens may cause more harm in urban than rural conditions. Cities may yet remain a relative haven for people suffering from hay fever, but efforts to identify novel risks and control them early should be a priority in urban nature management.

Phylogeography of the invasive amphipod (Crustacea) *Pontogammarus robustoides* in native and colonized range

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Pontogammarus robustoides is a large invasive amphipod successfully spreading in Europe. It was introduced in the 1950s to dam reservoirs on the Daugava and Nemunas rivers in the Baltic States. Next, probably along the southern coast of the Baltic Sea, the species spread westwards to the Vistula and Oder rivers, to the Mazurian Lake District in Poland, Mecklenburg Lake District in Germany, as well as northwards to the Gulf of Finland, Neva River and Lake Ladoga.

We determined the level of genetic diversity of the *Pontogammarus robustoides* in the native (Ponto-Caspian region) and colonized waters (Poland, Germany, Lithuania, Latvia, Estonia, Russia). The material consisted of about 700 individuals (80 localities) from its entire European range, sequenced for mitochondrial and nuclear markers. We aimed to answer the following questions: a) What is the species phylogeography in the native Pontic area, including cryptic diversity, historical demography of populations that may be the source for its invasion across Europe? b) Is there a loss of genetic diversity associated with the colonization process? c) What were the source populations for the first populations established in dam reservoirs in the Baltic States? d) Was the introduction of *P. robustoides* in the Baltic States a single or multiple event? e) Do the populations occurring westwards (Poland, Germany) originate from populations that already colonized Baltic States, or from independent introductions from the native area?

Quantifying and categorising the environmental impacts of alien birds

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Despite the increasing numbers of alien species, and the damage they can cause, we lack comparable data on their impacts to allow us to determine the causes and consequences for different invasions, and the species we should worry about and why. Thus, an urgent challenge for invasion science is to develop measures to quantify and categorise the impacts of alien species.

The Environmental Impact Classification for Alien Taxa (EICAT) can be used to categorise alien species by the severity and type of their impacts. It will shortly be adopted by the IUCN, which aims to publish EICAT assessments for all known alien species world-wide by 2020. In this presentation, I will provide an overview of a recent set of studies that applied EICAT to quantify and categorise the environmental impacts of all alien bird species world-wide. I will show how this work has improved our understanding of the severity and type of impacts generated by different orders of alien birds, and of the factors that influence whether we have impact data for alien bird species, the severity of their impacts, and the spatial distribution of alien bird impacts.

Biotic resistance, range size and residence time: invader performance decreases over millennia

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Invasions are dynamic processes. Invasive spread causes the geographical range size of alien species to increase with residence time. However, the longer an alien species resides in a given region, the more native competitors and antagonists adapt to the invader. This build-up of biotic resistance may eventually limit the invader's performance and reduce its range size. Using a species-for-time approach, we tested (1) whether the biotic resistance of native communities to immigrant plants increases with the species' residence time, and (2) whether the range size of immigrant plant species shows a unimodal response to residence time. To address these questions, we combined a common-garden experiment with historical and macroecological analyses using 352 Asteraceae species with a wide range of residence times in Germany (6-18,000 years). First, we measured the biotic resistance of native communities to 30 annual Asteraceae in a multi-species experiment.

For these and other species, we derived minimum residence time in Germany from the archaeobotanical and floristic literature. We then analysed how current range size depends on residence time and other important covariates, including global range size, potential suitable range in Germany, climatic distances, climatic amplitudes, affinity to soil fertility and plant functional strategies. The experimental results showed that native communities reduced survival, reproductive output and fitness of Asteraceae and this biotic resistance increased with the residence time of the immigrant species. We found a clear unimodal relationship between range size and residence time of Asteraceae in Germany, even when other important factors influencing range size were accounted for. The build-up of biotic resistance may limit the performance and geographical ranges of immigrant plant species over long timescales. Thus, the advantages of being introduced do not persist over millennia. Experimental macroecology offers great potential to study such eco-evolutionary processes and to predict long-term invasion dynamics.

Invasive alien pests threaten the carbon stored in Europe's forests

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Forests mitigate climate change by sequestering large amounts of carbon (C). However, forest C storage is not permanent, and large pulses of tree mortality can thwart climate mitigation efforts. Forest pests are increasingly redistributed around the globe. Yet, the potential future impact of invasive alien pests on the forest C cycle remains uncertain. In a recent study (Seidl et al. 2018), we used a combination of species distribution and carbon cycle modelling (i) to evaluate the potential consequences that invasion by five different non-native forest pest species may have on the carbon storage in Europe's forests; and (ii) to assess how different scenarios of climate warming (RCP2.6 and RCP8.5) may change pathogen invasion patterns and subsequently forest carbon storage capacity. Considering five alien pest species we show that large parts of Europe could be invaded already under current climate. Climate change increases the potential range of alien pests particularly in Northern and Eastern Europe. We estimate the live C at risk from a potential future invasion as 1,027 Tg C (10% of the European total), with a C recovery time of 34 years. We show that the impact of introduced pests could be as severe as the current natural disturbance regime in Europe. Furthermore, the potential negative effects of invaders on C storage are increasing under climate change, either because the pests' climatically suitable ranges increase, or because these suitable ranges overlap the distribution of their potential host tree species more strongly. Our results call for increased efforts to halt the introduction and spread of invasive alien species.

Reference Seidl R, Klonner G, Rammer W, Essl F, Moreno A, Neumann M, Stefan Dullinger (2018) Invasive alien pests threaten the carbon stored in Europe's forests. Nature Communications, in press.

Investigating the consistency of global niche shifts in invasive weeds

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Species native ranges are often used to predict the likely distribution of a species following its introduction to a new region based on the assumption of niche conservatism. However, we know that many species establish in areas outside of their native climatic niche space, which creates uncertainty in these predictions of alien species distributions. As yet the predictability of niche shifts has seldom been examined since most studies focus on a single species and introduced range. A global approach, comparing the native range of multiple species against several different introduced ranges can inform whether species are showing consistent niche shifts, both in type of shift and direction along climatic gradients. Here we assess whether niche shifts are consistent for four species of European origin that have been inadvertently spread by humans to all inhabited continents: *Rumex obtusifolius, R. crispus, R. conglomeratus,* and *R. pulcher* (Polygonaceae). These species are colonists of open, disturbed environments associated with human activity and thus generally occupy similar habitats across the globe. They were spread worldwide beginning several hundred years ago and thus may be close to climatic equilibrium. For each species, the native range was compared to six introduced ranges representing different climatic regions (e.g. Mediterranean, temperate) in both the northern and southern hemispheres each with different availability of non-analogue climate space. We used a subset of uncorrelated WorldClim variables to define climate similarities and supplemented global distribution data obtained from GBIF with additional literature records for undersampled areas. Our results highlight idiosyncratic patterns in the extent to which climatic niche shifts are observed, the climatic variables associated with climate niche shifts and the consistency among species in the patterns observed. These results are discussed in the light of the challenge of predicting climate niches in the introduced range and alternative methods for improving reliability.

Rafting communities of anthropogenic marine litter in the South Pacific Gyre

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Alien invasive species (AIS) are threatening biodiversity and ecosystems, as well as human health and interests (Regulation (EU) No 1143/2014). In the marine environment, rafting on floating substrata is a common phenomenon and a vector of introduction and spreading of AIS (Kiessling et al., 2015; Rech et al., 2016). The ever increasing amount of stable and persistent anthropogenic litter, particularly plastics, in the marine environment, strongly enhances the availability of floating rafts (Barnes, 2002). Recent studies suggest that the role of this vector of introduction has been underestimated in the past and major trans-oceanic rafting events have received broad attention by scientists, the media and the public (Katsanevakis and Crocetta, 2014; Carlton et al., 2017). It has been shown that floating plastics in the North Pacific Gyre, which is the biggest known accumulation zone of anthropogenic marine litter in the oceans, host a versatile microbiotic and macrobiotic community (Carson et al., 2013; Goldstein et al., 2014). Recently, another accumulation zone of floating litter particles has been discovered in the South Pacific. Here we present the results of marine and beach surveys in the area of the South Pacific Gyre. The abundance of anthropogenic marine litter items and the frequency of fouled itemd was compared between beaches from Easter Island and the Chilean continental coast (7 beaches in total). The macrobiotic fouling community was analyzed on 79 stranded litter objects from Chilean and Easter Island beaches, as well as on 103 floating litter items from the Chilean coast to Easter Island. Using a combined approach of visual identification and genetic barcoding, we identified more than 40 taxa rafting on these litter items. Among these species was the widespread invasive species *Bugula neritina*. This is the first overview of (potentially invasive) rafting biota in the South Pacific Gyre.

Monitoring ballast water mediated introduction of Non-Indigenous Species through metabarcoding

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The International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWMC) aims at preventing, reducing and controlling the introduction of Non-Indigenous Species (NIS) through ballast water. For that purpose, monitoring port and ballast water communities is essential for i) identifying ports with similar biological communities among which untreated ballast water transfer is considered safe, and ii) early detection of unwanted discharged organisms. In both contexts, metabarcoding, the taxonomic assignment of individuals from an environmental sample based on their DNA sequences, could represent a cost-effective and standardisable alternative compared to traditional morphology-based surveys. Here, we tested the suitability of metabarcoding for two purposes. Firstly, we performed port baseline surveys by analyzing 160 environmental DNA (eDNA), phytoplankton, zooplankton and invertebrate samples collected from sediment, water and fouling substrates of the port of Bilbao (Spain) during four seasons. Secondly, we depicted ballast water communities and tested different sampling protocols by collecting 91 eDNA and zooplankton samples from different locations of the ballast water tanks of ships arrived in the ports of Norfolk and Baltimore (USA). In both cases, comparison of the obtained cytochrome oxidase I and 18S ribosomal RNA gene fragments with reference databases revealed the presence of previously reported but also newly detected NIS and unveiled the importance of the sampling locations and protocol. Our results show that metabarcoding is an efficient method for biodiversity assessments in ports and discharged ballast water, which can be easily standardized thanks to our comprehensive sampling strategy, sample processing and data analysis protocols. Our work constitutes an important step forward in facilitating the implementation of the BWMC and reducing the spread of marine NIS.

Addressing uncertainty in S/EICAT assessments

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Impact assessments are subject to uncertainty. Ignoring uncertainty or inconsistencies in its handling can lead to errors in the listing of impacts and accordingly in prioritization procedures.

Two methods have recently been developed to assess the negative impacts of alien species on the environment (Environmental Impact Classification of Alien Taxa - EICAT) and on the socio-economy (Socio-Economic Impact Classification of Alien Taxa - SEICAT). Based on the available literature, S/EICAT classifies all observations of impacts caused by alien species in their introduced range. These methods allow comparing all types of impacts across all taxa, and EICAT has been adopted by the IUCN in 2016.

A suggestion of dealing with uncertainty has been proposed in the guidelines of these methods: the assessor has to assign a confidence score (high, medium or low) to each observation of impact, depending on how confident s/he is that the assigned impact magnitude is correct.

Performing EICAT assessments on alien ungulates worldwide we found that the suggested way of dealing with uncertainty is prone to subjectivity and therefore inconsistencies among assessors. Moreover, it is still unclear how to include uncertainty in the final impact classification.

Here, we suggest a more systematic, consistent and transparent way to estimate uncertainty in impact assessments. We identified different types of uncertainty and their respective consequences on the impact assessment. We also argue that proper training of assessors and regular cross-checks in groups significantly reduce inconsistencies in the handling of uncertainty. This framework also provides a basis to incorporate uncertainty in future impact classification.

Invasive small mammals: trophic dynamism and modified food webs in Irish hedgerows

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Early Irish small mammals, the wood mouse and the pygmy shrew are subject to species replacement by invasive alien species (IAS), the bank vole and the greater white toothed shrew. All four species are found in hedgerows of improved and semi-improved grassland constituting the major source of terrestrial biodiversity and providing key ecosystem services across 70% of the island. Small mammal IAS are a potential threat to Ireland's biodiversity and to the ecosystem services derived from hedgerows and it is predicted that all suitable field boundary habitat will be occupied by both species by at latest 2100AD. This paper examines: whether species replacement involves trophic equivalence using Stable Isotope Analyses (SIA); the potential indirect effects of IAS by comparing biomass of each species and species with similar trophic signatures in different zones of invasion; the impact of IAS on ground dwelling invertebrates and the ecosystem services they support. IAS are not direct replacements of native species: wood mouse and bank vole differ with respect to amount of invertebrates they eat and there is a marked increase in absolute and proportional biomass of insectivores where GWTS replaces pygmy shrew. Individual and seasonal effects may also influence trophic position. Composition of small mammal communities affects overall invertebrate abundance and species richness as well as particular taxa. Presence of GWTS is associated with reduction in number of larger invertebrates in most taxa with slow moving larger arthropods – larger beetles, millipedes and woodlice particularly vulnerable. It is concluded that IAS small mammals will alter the ecology of hedgerows throughout Ireland with the only potential mitigation being an increase in the area of non –linear woodland and landscape connectivity.

Integrating the impacts of non-native species on ecosystem services into environmental policy

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As momentum increases to apply ecosystem service perspectives to a wide range of environmental and conservation related policy issues it is increasingly important that this approach can be applied to the prevention and management of harmful non-native species. A tiered approach can be applied that first recognises the value of the ecosystem service at risk from non-native species, subsequently demonstrates the impacts quantitatively, and finally captures these impacts through the introduction of mechanisms that incorporate the values of ecosystems into decision making. A few risk assessment approaches follow this tiered approach but as yet do not capture the complexity of ecosystem service impacts generated by non-native species. The absence of quantitative ecological and economic data on the impacts of certain ecosystem services limits the development of regulatory initiatives. Most non-native species introduced by humans have value to one or more sectors of society. As a result, conflicts arise in the estimates of the net value of non-native species to ecosystem services. A series of scenarios are used to illustrate how the strength of such conflicts might vary under different circumstances and what options might exists to achieve resolution. Addressing the impacts on ecosystem services will require understanding of environmental conflicts and policy tools that can better capture impacts of commercially important non-native species. Conflict resolution may involve management rather than eradication of a particular non-native species if this species proves to be appreciated by certain stakeholders. Alternatively, a polluter-pays principle could require those introducing non-native species internalise the costs of any subsequent environmental impacts.

Impacts of *Gunnera tinctoria* on soil carbon and nitrogen and its reduction effect on greenhouse gas emissions in Ireland

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Invasive alien plants can alter soil attributes, impacting on soil carbon and nitrogen, and affecting greenhouse gas emissions. *Gunnera tinctoria* Molina (Mirb.) is one important invasive plant associated with significant negative impacts on ecosystems in Ireland and elsewhere. To assess the impacts of *G. tinctoria* on greenhouse gas emissions, and soil carbon and nitrogen, we conducted a field experiment in Achill Island, Co. Mayo, Ireland. We compared areas invaded by *G. tinctoria* with uninvaded natural grasslands, as well as invaded areas subjected to mechanical removal (MER) and herbicide application (HER, using glyphosate). Despite being present for ~100 years with a >5 fold higher biomass productivity than the uninvaded grasslands and an annual litter input of >10 Mg.ha^{-1}, *G. tinctoria* invasions did not increase soil C or N but were associated with a temporary increase in nitrate levels. Contrary to what might be expected, *G. tinctoria* invasions were associated with >50% lower soil greenhouse gas emissions, mainly due to a reduction in autotrophic respiration because of the lower root mass per unit area. However, areas invaded by *G. tinctoria* showed peak emissions of N_2O emissions, at the end of the growing season, of an order of magnitude more than the other treatments. After removal (MER or HER), the reestablishment of the vegetation cover was rapid and soil greenhouse gas emissions returned to the values found for the uninvaded grasslands. These results indicate that an invasion-related increase in productivity does not necessarily translate into higher soil carbon or nitrogen stocks. In addition, even though *G. tinctoria* may increase N_2O emissions the overall effect is to reduce the global warming potential.

How does restoration impact native ant communities? The case of *Acacia saligna* invasions in South Africa's fynbos

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Detrimental effects of invasive plants on resident plant communities can be substantial. Such impacts may have knock-on effects on associated native fauna, for instance, when plant-animal mutualisms are disrupted. The dispersal of plant seeds by ants (myrmecochory) is an important plant-animal mutualism in South African fynbos, which is considered a myrmecochore diversity hotspot. At the same time, fynbos is also the most heavily invaded vegetation type in South Africa, with *Acacia saligna* being a major invader. Control and restoration measures are underway but their success is mixed and knowledge about their effects on associated fauna is limited. This study set out to determine the effect of (i) *Acacia saligna* invasions and (ii) subsequent vegetation restoration measures on resident ant communities in lowland fynbos. For this we compared invaded areas, areas cleared of *A. saligna*, and areas never invaded by *A. saligna*. Vegetation surveys were conducted and pitfall traps were placed at nine sites: one invaded, cleared and uninvaded site at each of three different locations. Plants and ants were identified to species level resulting in information on community composition, relative coverage/abundance of species, and species richness and diversity. We report differences of plant and ant communities between sites, as well as relationships between plant and ant occurrences at the level of species and of broader taxonomic (e.g. Restionaceae, Myrmicinae etc.) and functional groups (e.g. plant growth forms or ant dominance hierarchies). We discuss the implications of these findings, particularly with regard to connections and potential synergies between vegetation restoration and recovery of native ant communities.

Field validation of a novel method for marine salt selective application as environmentally friendly herbicide for *Baccharis halimifolia* mature infestations elimination in estuarine habitats

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Baccharis halimifolia is a broadleaf shrub species native to north America, which has become naturalised in several countries worldwide. It is included in the Invasive Alien Species list of Union Concern since 2016, as one of the 23 most damaging invasive alien plant species in Europe, where it invades a wide range of habitats along both, the Atlantic and the Mediterranean coasts.

Chemical management has been proved to be the most effective control method, especially to combating mature infestations. However, conventional herbicides are frequently not allowed to be applied close to water bodies, and some of the most widespread used herbicides, such as Glyphosate, are currently under revision to be phased out in the European Union due to their implications for ecosystems and human health. Aiming to provide an alternative, and to ensuring ongoing control programmes sustainability, we have successfully developed an innovative, efficient, cost-effective, environmentally friendly and safe for the workers method based on marine salt selective application as herbicide for *Baccharis halimifolia* control at all post-emergence stages of its life cycle.

In this paper, we present the results of a field project conducted in Tina Menor estuary (North of Spain) over two sample groups of 390 mature well-established individuals each, distributed in representative areas of two of the most affected habitats in the European coast, Atlantic salt meadows (1330 EU Habitats Directive) and highly artificial man-made waters and associated structures (J5 EUNIS habitat). Efficacy monitoring resulted in death rates up to 99% and 80% in each habitat respectively. Tested techniques and tools, acquired know-how, work performance, implementation costs and scalability estimations are discussed.

This project demonstrates marine salt feasibility as alternative to conventional herbicides and represents the base of a desirable change of paradigm not only regarding *Baccharis halimifolia,* but also other invasive alien plant species management sustainability.

Cold as Ice: a novel eradication and control method for invasive Asian clam, *Corbicula fluminea*, using pelleted dry ice

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Since its first detection on the in April 2010, the Asian clam, *Corbicula fluminea*, (Müller, 1774), a high impact freshwater invader, has been confirmed present at seven sites across the Island of Ireland. Globally, despite repeated efforts to mitigate spread and implement substantial population control measures, *C. fluminea* continues to invade and disperse. Accordingly, effective population eradication and control measures are urgently required. In a series of five experiments, we examined the efficacy of commercially available dry ice (DI) pellets (i.e. solid CO_2 pellets at -78 °C) to kill *C. fluminea*, when both directly (water absent) or indirectly applied (clams submerged). Experiment 1 revealed the ability of 9 mm DI pellets to induce substantial *C. fluminea* mortality, with a direct application of 300 g DI at 5 min exposure inducing 100% clam mortality. While experiments 2 and 3, have shown that 9 mm DI pellets induced higher clam mortality than 3 mm pellets, DI slices and mixed DI pellet sizes (3 and 9 mm) at simulated clam densities of 1179 and/or 3930 individuals m-2, especially when clams were submerged. Experiments 4 and 5 showed that DI application was highly effective even with clams that were covered in gravel or mud, due to the freezing of their surrounding substrate. Accordingly, these results demonstrate that DI can potentially be used for effective, rapid response control and eradication of *C. fluminea* populations. Whilst promising, our laboratory results require scaling up to field application and examination of the effects of water current, substrate, increased water depth, and greater *C. fluminea* population densities.

Remote sensing approach to study the spread of invasive species

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Invasive plant species spread rapidly, and eradication measures in later stages of invasion are problematic. By improving opportunities for early detection of invading plants, remote sensing approach can make their management more efficient and less expensive since repeatable and efficient computer-assisted methods of timely monitoring applicable over large areas reduce the costs of extensive field campaigns. The detection success depends on the target species characteristics and appropriate data spatial, spectral and temporal resolution. The seasonal dynamics and spectral characteristics of the target invasive species are important factors, since, at certain time of the vegetation season (e.g., at flowering or senescence), plants are often more distinct (or more visible beneath the canopy). The best mapping strategy therefore needs to reflect the morphological and structural features of the plant under study and choose not only the appropriate data spatial and spectral resolution but also the phenological stage at which individuals are most efficiently captured by monitoring. In our study, we used unmanned aircraft offering high flexibility at low cost that represents an ideal mean to explore the effect of the timing of the data acquisition. Comparison to the VHR satellite imagery with lower spatial and temporal but higher spectral resolution enabled us to study the effect of the three components of resolution on detection of model invasive species (both trees and herbs), addressing the trade-offs between precision of detection and economic feasibility. Required resolution of the data depended largely on the mapped species characteristics, size of the area of interest and the detail needed. High accuracies achieved for very high resolution data indicate the possible application for monitoring invasions and their long-term dynamics elsewhere, making management measures comparable precise, fast and efficient. Our results serve for prediction, monitoring and prioritization of management targets.

Poster Abstracts

P001

The role of the invasive weed *Panicum miliaceum* in the epidemiology of cereal viruses

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Different crops, such as wheat (*Triticum aestivum*) and barley (*Hordeum vulga*re), can be considered as indispensable foods on all continents, in each country. Their use is essential in the food industry and feed production.

Millet is the only cultivated species, however as weeds, nearly fifty millet species are listed in Hungary. Common millet (*Panicum miliaceum* L.) is a perilous weed in Hungary, occurring not only on maize fields, but also occurred in other crops like potato, sunflower, wheat and other cereals. It is widely spread because of the lack of seed dormancy. Common millet is closely related to the wheat, so it seemed plausible to check wheat pathogenic viruses infecting this plant.

Forty-five millet leaf samples have been collected from the fields near Keszthely and Lesencefalu (South-western Hungary) in the autumn 2014 and 2015. After collection, the samples were frozen immediately, and stored at -20 °C. The DAS ELISA (double sandwich enzyme linked assay) method was used to determine wheat virus infections.

Among the collected millet leaf samples 19 gave positive results to virus infection. Simple infections were observed in 15 samples. Ten times *Wheat streak mosaic virus* (WSMV), in 6 *Wheat dwarf virus* (WDV), in 6 *Barley stripe mosaic virus* (BSMV), in 2 *Barley yellow dwarf* virus (BYDV) and in one case *Brome streak mosaic virus* (BStMV) were found. *Brome mosaic virus* (BMV) was not detected in the samples. Complex infections were also identified: in three samples WDV and WSMV, and in one case WDV, WSMV plus BYDV infections were identified. These results indicated that millet as weed plant could play a significant role in the distribution of cereal viruses.

Recent study emphasized the epidemiological impact of common millet as a weed plant. The main priority in the control of virus spread in cereals is the successful weed control.

P002

Allelophatic effect of *Ailanthus altissima, Asclepias syriaca* and *Heracleum sosnowsky* on germination and early growth of oilseed rape

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Allelophatic effect of *Ailanthus altissima, Asclepias syriaca* and *Heracleum sosnowsky* on oilseed rape was examined in bioassay under laboratory conditions. These species are adventive invasive plants in Hungary. *Asclepias syriaca* continuously cause damages on larger and larger part of our fields. *Ailanthus altissima* is very frequent on the side of fields or roadside and have strong allelophatic effect on the plants in its neighbourhood. *Heracleum sosnowsky* is dangerous because it produces not only allelochamicals, but contains furanocoumarins, which can cause human phytophotodermatitis.

During our trials we examined the allelophatic effect of aqueous extracts prepared from shoots of the weeds in three concentrations: 2.5, 5 and 7.5 m/m % on germination and early growth of oilseed rape (ONTARIO). We established that extracts of *Ailanthus altissima* decreased germination of rape with 20% on 20 °C. Furthermore growth of shoots decreased continuously, 7.5% treatment also with 20% compared to the control.

Asclepias syriaca shoot extracts hindered the germination the most strongly, almost halve at the 7.5% treatment. 2.5% and 5% extracts inhibited growing of rape shoots' and all three concentrations of roots' significantly.

Heracleum sosnowsky also inhibited germination of rape seeds, the strongest effect had 7.5% extract with 25% decrease. The length of primary root decreased continuously, but this effect was significant only at 7.5% treatment. Growing of shoots reduced the all extracts, 7.5% treatment from 64 mm to 25.7 mm.

Our results indicate that extracts from shoot of *Ailanthus altissima, Asclepias syriaca* and *Heracleum sosnowsky* reduced germination and growth of shoot and root of oilseed rape, the strongest in the latter case. Inhibitory effect depended on concentration of extracts.

P003

Superior functional response and abundance predicts significant ecological impact by invasive killer shrimp (*Dikerogammarus villosus*) towards early-stage anurans, compared to native *Gammarus pulex*

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Within freshwater ecosystems, invasive non-native predators can have a devastating impact on native biodiversity, with intense predation upon resident species responsible for extreme population declines and extinctions. Amphibians have suffered considerable losses as a result of invasive predators, particularly large-bodied fish, decapods and other amphibian species. However, there is a lack of research regarding the ecological impact of comparatively smaller invaders, such as the killer shrimp (*Dikerogammarus villosus*) – an invasive freshwater amphipod crustacean recognised as a top trophic predator capable of consuming a wide range of native freshwater species, including some vertebrates.

Amphibians native to the UK are in decline, with several 'threatened' species classified as 'Biodiversity Action Plan' (BAP) species. Here we explore the potential ecological impact of invasive *D. villosus* on early-stage amphibians. We apply the novel metric, Relative Impact Potential (RIP), combining measurements of relative *per capita* effect (i.e. functional response; FR) and relative field abundance (RIP = FR x Abundance) in order to assess the predatory impact of invasive *D. villosus*, compared to native *Gammarus pulex*, on the eggs and larvae of native and invasive anurans (*Rana temporaria* and *Xenopus laevis*). We compared size-matched amphipods, as well as naturally larger *D. villosus*.

Predation of early stage amphibians was confirmed, with invasive *D. villosus* generally consuming greater numbers of anuran eggs and larvae, as a function of body size. Maximum feeding rates recorded in *D. villosus* were up to three times greater than native *G. pulex*. Furthermore, inclusion of FR and relative field abundance into the RIP metric highlighted the potential for *D. villosus* to impose a significant population-level impact upon early-stage anurans, up to nine times greater than that of native *G. pulex*. The additional predatory pressure imposed by *D.* villosus could impair amphibian recruitment within invaded regions.

Invasive neophytes and diversity – a glance across species borders

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Invasive alien species are important drivers for changes in flora and vegetation of invaded areas as well as in structure and function of invaded habitats. For the presented study seven of the most invasive alien taxa of the North Tyrolean Flora (Austria), *Impatiens glandulifera*, *Impatiens parviflora*, *Solidago canadensis*, *Solidago gigantea*, *Fallopia japonica*, *Fallopia sachalinensis* and *Fallopia x bohemica* were chosen to study effects of invasive aliens on the native Flora and vegetation. This was done by comparison of heavily invaded and alien free plots of 16 m² and transect analysis.

The results show a gradient of decrease of diversity and abundance of native plant species, with strongest impact caused by *Fallopia* spp. which led to a reduction of the native flora and vegetation up to 50%. In contrary, *Impatiens parviflora* had almost no effect. Especially woody plants were suppressed missing in dense stand of neopyhtes, seedlings were missing.

The study further showed that the results of different invasive species are similar and the effects are highly overlapping. Both, sets of remaining and suppressed species, are similar. This indicates a cumulative effect of different alien species which lead to a homogenization of flora and vegetation of invaded areas.

Introduction and naturalisation of key non-native forest trees in Europe: Results from the COST Action FP1403 NNEXT

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Non-native tree species are widely used in forest plantations and agroforestry systems worldwide for their often-high productivity and performance compared to native trees. In addition, they have been and are introduced and used for multiple reasons, such as gardening, protective functions, arboreta, erosion control and for increasing the forest area through afforestation of abandoned or derelict land. However, these advantages may be compromised in situations where non-native trees establish outside plantation sites or start to become invasive in sensitive habitats. As such, the use of non-native tree species creates both opportunities and risks.

Information regarding the initial introduction of non-native tree species to Europe is very important for the evaluation of its present status in the introduction-naturalisation-invasion continuum. The transition from introduction to invasion often spans many decades (a lag phase), or it may never occur at all. Introductions may date back to the beginning of the 17th century (e.g., for *Robinia pseudocacia*) as well as to more recent times (e.g., *Cryptomeria japonica*), with significant differences among countries concerning the period, the total area, the habitats, the biogeographic region and the human-mediated disturbances and management. This provides us with a series of "natural" (i.e., nonmanipulative) experiments presenting opportunities for gaining useful insights on central issues in invasion ecology (Richardson et al. 2012).

To these aims, in the framework of the COST Action FP1403 NNEXT (Non-native Tree Species for European Forests – Experiences, Risks and Opportunities) we collected information on a selected set of 15 non-native tree species in 16 European countries. We determined the date (or period) of first introduction, the present status (in the introduction-naturalisation-invasion continuum), the date of the first detection in the wild as casual and/or naturalised, the period in which the species was used more intensively in forestry and the total area of plantations.

Evaluation of *Celastrus orbiculatus* (Celastraceae) invasiveness: a case study

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Celastrus orbiculatus is a woody liana native to East Asia, introduced to Europe around the 1860s. To date, *Celastrus orbiculatus* has been registered in 12 countries of Europe: Austria, Belgium, the Czech Republic, Germany, Lithuania, the Netherlands, Norway, Sweden, Poland, the United Kingdom, Ukraine and Russia.

Four populations of *Celastrus orbiculatus* currently occur in Lithuania and the total area of the stands comprises ca. 0.42 ha. The coverage of *Celastrus orbiculatus* ranged from 10% to 20% in the tree canopy layer, from 10% to 50% in the shrub layer and from 30% to 60% in the herb layer.

Studies on *Celastrus orbiculatus* revealed its intense generative reproduction. Mean density of saplings in a dense stand was 8.10±1.94 saplings/m^2. According to the number of annual rings of the xylem, the oldest living individual was 21 years old. Mean width of annual rings (n=376) of *Celastrus orbiculatus* of all studied individuals (n=40) was 0.77±0.26 mm and no significant correlation between the width of annual rings and minimum temperatures of the previous winter was found.

A risk assessment of *Celastrus orbiculatus* in the EU with special focus on the Netherlands has been performed and this species has been proposed to add to the watch list. We used the risk assessment system that emphasizes on species traits, previously documented invasive behaviour and the existence of suitable habitats in the invaded area. This assessment revealed high risk of *Celastrus orbiculatus* invasion and strong negative impact on a wide range of natural and disturbed habitats in temperate regions of Europe. Therefore, we strongly recommend including this species into the list of alien species of the Union Concern. At this stage of invasion and distribution in Europe, measures for control, management and eradication of *Celastrus orbiculatus* may be effective and economically feasible.

Resistance to the limit. Fragmentation, storage, and transport across the sea do not affect *Carpobrotus edulis* viability

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Coastal dune ecosystems include habitats with high relevance and conservation value, vulnerable to the introduction of invasive alien plants (IAPs). The succulent *Carpobrotus edulis* threaten coastal ecosystems displacing native species or producing soil physic-chemical changes being the plant genus with the largest record of control actions in Mediterranean areas. Removal of *C. edulis* is essential for habitat restoration but plant fragments have an extraordinary potential to resist extreme conditions facilitating plant reintroduction. Here, we explore the viability of *C. edulis* after fragmentation and long-term storage, and after seawater immersion. Based on viability, we model possible propagule transport and invasion along a specific coastline.

After 6 months of storage, fragment viability was reduced. Nevertheless, alive fragments remain completely viable, being capable of rehydrating, develop new roots and with intact capacity to grow and produce biomass. Physiologically, fragments maintained their photosynthetic efficiency in the long-term. Fragments of *C. edulis* also resist seawater immersion. After 6 days of immersion, plant fragments showed a survival rate near to 100%, maintaining their photosynthetic ability and showed an intact capacity to grow and emit adventitious roots. According to seawater viability, an ocean hydrodynamic model forced by tides and wind diagnosed its potential of advection to areas significantly distant from their sources (up to several tens of km), with decisive implications for *C. edulis* dispersal.

We evidenced that *C. edulis* fragments can rehydrate and remain viable for long periods after fragmentation, extending plant viability longer than expected. Moreover, the absence of differences between controls recently detached and fragments stored for 6 months suggests that survival can be further extended. Since fragments have larger possibilities and need shorter time than seeds to become successful adult plants, these results emphasize that *C. edulis* fragments seriously jeopardize habitat restoration as they can remain latent and reappear when conditions are suitable.

Native species as predators for the invasive apple snail, a new ricefield invader in Europe

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The apple snail *Pomacea maculata* has become a new invader in rice fields and wetlands in Europe. It is considered a highly invasive and damaging species, resulting in large economic losses worldwide. Despite the great negative impact of the invasive apple snail in the agriculture and natural wetlands, it has become an abundant potential resource for native predators including birds, mammals or fish. In the present study, we used isotopic analysis to evaluate the consumption of the apple snail by different native species in the Ebro Delta (northeastern Span). The results reveal the importance of the apple snail in the diet of some of these native species, accounting for 26-40% for some of the them. Thus, these native predators could potentially help in the biological control of this invasive snail, but it is not expected to eradicate it. While the spread of this pest in rice fields and wetlands is not desirable, we predict that the apple snail will follow a path similar to other invasive species, such as the red swamp crayfish *Procambarus clarkii*, in establishing itself as part of the wetlands food web.

Do alien species of amphipods impact on benthic community structure in the Belarusian part of the Central European invasion corridor?

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So far, nine Ponto-Caspian species of amphipods established in the Belarusian part of the Central European invasion corridor. It is known that alien amphipods affect native benthic community in Europe and their effects depend on temperature, species and trophic structures of river community on the invaded area. The aim of this study to check whether alien species of amphipods affect benthic community in the rivers.

The laboratory experiments on consumption of macroinvertebrates by alien amphipods (*Dikerogammarus villosus SOVINSKIY* and *Gammarus varsoviensis* JAZDZEWSKI) were conducted in 2017. The range of gammarids diets was evaluated as well as prey preference and combinations of prey species. Moreover, predator-prey experiment was carried out to estimate maximum gammarid predation rates. The results of laboratory experiments showed that *D. villosus* and G. *varsoviensis* consumed 4 of 6 prey types (larvae of Chironomidae, Baetidae, Lestidae, and *Neureclipsis bimaculata*). Consumption rate did not varied between gammarids in the mixed-prey experiments (Mann-Whitney U-test: P = ns). In the single-prey experiment with high prey density, consumption rates differed between gammarid species (one-way ANOVA: Baetidae, F = 11.91, P = 0.001; Kruskal-Wallis ANOVA: *A. aquaticus*, H = 7.9, P = 0.001). *D. villosus* consumed a greater number of *A. aquaticus* and larvae of Baetidae, than *G. varsoviensis*.

Analysis of field samples showed that there is moderate negative relationship between abundant of alien gammarids and *Asellus aquaticus* (r_s = -0.46), and weak negative relationship between abundant of alien gammarids and Baetidae larvae (r_s = -0.25).

The results of laboratory experiments shoved obvious effect of alien gammarids on some benthic groups. Whereas, in field observations, their impact on native communities is seems to be variable and probably depends on abundance of alien amphipods on particular site.

A review of invasive dilemma: the ecological and socialrol of the invasive European rabbits in the Canary Islands

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The European rabbit, a species that was introduced from the Iberian Peninsula in the Canary Islands during the conquest of the archipelago 500 years ago, currently occupies all islands, almost all islets, and all the habitats of the archipelago. Despite it is considered among the worst 100 invasive species of the world, rabbit management in the Canary Islands is controversial and lay out a conservation dilemma. From a review of the positive and negative ecological impacts, we draw the conclusion that rabbit negative impacts are considerable and are manifested at different ecological levels (from affecting endangered animal and plant species populations and the mutualistic interactions between them to completely alter the structure of the ecosystems), while are as well the main prey for mostly all the native populations of raptors in the archipelago. To minimize negative effects, several control and eradication actions have been undertaken in natural particularly biodiversity-rich areas. However, on the other hand, rabbits are socially (and politically) a key species in the archipelago as they are core in maintaining traditional hunting activities, which are promoted by island governments through different actions that aim to increase and maintain rabbit populations in mostly all the islands (i.e. rabbit repopulations, growing crops at public and private lands to increase the species food resources). State and autonomic legislations do not represent this complex situation: the species has not been considered as invasive by the national law (native in mainland Spain) and its consideration as a hunting species legitimizes actions reinforcing rabbit populations. Overall, it is urgent to jointly raise a cooperative strategy, involving scientists, managers, hunters, policy-makers, politicians, etc., that allows managing this invasive species under a social supportive framework but pursuing to minimize the ecological impacts that rabbits are provoking to the incomparable and unique ecosystems of the Canary Islands.

The occurrence of micropathogens in European populations of raccoon (*Procyon lotor* L.)

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The devastating results of the raccoon's presence in Europe, on both the global and local scales, pose one of the greatest dangers to the old continent's biological diversity. Aside from the negative influence of raccoons on native zoocenosis, the possibility of transmitting new, foreign species of pathogens to the European fauna is a serious problem. While the state of knowledge about the parasitic helminths of European raccoons increases, the knowledge of their micropathogens is still limited or fragmentary. Therefore, the objective of this study was to investigate the occurrence of microparasites, both intestinal and vector-borne, in the introduced raccoons obtained from localities in Poland and Germany. A PCR-based approach that permitted genetic characterization via sequence analysis was applied to various samples (blood, spleen, liver, skin, and stool) that were derived from 170 raccoons and collected from 2012–2017. The results of our research confirmed the presence of intestinal microparasites (*Cryptosporidium* skunk genotype and *Enterocytozoon bieneusi* NCF2 genotype) as well as vector-borne pathogens, such as *Anaplasma phagocytophilum* ecotype I, *Borrelia burgdorferi* s.l., and *Rickettsia* spp. The results suggest a possible role of raccoons as environmental reservoirs of these micropathogens of epi- and zoonotic significance. Additionally, the role of this animals in the transmission and introduction of intestinal pathogens in newly colonised areas has been observed. As far as the raccoon's epidemiological impact is concerned, and in view of its possible further spread in Europe, this invasive species should be monitored more intensely in terms of vector-borne diseases.

Impacts of invasive common myna on native and introduced competitors in a New Zealand agricultural matrix: do Australian findings transfer?

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The common myna (*Acridotheres tristis*) is a cavity-nesting bird native to central and southern Asia, and is listed as one of the world's 100 worst invaders. This due in part to their aggressive territorial behaviour, which is thought to negatively affect populations of native competitors. However, empirical evidence of these impacts is scarce. In Australia, negative impacts of myna establishment have been documented on some native species that compete for tree cavity nest sites or are smaller-bodied than the myna. In New Zealand, myna are regarded as pests, but their impacts on native birds are largely anecdotal.

We investigated whether findings from Australia translate to a forest-agricultural matrix in the Auckland Region of New Zealand, and whether there is evidence of negative impacts of myna on potential avian competitors. Point counts were taken over 5 months at 69 locations in the Tawharanui Regional Park, representing the suite of available habitat in the reserve (pasture, native forest, mānuka shrub and edge habitats).

We asked whether the presence and abundance of Myna is negatively correlated with native bird abundance, and in particular cavity-nesting and smaller-bodied species. We also examined whether reported interactions between myna and Australian species (e.g. eastern rosella (*Platycercus eximius*), Australian magpie (*Cracticus tibicen*)) are present in Tawharanui where both interacting species are invasive. Finally, we tested whether the effects of myna on other birds vary with habitat and over time, and if myna displace competitors to other habitat patches in the regional park.

Our study is one of few to assess the veracity of claims that myna are a troublesome pest and to investigate their competitive interactions with native species. Our findings also provide insight into whether competition between native and invasive species is consistent between geographic regions, or whether interactions differ when both species are invasive.

The composition of life-history traits of moth assemblages in invasive Robinia pseudoacacia stands – an opportunity for light-forest dwellers?

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Alien invasive plants are one of the main threats to global biodiversity, including insects. Therefore it is important to understand the mechanisms of how invasive plants impact native species. The insect assemblages are more affected by woody invaders directly altering habitat structure. *Robinia pseudoacacia,* a worldwide invader, changes local environmental conditions in invaded habitats and subsequently influences plant communities and habitat structure. We investigated the composition of moths' life-history traits in 20 native deciduous forest stands and in 19 stands dominated by the invasive tree *R. pseudoacacia* in the Czech Republic (Central Europe). We captured 384 moth species using automatic portable light traps and determined their general, larval and adult life-history traits. Both stand types differed in habitat structure: *R. pseudoacacia* created more open and more heterogeneous stands, with sparse canopies, well-developed shrub layer and higher coverage of taller herbs. Contrary to this, the native stands were shadier, with poorly developed understories. The altered habitat structure in novel habitats influenced the composition of moths' traits. Specifically, the diversity of feeding guilds was higher in the stands of *R. pseudoacacia*, where moths with rather faster life cycle prevailed, likely due to more heterogeneous and open habitat structure. Moth assemblages observed in the stands of *R. pseudoacacia* thus resembled communities of more threatened open-forest or forest-steppe habitats. On the contrary, the native stands were dominated by larger moths inhabiting forest canopy, including both forest specialists and habitat generalists. Despite these results, further spread of *R. pseudoacacia* in forest landscape should be prevented because it reduces the total richness of Lepidoptera. We strongly recommend to promote the habitat heterogeneity of native forests by using active forest management supporting functionally more diverse moth communities.

Evaluation of species composition in the Cruciferae family in Latvia

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Cruciferae Juss. is one of the largest families in the flora of Latvia and is represented by 49 genera and 102 species. An essential part of the Cruciferae family species composition in Latvia – 58% of the total number of species of the family – consists of alien species. The main species introduction regions are Asia, Central Europe, and the Mediterranean region. In the flora of Latvia, a large number of native as well as alien species of Cruciferae are characterized by habitats with sparse vegetation and low competition from other species. This type of habitat enables better adaptation of species and can promote their spread in natural habitats.

The most widespread alien species is *Bunias orientalis* L., which has become invasive and is rapidly spreading both in ruderal and natural habitats. Its most common habitats are railway embankments, roadsides, fallows, and field edges. Increasingly *B. orientalis* is being found in semi-natural grasslands and river embankments.

Both the study of herbarium materials and field surveys indicate that the occurrence of *Brassica napus* L. in different ruderal habitats has increased rapidly in recent years and is distributed throughout all of Latvia. *B. napus* is found as single individuals in weedy places, along roadsides, street edges, and railway embankments and tracks. Although the species is not observed in natural habitats, it needs to keep up with the trends of species distribution. Analysis of changes in the distribution of species allows the species status to be assessed in order to take the necessary measures for limiting the species or assessing their potential risk.

Spatial pattern and feeding ecology of house cats on a human-inhabited oceanic islet (La Graciosa, Canary Islands)

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The impact of cats (*Felis silvestris catus*) has been especially notorious for seabirds in the Canary Islands, contributing to distribution restrictions and the extinction of endemic species. In 2014, at least 200 individuals of seabirds, belonging to *Hydrobates pelagicus* and *Pelagodroma marina* species were killed by cats on La Graciosa islet, a small inhabited island in the north of the Canaries. Considering the importance of the islet in terms of biodiversity, the main objectives of this study were to determine the current distribution of cats on the island and the pattern of their spatial feeding ecology. Islet were divided into 500x500 m quadrats where all scats where located to study distribution and collected for their subsequent analysis. Cats were more abundant in central areas, where farms are located, followed by places around and close to the villages. A total of 650 living preys were found from 285 scats collected during sampling period. Mammals were the most important prey, both in number of prey, frequency of occurrence and biomass consumed, followed by invertebrates, reptiles and birds. A strikingly large amount of garbage was found in the scats, appearing in 66.1% of the scats, with an average percentage rubbish volume of 39%. Introduced species (mammals and some insects) were significantly predated in high proportion at localities close to anthropic areas. Spatial variations were not found in the predation upon birds, and consumption of human refuses was significantly higher in areas closer to anthropic areas. Our results suggest that human refuses and introduced mammal availability seems to be the main factor determining cats' density. This is one of the scarce contributions where diet and distribution of cats is study in a small and inhabited island being interesting to researchers, stakeholders and general society to carry out effective control of this invasive species.

The potential for *Bombus terrestris* invasions into South Africa and niche conflict with native pollinators

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The commercial trade of pollinator species for agricultural use has resulted in many bee species invasions on a global scale. A generalist bumble bee, *Bombus terrestris*, is a commonly reared species for crop and greenhouse pollination. Approximately two million colonies of *B. terrestris* are shipped throughout the world every year. Previous studies have shown that the introduction of *B. terrestris* for agricultural use has resulted in their successful invasion of several regions outside their natural range. Furthermore, their capability to outcompete local pollinator species in their native environments has threatened the local pollinator species' diversity and abundance worldwide. *B. Terrestris* is currently not found in South Africa but there is a potential risk of introduction for agricultural use. In this study, ensemble of species distribution modelling techniques were used to predict areas of suitable habitat for *B. terrestris* in South Africa in order to identify areas where succesful invasion might be likely. Furthermore, the potential for conflict with native pollinators was assessed by using niche-overlap analyses, and then projected under different future climate change scenarios in order to examine how patterns of niche overlap might change. The results indicate that South Africa is a high-risk area for *B. terrestris* invasions, as several eastern regions have similar environmental conditions to its native range. There is also a potential niche overlap between *B. terrestris* and native pollinator species, as it partially shares an environmental niche with species including *Amegilla atrocincta, Anthophora vestita, Colletes marleyi, Lueconomia candida, Rediviva fufocinta,* and *Xylocopa* species. The most notable niche overlap is between *Bombus terrestris* and *Xylocopa* species. The findings of this study indicate that the potential invasion of *B. terrestris* can threaten the diversity and distribution of native pollinator species in South Africa.

Analysis of the global environmental impact of alien ungulates

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Impacts made by alien ungulates are known to have dramatic effects on native species in the introduced environment. In this study we are interested in exploring the conditions in which these alien mammals can cause strong or weak impacts. We assessed the global impacts of alien ungulates with the Environmental Impact Classification of Alien Taxa – EICAT. The impact magnitude recorded for most alien ungulate species are context dependent. They can vary according to environmental conditions, local biota, disturbances etc. In addition, traits amongst ungulates can also affect the impacts they have on the introduced environment. Accordingly we investigated

(a)Traits of impacted native species which could make them more susceptible to alien ungulates.

(b)Traits of different locations that could play a role in the success of alien ungulates. For e.g., in species causing impacts on both islands and mainland, we are interested in testing if there is a difference of impact severity and if so, what traits of these habitats that could be the cause.

(c) Life history traits of alien ungulates that influence the severity and type of impact they produce. Across ungulates introduced worldwide we have observed at least five different families causing a range of impact. We expect to find patterns that will explain why some can cause higher impacts than others.

This analysis will allow us to better predict how specific alien ungulates can impact specific environments. In turn, this information could also contribute towards prioritization for management purposes.

Isolated woody islets of invasive *Robinia pseudoacacia* in intensive agricultural landscape: refugium or threat for arthropods?

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Landscape simplification and spread of invasive species are considered as the main threats to global biodiversity. It has been well recognized that non-crop habitats bring complexity in arable land as they provide refugia for a wide range of organisms, including arthropods. However, the knowledge about the effects of invasive plants on arthropods in non-crop habitats in intensive agricultural landscape is still weak.

Therefore we examined the differences in arthropod abundance and species richness between 15 woody isles formed by the invasive, but well established *Robinia pseudoacia* and 15 isles formed by native deciduous species in the intensively managed agricultural landscape of central Czech Republic, Central Europe. All isles were isolated from the surrounding habitats by arable fields. We used a multi-taxonomic approach for assessing arthropod diversity by using pitfall traps, sweeping the vegetation and light trapping. The following groups were sampled: Chilopoda, Diplopoda, Opilionida, Araneae, Orthoptera, Heteroptera, Neuroptera, Carabidae, Elateridae, Staphylinidae, Silphidae, Curculionoidea and nocturnal Lepidoptera.

Total abundance of arthropods was significantly higher in native woody islets but no difference in total species richness was found. In the *Robinia* isles significantly higher species richness of Araneae and Opilionida, and higher abundance of Elateridae and Heteroptera were found. In contrast to that, abundances of Lepidoptera and Carabidae, and species richness of Neuroptera and Lepidoptera were higher in native woody isles. No differences were found in case of the remaining taxa. Observed effects of *R. pseudoacacia* on arthropods in the woody isles could be partly associated with the different vegetation structure besides the native tree species. Our results suggest that invasive plant does not have to have negative effects on the native arthropod fauna.

Keywords: invasive plants, black locust, arthropods, multi-taxonomic approach, agricultural ecosystems

***Silphium perfoliatum* L. in the flora of the Romensko-Poltavsky Geobotanical Region (Ukraine)**

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Silphium perfoliatum L. is the kenophyte (North American origin), ergaziophyte. The species has been cultivated since 1971 on the M.I.Vavilov Poltava Research Station and Research Station of Medicinal Plants (vill. Berezotocha, Poltava Reg.) as ornamental and forage plant. On the territory of the Romensko-Poltavsky Geobotanical Region as escaped plants noted in 90-th of the XX c.

At present we have discovered tree localities of the species in the Region beyond places of its cultivation. The most numerous is the localitet in the Poltava Dendrological Park in the marginal ecotopes where species sporadically distrubution; show a tendency to incorporation in to the shrubs and rare in forest plant community.

The population of *S. perfoliatum* is characterized by high density, and participation of the generative plants (44 %) in the age spectra'.

Invasive Black cherry *Prunus serotina* enhances epiphytic moss diversity

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Invasive species are usually considered as one of the main threat for nature conservation in forests by their direct impact on vegetation expressed i.e. in higher competition with native species. It results in exclusion of many native species and decrease of plant species diversity, especially in field layer. The aim of our study was to check the impact of invasive tree species *P. serotina* on the diversity of epiphytic mosses in in mesic Scots pine *Pinus sylvestris* and Pedunculate oak *Quercus robur* forests. We hypothesized that *P. serotina* enhance diversity of epiphytic mosses. Data were collected on circular plots with and without *P. serotina*, where only *Q. robur* occurred under *P. sylvestris* canopy. Our preliminary results showed 13 epiphytic moss species occurring on research plots – with *P. serotina* 11 species and where only *Q. robur* occurred – 8 species. We reported five moss taxons occurred exclusively on *P. serotina* plots (*Plagiomnium affine*, *Hypnum cupressiforme* var. *filiforme*, *Dicranum scoparium*, *Tetraphis pellucida*, *Brachythecium rutabulum*) and only two exclusively on *Q. robur* (*Pohlia nutans*, *Brachytheciastrum velutinum*). The similarity between both moss communities expressed as Jaccard index was moderate (IJ = 0.46), supposedly because of higher number of moss species occurring exclusively on plots with *P. serotina*. The plots with *P. serotina* were also characterized by higher mean number of epiphytic moss species (6.5±1.29) in comparison to *Q. robur* (5.0±0.82) (ANOVA, F = 3.857, P = 0.097). Our results allowed us to conclude that invasive *P. serotina* may affect epiphytic moss diversity in positive way in mesic Scots pine and Pedunculate oak forests.

Alien invasive *Aedes albopictus* as the dominant mosquito in a complex residential-agricultural ecosystem: One Health biosurveillance for emerging infectious disease vectors

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Rapidly spreading global pandemics of Chikungunya and Zika viruses within the past five years have caused renewed interest in the spread of these and other emerging infectious diseases that are transmitted by mosquito vectors. Emergence of such mosquito-borne diseases is often made possible or is exacerbated by the invasion of new areas by exotic invasive species of mosquitoes. We initiated a comprehensive One-Health biosurveillance program for potential mosquito vectors of human, animal, and zoonotic diseases on the Berry College campus in Georgia USA, which with more than 107 square kilometers constitutes the world's largest university campus managed for environmental research. We employed diverse methods based primarily on trapping adults with: 1) CDC mini light traps; 2) BG2 Sentinel traps; 3) Mosquito Magnet traps; 4) gravid traps, and 5) resting traps, all variously supplied with CO_2 emission and other lures. Trapping was conducted from May 2017 through April 2018 at nine sites representing different habitat types and proximity to blood meal sources. We identified 24 species of mosquitoes belonging to six genera. Among these, two invasive species originating in Asia, *Aedes albopictus* and *Aedes japonicus*, were discovered. The Asian tiger mosquito, *Ae. albopictus*, was the most abundant species; accounting for 66.4% of all specimens collected, it greatly outnumbered all of the 22 native species combined. *Ae. albopictus* was also among the most widespread species, occurring at four sites, which was exceeded only by native *Aedes vexans* and *Culex erraticus*. The vast majority of *Ae. albopictus* occurred in a residential complex housing many students, thus creating conditions for a potential outbreak if human or animal residents arrived infected by an appropriate pathogen. Very few native mosquitoes occurred in this area. We conclude that this constitutes a new potential risk for several emerging infectious diseases due to bioinvasion by an exotic vector species.

Competition between native and Ponto-Caspian invertebrates and fish species in a shipping canal ecosystem

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The largest canal in Belgium is invaded by different Ponto-Caspian invertebrate and fish species. The five most abundant invertebrate species in the canal are Ponto-Caspian and the benthic fish community is dominated by round goby (*Neogobius melanostomus)*. Interaction between the killer shrimp (*Dikerogammarus villosus)* and the native common freshwater shrimp (*Gammarus pulex)* are investigated in the lab as well as the food preference of round goby. Interspecific competition between the native fish species roach (*Rutilus rutilus)* and round goby are tested.

Round goby predates more often on the common freshwater shrimp than on the killer shrimp mainly because differences in behaviour between both prey species. Competition experiments between the killer shrimp and the common freshwater shrimp shows a difference in choice of shelter. Where the killer shrimp selects *Dreissena*-shells and is found in the lower water layer, the common freshwater shrimp is found between plants and more often in the higher water layer of the test container. Predation of killer shrimp on common freshwater shrimp was recorded as well. The difference in habitat results in a higher predation of the common freshwater shrimp in comparison to killer shrimp.

In competition experiments, round goby consumes significantly more freshwater shrimps than roach. In combination with the interspecific aggressive behavior of round goby towards the native roach, round goby has an important competitive advantage on roach in shipping canals and important angling waters.

Both the presence of invasive killer shrimp and round goby results in the overall absence of the native common freshwater shrimp in Belgian canals. Round goby is found to be a better competitor for benthic food in comparison to native roach, severely impacting the native invertebrate and fish communities in artificial water bodies in Belgium. This ecosystem change has consequences for the attractivity of the canal as an angling water.

Biological invasions: reconsidering the study paradigm

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The study of biological invasions have evolved to encompass fundamental and applied aspects of natural as well as social and technological sciences. Over time, we will have relied upon a wide range of different biota from separate world regions, which have become part of our economies. However, there are opposing concepts that remain in invasion biology, for example "native alien", "spreading not propagating", "harmful harmless", while generally, the category "useful" is not considered. The criteria to ascribe the "alien" ("non-indigenous", "introduced", etc.) status to a species can be different in botany or zoology, especially for early introductions. The very legitimacy of this concept ("native vs alien"), and its value for the development of ecology as a science is being increasingly challenged. The separation of species based on their origin can unnecessarily diminish opportunities within a changing world where alterations in climate, habitats and evolving of modern technologies may require new approaches to the management of invasion species. We should recognize that human habitat degradation, overexploitation and waste plastic interference, issues in themselves, may require an acceptance that introduced species may provide a future resource. We discuss a need to revise the paradigm of invasive ecology based on the political context of the "struggle" with invasive species on a practical level. The most urgent task within invasive ecology is to learn objectively assess the negative effects of introduced species as well as their usefulness, and how these may be practically managed for society.

A review of literature on managing connectivity for controlling invasive species

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The spread of invasive species is determined by the connectivity of the landscape for these species. Understanding connectivity is therefore of crucial importance to managing invasive species. However, often practitioners are not fully aware of dispersal routes and transport mechanisms in the landscape. Furthermore, because of administrative, sectorial or institutional boundaries stakeholders may not be fully empowered to manage connectivity. We conducted a literature to assess if connectivity is considered in the management of invasive species and if yes, how it is managed. This review has practical implications for management, as it 1) provides examples of dispersal routes and transport mechanisms such that stakeholders can be made aware of landscape connectivity, 2) raises awareness of the effects of connectivity on the rate of spread of invasive species as well as the potential for native species to recolonize sites, and 3) presents case studies and best practice examples, which help practitioners to collaborate with relevant stakeholders across administrative, sectorial and institutional barriers to managed connectivity and identify source populations. Awareness raising of connectivity is particularly important because it is often not understood that connectivity can lead to non-linear dynamics in the spread of invasive species. The study thus aims to communicate how scientific knowledge regarding the importance of connectivity can be presented to practitioners so they can incorporate connectivity aspects in their management plans of invasive species.

Keywords: complexity, evidence-based management, dispersal, metapopulations, stakeholders.

Assessing the incidence and extent of hybridization between invasive Mallard Ducks (*Anas platyrhynchos*) and native Yellow-billed Ducks (*Anas undulata*) in South Africa

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Hybridization with invasive alien species can negatively impact native congeners through genetic introgression and pollution. This can lead to reduced fitness of the native population through the loss of unique genotypes and/or co-adapted gene complexes.

Invasive Mallard Ducks *(Anas platyrhynchos)* hybridize with several closely related native species within the genus *Anas*, including the native South African Yellow-billed Duck (*Anas undulata*). These two species are able to produce fertile offspring and therefore Mallards are a potential threat to the long-term genetic integrity of this native duck. However, there has been a lot of public opposition to the control of Mallard Ducks in South Africa, founded upon a lack of awareness of the potential threat that Mallard Ducks pose to native biodiversity. Despite the threat from hybridization, the perceived hybridization between the two species remains based on observation and anecdotal evidence, with no work having been done on the genetic extent of hybridization between the two species.

Consequently, we used genomic data to investigate hybridization between invasive Mallard Ducks and native Yellow-billed Ducks in South Africa. We examined the genetic structure and diversity of a population of Yellow-billed Ducks not occurring in sympatry with Mallard Ducks, as a baseline population. We then investigated the incidence of hybrids and whether introgression was occurring within a population where Mallard Ducks are naturalized and co-occurring with Yellow-billed Ducks. We found significant evidence of hybridization, indicating that Mallard Ducks are a major threat to the native Yellow-billed Duck. This evidence can be used to gain public support for control of Mallard Ducks in South Africa.

Assessing the trophic structure of an alien dominated pond community in Central Italy through the combination of stomach content and stable isotope analyses

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The North American bullfrog *Lithobates catesbeianus* is a major threat to native amphibians, causing disturbances in invaded communities. To assess the trophic structure of a pond in Central Italy invaded by bullfrogs and other alien species (e.g. the red swamp crayfish *Procambarus clarkii*, six alien fish), and inhabited by the native grass snakes *Natrix tessellata* and *N. natrix* and green frog *Pelophylax* kl. *esculentus*, stable isotope and stomach content analysis of 18 species were conducted during summer 2016.

Our results indicate that invaders are the main component of the food web and that native grass snakes highly depend on alien species. Up to four alien species are present at each trophic level, and among the interspecific interactions characterizing the community, the role of *P. clarkii* and *L. catesbeianus* is noteworthy. These alien species are abundant, occupying different trophic positions, interacting with each other in a predator/prey relationship. However, bullfrogs and crayfish seem to have a marginal role in affecting the entire community, because their intense interaction limits their impact on other species. Alien fish are an essential intermediate link in the food chain, providing a continuum between trophic levels, being both predators and prey. Some overlap between green frogs and bullfrogs was observed, likely due to common diet, but adult bullfrogs may affect green frogs via other mechanisms, i.e. influencing their acoustic niches and thus affecting their reproductive success. No competition was observed between juvenile and adult bullfrogs, as they occupy different levels. Even if a long-term study is necessary to better assess the evolution of this community, our study presents one of the first combined stomach content and stable isotopes analysis on the level of an entire species community composed of terrestrial and aquatic, native and invasive species, increasing our understanding of the relationships among freshwater invaders.

Survival, growth and speed of maturation: Comparison of marbled crayfish with four prominent crayfish invaders

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Many freshwater crayfish (Decapoda: Astacidea) are globally successful invaders with an ability to alter entire ecosystems. Previous studies clearly demonstrated the superiority of non-indigenous crayfish species (NICS) over European native counterparts. These findings were mostly derived from comparisons involving North American spiny-cheek crayfish *Faxonius limosus*, signal crayfish *Pacifastacus leniusculus*, or red swamp crayfish *Procambarus clarkii*. However, comparisons among other gradually spreading NICS are rather scarce, so predicting future changes is difficult. Among newly appearing species, marbled crayfish *Procambarus virginalis* is mainly known for its unique mode of reproduction, apomictic parthenogenesis, and is also expected to be particularly troubling. Marbled crayfish are becoming increasingly present across Europe, often living in habitats with conditions suitable for already established NICS populations. We will present results from a set of experiments on survival, growth and maturation of marbled crayfish vs. other above-mentioned NICS as well as Australian yabby *Cherax destructor* (using single-species and mixed stocks of juveniles from the onset of exogenous feeding, temperature ca. 21.5 °C). Among other findings, red swamp crayfish and yabby grew faster than marbled crayfish, while marbled crayfish were superior to both spiny-cheek and signal crayfish. Importantly, only marbled crayfish gained maturity (laid eggs) as early as 14 weeks, which is considerably earlier than the 20 and 36 weeks in 25 and 20 °C reported previously. In contrast, females of European native astacids usually mature at age of 3+ years. The success of marbled crayfish among invasive crayfish is probably driven by early and frequent production of offspring which overweighs other species' shortcomings (e.g. smaller size of juveniles).

A New Old Friend: Studying the arrival of American Mink to carnivore community in new territory compared to preceding stages of invasion in Chilean Patagonian temperate forest

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Biological invasions have been recognized as one of biodiversity major threats. Since the introduction of American mink in southern ecosystems of Chilean Patagonia about 40 years ago, devastating effects on vulnerable fauna as birds and native carnivores like Darwin´s fox and river otter, have been identified. The arrival of this harmful mustelid to Chiloe Island (2010) represents an opportunity to study the invasion process from early stages, and comprehend how occupies the territory interacting with native carnivore community in Patagonian evergreen forests.

We aim to understand the expansion of *Neovison vison* range in Chiloe Island, and compare it with the advanced stages of invasion in surrounding mainland, given the coexistence with the native carnivores and assess if any of them are determining it occupancy significantly. To achieve this goal, Bushnell camera traps were placed in mainland and island sites including patches of native riparian forest within protected areas during 2012- 2016.

Obtained data set and relevant co-variables were used as input data in occupancy models. The first results suggest American mink occupy places with low and high altitude compared to Chiloe Island where only occupy lowlands. Mink were registered in more than a half of the surveyed areas, but sites are separated by several kilometers without any signal of their presence, implying that the expansion is taking place through multiple introductions mostly from north, increasing the probability of establishment in the new area. Furthermore, mink occupancy increases when the tree cover percentage is higher.

Observed trends about the coexistence with otter and foxes infer that are affecting the occupancy of mink at regional scale. More analysis is being carried out to go into detail about it.

Conclusions could be useful to mink management inside protected areas, as well as Darwin´s fox and river otter conservation.

Going above and beyond: patterns of exotic vegetation in mountain ecosystems

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Despite a surge of research on alpine invaders, a lack of reliable baseline data has inhibited long-term understanding about exotic species dynamics in mountain communities across the world. A long-term study of species invasion in the Drakensberg region of South Africa provides an important exception. Here we investigated the change in exotic plant species richness and composition in and adjacent to a mountain pass road verge over a 10-year period; and explored the role of the road verge in exotic species establishment. To do so, we surveyed the road verge and adjacent transects in semi-natural habitat (N = 80) across an elevational gradient of 1500-2874 m a.s.l. in 2007 and 2017. Along each transect, we estimated exotic and indigenous species cover. Generalized Linear Models were fitted to test whether exotic richness, vegetation cover and bare soil had changed over time and a Canonical Correspondence Analysis was used to estimate changes in exotic species composition. Exotic species richness increased significantly over time across the entire elevational gradient, particularly in the mid-elevational zones, indicating that their expansion is driven by human-mediated activities rather than natural range expansion. Exotic species composition became more homogenous between road verge and semi-natural transects, showing that exotic species are spreading into natural habitat. By calculating the distance of each transect to four identified potential points of introduction for propagules, and relating this to exotic species richness, we show that propagule pressure is not a primary driver for invasions in this system, at the scale of investigation. Rather, our results show that disturbance in the road verges is a primary conduit for the spread of exotic species, and that further expansion into the natural area can be expected. These patterns of exotic species along an elevation gradient in South Africa mirror those seen on a global scale.

Distribution patterns in a native and invasive seaweeds from genus *Codium* species at a different spatial scale in the Cantabrian Coast, NE Atlantic Region

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The infamous green seaweed invader *Codium fragile* subsp. *fragile*, distributed on rocky shores worldwide, is officially listed as one of the 100 worst invading species in Europe. The cryptic nature facilitates the invasion of *Codium fragile* subsp. *fragile*, thus molecular assignment is necessary for a proper species identification before the assessment of future propagation. *Codium* spp. are recorded in a checklist of the benthic flora in the Cantabrian Sea (North of Spain) but detailed biogeographical distributions explaining their successful establishment are indeed scarce. In general, the spatial distribution pattern of seaweed assemblages in Cantabrian Sea had changed significantly in the past years, showing that cold-temperate seaweeds are displaced by warm-temperate seaweeds due to increasing temperature. In this work, the main aim was to assess the *Codium* spp. spatial distribution, supporting these data with DNA – based identifications, using sequencing of the RuBisCO and plastid elongation factor TU (tufA) genes. By using hierarchical ANOVA, we wanted to determine the variability pattern of spatial scale between native and invasive congeneric *Codium* spp. Results showed that three different species of *Codium*: the invasive *Codium fragile* subsp. *fragile* and the native *Codium vermilara* and *Codium tomentosum* are cohabiting this area. A significant difference in the proportion of *Codium* spp. between sampled beaches was found, suggesting there is a spatial pattern between invasive *Codium fragile* subsp. *fragile* and native Codium species. Based on our current knowledge and previous records of their distribution in the Cantabrian Sea, we propose guidelines for the future monitoring studies and mitigation measure of invasive *Codium fragile* subsp. *fragile* in the Cantabrian Sea (Biogeographic Region of NE Atlantic).

Antagonistic effects of the white garden snail *Theba* pisana on the flowers of *Carpobrotus edulis*

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The intentional or unintended movement of species throughout worldwide favours the encounter of native and non-native species that have never interacted, producing changes in the functioning of ecosystems. In recent years, we have observed that the native white garden snail *Theba* pisana (Müller, 1774) feeds on the flowers of the invasive *Carpobrotus edulis* (L.) N.E. Br. in NW of Iberian Peninsula. The aims of this study were to relate the presence of flowers of *C.* edulis eaten by *T.* pisana with the abundance of the snail and to assess if those flowers that were eaten by the snail produced fruits with seeds. We selected ten coastal populations with the presence of *C.* edulis coinciding with its flowering period, where we recorded the presence and abundance of the snail both in invaded and not invaded areas by *C.* edulis. We marked flowers eaten by the snails and intact flowers for subsequent follow-up of seed production. Our results show that there are no differences in snail abundance between the invaded and non-invaded areas. However, we found there is a positive correlation between the presence and abundance of the snail *T.* pisana in the area invaded with the appearance of eaten flowers. In addition, our results demonstrated that flowers eaten by the snail form fruits without seeds. We conclude that *T.* pisana is widely present in both invaded and non-invaded areas along coastal areas of NW of Iberian Peninsula. Besides, we found this snail feeds on the flowers of *C.* edulis, affecting the production of seeds in fruits. This fact can help a possible reduction in the production of *C.* edulis seeds, acting as a natural biological control.

Developing a risk assessment database for the Great Lakes region

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Risk assessments are essential tools for predicting the likelihood that an invasive species will enter, establish, and spread in a novel region or environment. The Invasive Species Centre (ISC) identified that much existing information on risk assessments was decentralized; a wide range of species had been assessed, and the methodologies for assessment varied greatly by jurisdiction and assessing body. In an effort to consolidate this information, the ISC developed a searchable risk assessment database for invasive species. This database is a valuable tool enabling stakeholders to quickly access risk information to inform the response. This presentation will discuss the development of the database, how to access and use the database, and future expansion of the database.

Mapping the global state of invasive alien species: patterns of invasion and policy responses

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To use global databases to (1) provide a visualization of global geographical patterns of species invasions, origins and pathways and (2) depict the international uptake of legislative and policy responses to invasive alien species (IAS). Patterns of recorded species invasions and pathways of introduction were mapped and visualized using data from the Global Invasive Species Database (GISD) and the CABI Invasive Species Compendium (CABI ISC), along with associated legal instruments relevant to IAS compiled from the ECOLEX database. A novel indicator of the asymmetry between each country's 'ingress/egress' of IAS (kappa, K), was developed to further explore spatial patterns. Substantial variation in the spatial patterns of invasion was determined, with the Global North, some newly industrialized countries and small tropical islands being the main recipients of IAS and asymmetry (K) being

highest in New World countries and small islands. Of the 1517 recorded IAS, 39% were introduced only intentionally and 26% only unintentionally, 22% both intentionally and unintentionally, while 13% had no information available. The dominant pathway for species invasions was horticulture and the nursery trade, with 31% of the species introduced outside of their natural geographical range. Large increases in legislation on IAS have occurred since the 1990s, particularly for those countries that have high numbers of species invasions. Clear global patterns in the distributions of IAS are determined, supporting arguments emphasizing the role of colonial history, economic development and trade in driving the human-mediated movement of species. Dominant pathways for species invasions are similar across different regions. Policy responses towards IAS show an increasing desire from the international community to act on species invasions. Current patterns suggest that Africa and Central Asia are priority areas for future IAS research and control.

A coordinated management strategy for the invasive alien species of the Loire basin to improve data mutualisation

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Since its creation in 2002, the objectives of the working group "invasive alien species of the Loire basin" led to the realization of common tools and to scientific and technical advances concerning the freshwater invasive plants management. Between 2007 and 2013, several regional groups have emerged on the greatest part Loire watershed, relaying the basin actions and multiplying the dissemination of the information. The basin working group is formed by a wide range of stakeholders (experts, awareness and management project leaders, community representatives, institutions, etc.) and relies on a network of practitioners. Based on the learnings of more than 10 years, a strategy and its action program were validated in 2015.

The Loire basin invasive alien species management strategy 2014-2020 is articulated with the strategies at European, national and regional levels. It aims to coordinate relevant actions at the scale of a large river basin and to exchange on the management of freshwater invasive plants and animals methods. As well as giving a frame to the information exchanges between managers on the field, the implementation of the strategy promotes the surveillance and rapid response to new populations (e.g. new species or on colonization fronts). To achieve a better, more efficient response to biological invasions, data on invasive species distribution were compiled in 2016. The gathered data targeted the Loire basin's scale, data on some eighty main species, on a 2002-2014 period. While the results are considered usable, only part of the existing information could be used. To understand the reasons of the difficulties encountered while aggregating the distribution data, a survey was conducted in 2017. The major impediments identified by the stakeholders are the lack of data management dedicated time and the lack of data feedback process information.

TrIAS - Mobilizing data to improve IAS policy beyond good intentions

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In recent years, there has been several initiatives raising the importance of reliable data for invasive alien species research, policy and management (Groom et al. 2015; Lucy et al. 2016). Some of them are calling for considerable effort to maintain, update, standardize, archive, and aggregate datasets, to ensure proper valorization of data and information (Groom et al. 2017).

To move beyond good intentions and toward concrete action, the TrIAS project (Tracking Invasive Alien Species) is building a data-driven framework to inform policy (Vanderhoeven et al. 2017). Imagine a future where dynamically, from year to year, we can track the progression of alien species (AS), identify emerging problem species, assess their current and future risk and timely inform policy in a seamless data-driven workflow. One that is built on open science and open data infrastructures. By using international biodiversity standards and facilities, the TrIAS project

ensures interoperability, repeatability and sustainability. The project is built on two components: 1) The establishment of a data mobilization framework for AS data from diverse data sources and 2) the development of data-driven procedures for risk evaluation based on risk modelling, risk mapping and risk assessment. We will use facilities from the Global Biodiversity Information Facility (GBIF), standards from the Biodiversity Information Standards organization (TDWG)

Groom et al. (2015) Management of Biological Invasions 6 (2): 119–125. HYPERLINK "http://dx.doi.org/10.3391/mbi.2015.6.2.02"https://doi.org/10.3391/mbi.2015.6.2.02

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Vanderhoeven et al. (2017) Research Ideas and Outcomes 3 https://doi.org/10.3897/rio.3.e13414

Exploring CABI's Invasive Species Compendium usage and content at different geographical scales

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The Invasive Species Compendium (ISC) is an open-access resource that draws on existing scientific knowledge to provide information on invasive alien species (IAS). Since its launch in 2012, more than 8000 datasheets have been published, reviewed and updated. Of these, over 2000 provide comprehensive information on species biology/ecology, distribution, impacts and management practices.

Here we explore interesting features of the ISC, using an approach directed at different geographical scales. We look at website usage of the ISC at a global, regional and national level, using Google Analytics. In parallel, examples of global, regional and national ISC content relevant to IAS management are provided.

From a global perspective, in 2017, the ISC had an average of 96,554 users/month and 212,869 page views. Users were located all around the globe, but mainly from the USA, India and the Philippines. The datasheets most frequently accessed belong to a lepidopteran pest, the fall armyworm (*Spodoptera frugiperda*) (over 10,000 page views/year), followed by Siam weed (*Chromolaena odorata*) and goose grass (*Eleusine indica*). Taking a regional approach, datasheet usage in Europe for the IAS of Union concern was analysed. The most accessed datasheets were *Vespa velutina* and *Impatiens grandulifera*, each with over 1000 page views in 2017. Page views for IAS of Union concern more than doubled from 2014 to 2015, surely a result of EU Regulation 1143/2014. Since 2015, the average time spent by users on datasheets of species of Union concern has increased by 34%. Using Ireland as a single country example, usage of the ISC and that of datasheets of IAS of Union concern were examined. Users of the ISC have steadily increased over the years, with 3576 users recorded in 2017. While *Fallopia japonica* was the species most viewed, *Pacifastacus leniusculus* was the species of Union concern most accessed.

Distribution of terrestrial invasive alien plant species of Union concern in Ireland

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Invasive Alien Plants (IAPs) represent a major threat to Ireland's biodiversity and ecosystems. Knowledge of changes in the distribution of high impacting IAPs and the speed at which these species colonise new areas is critical for understanding the mechanisms and processes, including socio-economic drivers, underlying their spread and to prioritise the species and the key habitats that need to be managed. Here, we used records provided by the National Biodiversity Data Centre to describe recent changes in the number and density of records for the four terrestrial plant species of Union Concern that are present in Ireland [Regulation (EU) No 1143/2014] (*Gunnera tinctoria*, *Heracleum mantegazzianum*, *Impatiens glandulifera*, and *Lysichiton americanus*), as well as for *Rhododendron ponticum*, given its strong impacts in protected areas. The cumulative number

of records for all species has greatly increased since 2000, with *I. glandulifera* showing the highest annual increase (72%), followed by *H. mantegazzianum* (63%), *R. ponticum* (60%), *G. tinctoria* (55%) and *L. americanus* (26%). The density of records per hectad was highest for *H. mantegazzianum* and *I. glandulifera*, suggesting effective seed dispersal and successful recruitment from seeds of invasive populations, typically along riparian corridors. For *G. tinctoria*, these changes suggest effective long-distance seed dispersal by birds or anthropogenic means, with a more heterogeneous distribution within the landscape. Rapid increases in the number of recent records might partly reflect increasing efforts in mapping these species. However, for species such as *H. mantegazzianum* and *R. ponticum*, which have been the target of extensive eradication efforts, remarkable increases in the number of records indicate that their distribution is still expanding. Clearly, only when the current distribution of these species is complete will it be possible to distinguish those changes associated with the expansion or decline of existing populations from those due to new invasive populations.

Invasive species near irrigation channels inVojvodina region (Northern Serbia)

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All weed species, deliberately or accidentally transferred from their natural habitats into new ecosystems, where in the process of competition they repress native ones by invading their areas are considered as invasive species. This definition could be accepted as relative, not all introduced weed species are invasive and some native species can behave as invasive ones, spreading fast and aggressively. In Vojvodina region (Northern Serbia), located at south of Panonia valley, many invasive weed species are present, causing

damages in ecosystems, agriculture and water management. The most frequent invasive, but also allergenic weed species present near irrigation channels and river banks are *Ambrosia artemisiifolia*, *Asclepias syriaca*, *Iva xanthifolia*, *Artemisia vulgaris*, *Amorpha fruticosa* and some species from the family *Poaceae*. These species are a major threat to the irrigation channel network functionality. Also, these species easily spread to agroecosystems and urban environment causing multiple damages. Decision on their management must comprehend the most efficient and ecologically safest control measures. Invasive weed species can be controlled mechanically, chemically, as well as by combination of mechanical and chemical control measures on the canals for irrigation and drainage. Application of low rates of herbicides proved very efficient in control of invasive and allergenic weeds.

Citizen science model in Invasive Alien Species management in Croatia

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Citizen science defined as the involvement of the wider public in science has been repeatedly used to gather valuable data on invasive species. Its effects bring benefits to scientists, volunteers as well as generally to contribute to our knowledge of invasive plant species distribution. Invasive species are considered mostly a consequence of globalisation, and they may spread into new environments intentionally and accidentally. Their inventarisation and management requires high financial and human resources with often uncertain outcome. Citizen science has a huge potential to confront these problems. General public involvement, accompanied with systematic training, enables more complex biological recording and collection of larger environmental datasets. Moreover, coordination of the local population will create new approaches for garden-use practices and social behaviour that will result in long-term environmental improvements and ultimately prevent unintended negative ecological consequences.

Croatia has in recent decades, undergone radical changes in its nature protection models. Approaches to environmental management have shifted from a traditional centralised system to a community-oriented and holistic way.

The present paper has the aim to describe the case study of bottom up invasive species management approach in the City of Poreč and Istrian County, Croatia. Invasive Species Centre was initiated in 2015 by scientists who engaged the local community and by a still ongoing participative ecological project involving local and national bodies and educational institutions. Local residents are strongly invited to actively participate in the problem identification, data gathering and processing, and decision making. The project is resulting in the involvement of an extended stakeholders consortium and the preparation of a long-term regional invasive risk management plan. This is possible only with the collaboration of local and national authorities, scientists, citizens, and teachers, and its success is measured through their interest and involvement in future monitoring and management actions.

***Acacia dealbata* in Chile: is the invasion process at equilibrium?**

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In order to be successful, invasive species must overcome barriers to introduction, acclimation, reproduction and expansion. The invasion success can be explained at a global scale, that can be controlled by climate, or at a regional scale, where they can be controlled by biotic factors (competition, predation) or dispersal limitation. The magnitude of spatial spread (a proxy of invasiveness) can be predicted from species climatic requirement (climatic niche) and can be represented by Species Distribution Models (SDM). These models are one of the most popular tools to predict species potential distribution. We used a combination of global, native and regional data to improve the estimation of the potential distribution of *Acacia dealbata*, a tree native to the

Southeast coast of Australia, which has been considered one of the most invasive species of the genera, being registered in at least 34 countries in all the Continents. We assessed whether *A. dealbata* conserves its niche in the new environment and even, estimated the invasive stage of the species. Our results show that *A. dealbata* does not conserve its niche in the study area, invading areas with climatic conditions different from those in its native range. It is also not at equilibrium with the environment. Populations present in South-central Chile present different stages of the process. There are stable populations, but other populations are colonizing new areas, other occupy unsuitable habitats and some of them are adapting to new climatic conditions. Climatic factors, such as precipitation seasonality, act behind the expansion to new environments and biotic factors or dispersal limitations could be preventing the species to colonize suitable areas. More research is needed to complement our results and enhance the development of effective management strategies.

Intraspecific plant-soil feedback as an explanation of plant invasiveness

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Intraspecific plant-soil feedback (PSF) is a mechanism in which plants affect the soil composition and such modified soil then affects the growth of the same species. While most species show negative intraspecific PSF, i.e. perform worse in self-cultivated than in other-cultivated soil, invasive species are expected to show positive feedback. Most evidence for this comes from meta-analyses, modelling studies or studies comparing a few species, but studies on larger species sets are missing. Moreover, very few studies compare PSF between invasive and alien non-invasive species and thus cannot say if PSF could serve as an explanation for plant invasiveness.

To test whether PSF might be a general mechanism underlying plant invasiveness, we study PSF in a large set of alien species of the Czech Republic with varying level of abundance in the field and different invasive status. Results based on data on 68 species show that invasive species have slightly more positive feedback for germination but not for biomass than non-invasive species. Species that are common in the field have more positive feedback for both germination and biomass than species that are scattered or locally abundant. Moreover, PSF for germination was one of the best predictors of invasive status and abundance in the field when compared with other plant traits commonly used for explaining plant invasiveness.

Stress resistance and immune system in ladybirds: Is there a difference between native and invasive species?

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The harlequin ladybird, *Harmonia axyridis*, is considered to be one of the most successful invasive insect species. It has been hypothesized that successful invasive species could systematically differ from other species by their specific species traits. Resistance to environmental stress and against various pathogens are supposed to be among the most important traits related to invasive success. In our study, resistance against starvation and desiccation, and immune system function of *Harmonia axyridis* was compared with several other ladybird species native to Central Europe. Longevity of invasive *Harmonia axyridis* adults under stressful conditions (no food and no water) was much shorter than longevity of *Coccinella septempunctata*, representing native ladybird species of similar size. In general, longevity of particular ladybird species was related to species body size and habitat preferences: larger species outcompeted smaller in their stress resistance and species from dry habitats outcompeted these from mesic habitats. Longevity of *Harmonia axyridis* was comparable to longevity of several smaller native ladybird species. Immune system of invasive *Harmonia axyridis* clearly outcompeted immune system of *Coccinella septempunctata* in means of antimicrobial activity against *Escherichia coli*, but there was only a small difference in immune function between *Harmonia axyridis* and *Ceratomegilla undecimpunctata*. The two later species are closely related to each other and thus actual functioning of immune system could be a result of species evolutionary history. However, future research focused on immune system function in additional ladybird species is needed to disentangle sources of interspecific variability.

Alien *Rumex* spp. in New Zealand host a different herbivore fauna, experience lower levels of herbivory and grow larger than in their native range

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Release from natural enemies in the introduced range may be a trait that could predict the success biological invasions. However, robust tests of the existence and impact of enemy release are rare. A thorough test of enemy release requires a comparative assessment of the diversity of the natural enemies in the introduced and native range, quantification of the damage and its consequence for plant growth. We undertook such a study for three *Rumex* species (*R. obtusifolisus, R. crispus* and *R. conglomeratus*; Polygonaceae) that are known to host specialist herbivores in their native European range. We conducted surveys in the United Kingdom and in New Zealand to test for differences in the variety and abundance of insects present on leaves and roots between the two ranges. In order to quantify the impact that insect herbivores have on our study plants, we also quantified damage on their leaves and roots. Our surveys showed support for enemy release, since specialist herbivores were absent in the non-native range. UK insect populations consisted mostly of chewing insects, whereas NZ insects were mainly sap-suckers. The most notable difference was in root herbivory, where 25% of UK plants had root damage while only 3% of NZ plants had root damage. Root herbivory, therefore, could have the greatest impact on fitness differences in our study plants. Comparisons of the above and below ground biomass of plants in the two ranges indicated individual species differences that were less clearly linked to levels of herbivory. These results point to the importance of fully quantifying the nature of enemy release, because any single measure (enemy richness, damage or iomass) may be misleading on its own.

Comparing phenotypic plasticity in the native and introduced range for widespread weeds

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Phenotypic plasticity is thought to promote plant invasions, by allowing plants to quickly adapt to novel environments, but it is unclear whether such plasticity is present in native populations or evolves in introduced populations to promote further spread. For species with native ranges that span a wide variety of habitats or climates, understanding to what extent that spread is the result of plasticity in the native range can improve our understanding of the risks and mechanisms behind the increased invasion potential of species with large native ranges. We use three species of *Rumex* (Polygonaceae), *R. obtusifolius*, *R. crispus*, and *R. conglomeratus*, which are native to Europe and are invasive in New Zealand to examine plasticity in the native and introduced range. We examine whether phenotypic plasticity can maintain fitness across a broad soil moisture gradient and whether clones of native genotypes (UK) are as plastic as clones of introduced genotypes (NZ). By collecting seeds from plants growing in a variety of climatic regions and habitats, we can also assess how plasticity varies within the native and introduced range. We examine physiological traits that may contribute to water-use plasticity, including stomatal conductance, photosynthetic rates, and root to shoot ratios, and compare these results with total biomass, as a proxy for fitness. We examine the relationships between measures of physiological plasticity to those relating more directly to fitness. These species are able to maintain fitness across much of the soil moisture gradient, but results indicate some differences between native and introduced genotypes. This suggests that high plasticity in the native range allowed expansion into a wide variety of habitats in the introduced range, but that subsequent evolution in the introduced range may act to further enhance adaptive plasticity.

Finding a way through the jungle of concepts and hypotheses in invasion biology

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Invasion biology is a thriving ecological research field, and confusingly many hypotheses, concepts and ideas about biological invasions populate today's literature. Moreover, some of these hypotheses are very similar, whereas others contradict each other or represent completely different perspectives on biological invasions. We organized a workshop this February with a group of invasion biologists to find a way through the jungle of hypotheses and concepts. At this workshop, we discussed ways to structure invasion hypotheses and concepts, how to define "similarity" among hypotheses, and agreed on a Delphi technique to create a network of 39 hypotheses as a suggested conceptual "map" of the field. We will present this map at the conference. Hopefully, it will serve as a useful tool within and beyond the field; for scientists, managers, decision-makers and other stakeholders. Our approach is applicable across research fields and could help to create a navigation tool for science at large.

Trait-environment relationships across the native and non-native ranges of *Plantago lanceolata*

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Disentangling the drivers of intraspecific trait variation at global scales is crucial to understand current and future biological invasions. Here we present results from the collaborative project PLANTPOPNET, a study of the widespread herb *Plantago lanceolata* in multiple native (Europe) and non-native (N America and Australia) sites. We analysed the effects of an array of environmental factors on functional traits (plant size and specific leaf area) and fitness surrogates (reproductive investment) on *in situ* populations, and also in a common garden experiment. Non-native populations showed *in situ* higher plant size and higher reproductive investment per unit of plant biomass than native populations, which may have been advantageous in their expansion to new areas. However, non-native populations were exposed to higher temperature and aridity, and differences between regions in reproductive investment were explained by these environmental effects. This highlights the importance of testing for abiotic niche differences before considering biotic factors associated with species introductions as direct drivers of trait or demographic changes. Most environmental effects on plant traits were consistent between native and non-native areas, indicating that trait-environment relationships found in the native range can be used to predict non-native patterns. Finally, source environmental effects found in the field were also detected in the common garden experiment for fitness surrogates, but not for functional traits. Our results suggest thus that local adaptation may be more common for traits more closely related to fitness, and highlights the importance of global studies considering multiple sites and traits for a better understanding and management of biological invasions.

Are Ponto-Caspian species inherently better colonizers than species from other areas?

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Following the opening of the canals which link the North and Baltic Seas with the Black and Caspian Seas, fauna from the Ponto-Caspian region dispersed and became abundant in Northern European ports. The invasion history of the Great Lakes reveals a more intriguing pattern, with most of these invaders identified in the system after European invasions. Interestingly, this transfer has been asymmetrical with only a few species from the Great Lakes having invaded European waters and almost no species from freshwater invading brackish or marine habitats. To determine if Ponto-Caspian species are inherently better colonizers than species from other regions, we explored nonindigenous species (NIS) established in the North and Baltic Seas and Great Lakes–St. Lawrence River regions. We compared observed numbers of NIS in these two regions to expected numbers of NIS from major donor regions which were calculated based on the available species pool from donor regions, frequency of shipping transit, and an environmental match between donor and recipient regions. Then we conducted salinity tests on eight species native to Northern Europe, the Great Lakes-St. Lawrence River and Ponto-Caspian region, as well as experimental selection experiments on Ponto-Caspian gammarid *Pontogammarus maeoticus* to determine their salinity tolerance and adaptation potential for higher and lower salinity than the tested population was collected from. Our results demonstrated that Ponto-Caspian taxa colonized both types of habitats, marine areas of the North and Baltic Seas and freshwater of the Great Lakes–St. Lawrence River, in much higher numbers than expected. All eight species tolerate wide ranges of salinity. However, different patterns arose among species from different regions. Ponto-Caspian taxa showed lower mortality in fresh water, while Northern European taxa showed higher survival in fully marine conditions. Finally our selection experiments resulted in successful selection to lower, but not to higher salinity.

MHC class II diversity in native versus invasive raccoon population.

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Despite broad theoretical insights on genetic diversity of invasive expanding populations shaped by host-parasite interactions and the role of immunity genes in invasion, the empirical longitudinal studies, integrating population genetics, are still lacking. Diversity at the major histocompatibility complex (MHC) loci may be particularly important for invasive populations, as it provides the basis for rapid adaptive immunity. Revealing the mechanisms connecting MHC diversity and parasite resistance in invasive species is crucial for understanding the process of invasion itself. Differences between native and introduced populations arise due to genetic drift occurring during invasion process as well as due to differential selection pressure operating on native and invasive populations. To test the prediction of lowered genetic variation in introduced invasive populations we compared the levels of MHC DRB locus diversity in the native range of raccoon *Procyon lotor* with those observed in invasive European population.

Despite the limited number of individuals that formed invasive European raccoon population the diversity of MHC DRB locus was maintained at moderate level. All the alleles found in European population were previously detected in the native range, although we found only 6 (out of 45) alleles shared between our European and Florida population. The number of alleles ranged from 2 to 6 per individual, both in native and introduced population. The allelic diversity was significantly higher in native raccoon populations form Florida, despite smaller sample size. We found the evidence of positive selection acting on specific codons of MHC DRB locus both in European and native samples. Even though the significant geographic structure was previously detected among European raccoon populations, we failed to find such pattern for MHC locus, suggesting the possible role of contemporary selection in shaping MHC diversity in invasive raccoon population.

Worldwide asymmetry in plant species flows in the Mediterranean Biome

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Understanding the mechanisms that support the arrival, establishment and spread of species over an introduced range is crucial in research on invasion ecology. Although species invasiveness can be attributed to different factors (e.g. life history, propagule pressure and human disturbance), the ecological and biogeographic patterns determining the invasion success of plants still remains a key knowledge gap. We explored the global distribution patterns of exotic herbaceous plant species (excluding deliberately introduced pathway species) in the world's five Mediterranean-climate regions (MCRs). We describe the invasion level of each MCR and analyse the species flows among them. At the global scale, the exchange of species over the MCRs constitutes a relatively closed system with low entries from other regions, except for the Iberian Peninsula, where exotic species come mainly from non-Mediterranean regions. Additionally, the Iberian Peninsula presents the lowest level of invasion, whereas California and South and Western Australia exhibit the highest. Our results illustrate the asymmetry of these flows of species, highlighting the Iberian Peninsula as the main donor to the other four MCRs. Our findings clearly show that a high species frequency and a broad latitudinal and geographical range in the donor area determine invasion success at intercontinental scale. However, at intra-regional scale, minimum residence time of the species is the main factor determining expansion success, complemented by the potential of species for pre-adaptation in their native range. In this sense, high species occurrence and geographic variables related to specific locations in their native range (the Iberian Peninsula) control their expansion in each MCR. Our findings point out that in the context of global change, robust information on exotic species in their native range constitutes a strategic requirement for a better understanding of invasion mechanisms, which will help informing decision-making process and modelling the risks of future invasions

The invasive potential of introduced exotic trees: what do arboreta tell us?

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An increasing number of woody species are being listed as invasive in Europe. Forestry is the second largest pathway of invasive tree introductions and it is likely that climate change will encourage forest managers to plant exotic tree species to maintain wood production. In the early 1900's, several arboreta were established in Southern Belgium to assess the wood production potential of prospective exotic trees. However, they also offer the unique opportunity to assess their potential invasiveness. A systematic sampling method was used to conduct surveys in eight arboreta and a buffer zone surrounding them. Regeneration of all exotic trees was recorded as well as biotic (herbaceous competition, composition of the tree stand) and environmental variables (soil type, pH, thickness of litter, canopy closure and climate). A descriptive approach allowed us to identify species showing an abundant regeneration. Linear regressions were implemented to assess whether the patterns in the regeneration of these exotic trees could be explained by their functional traits, dispersal modes and environmental tolerances. Results revealed that several coniferous species from the North-American West coast exhibit rapid regeneration and/or dispersal, including *Tsuga heterophylla*, *Abies grandis*, *Chamaecyparis lawsoniana*, *Pseudotsuga menziesii* and *Thuja plicata*. We therefore recommend to exercise caution when planting these species in future forestry trials given their potentially invasive characteristics.

Ensemble forecasting of worldwide distribution of American Bullfrog, *Lithobates catesbeianus* (Shaw, 1802): using habitat suitability models to plan future management

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Global biodiversity is at risk as a consequence of climate change and freshwater ecosystems are expected to suffer the most (Gama et al, 2017). In recent years niche-based models have been used to predict species distribution and are an important tool for conservation and management of aquatic ecosystems. In this work, the current and future climatic suitability areas of the invasive species *Lithobates catesbeianus*, known for adverse ecological and economic impacts, were assessed at worldwide level. The species distribution modelling was based on nine different algorithms in the BIOMOD2 package (Thuiller et al, 2009) and summarized in an ensemble forecasting approach. To model the species distribution, six climatic variables ecologically meaningful for the selected species were considered. Three timeframes (current, 2050 and 2070) were modeled using two increasing CO_2 emission scenarios. The performance of individual models was fair according to the area under the receiver operating characteristic curve (AUC) and useful according to true skill statistics (TSS). The individual models that best performed where random forest (RF) for both AUC and TSS. Temperature seasonality, minimum temperature of the coldest month, maximum temperature of the warmest month and precipitation of the driest month were the most important variables predicting bullfrog occurrence. Current adequability maps identified that in the future an increase in adequate areas is expected at higher latitudes, especially in North America and Central Europe and a concomitant decrease in adequate areas around the Mediterranean. Current adequate areas for the species represent 3.8% worldwide and these are expected to increase up to 5.2% in the future. Overall, the results indicate that climate change will favor the expansion of *L. catesbeianus* into new river basins, and conservation efforts should take place in order to minimize negative impacts of bullfrog presence and protect native amphibian species under threat.

The effect of climate on diversity of native and alien urban floras across Europe

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Climate is an important factor influencing plant diversity, however it is not yet fully understood whether it has different effects on native and alien species in urban floras. We therefore compare effects of climate and anthropogenic management on native and alien plant species richness and composition across 60 cities in Western, Central and Southern Europe. During the standardize sampling, spontaneously occurring vascular plant species were recorded in 1-ha plots located in 7 urban habitat types in each city. The response of alien proportion and native and alien species richness in cities to main climatic gradients was compared using generalized linear models. Native and alien compositional variation across cities and urban habitat types was quantified using variation partitioning and principal component analysis on plot species data.

Proportion of alien species was almost the same in all cities in all regions, but their species numbers and the species composition differed between European climatic regions. Native and alien species composition was affected more by climate than by habitat type. The native species composition changed the most on the gradient from Mediterranean to Nemoral Europe, alien species also on transition from Oceanic to Continental Europe. We showed that in urban floras proportion of aliens does not respond to climatic differences because drought stress in Mediterranean Europe limits both native and alien species richness in comparison with cities located in mild climate. Alien species originating in warm regions are probably limited by relatively cold conditions in Oceanic Europe. It is likely that future warming of the climate will probably alter the alien species composition but not their proportional representation in city floras.

High air humidity is sufficient for successful incubation and early postembryonic development of invasive freshwater crayfish

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Freshwater biodiversity is globally threatened by various factors such as severe weather events, e.g. long-term droughts. When faced with this situation, freshwater crayfish has a tendency to stay in the shelter/burrow to remain in a contact with the water or at least stay in a sufficiently humid environment at drying localities. In order to assess whether freshwater crayfish can undergo embryogenesis and early postembryonic development under such conditions, we conducted two experiments using artificial burrows with high air humidity. In the first experiment, ovigerous marbled crayfish *Procambarus virginalis* females held for 3, 10 and 17 days in aquatic conditions were placed to the experimental burrows. Control females were kept in water during whole experimental period. Following ca. 21-days lasting incubation, successful hatching was achieved in all treatments. In the second experiment, only females incubating for 10 days in aquatic conditions were used and observed for progress in postembryonic development. Besides hatching, juveniles were capable of moulting to the second developmental stage just under high air humidity conditions. These juveniles stayed viable for extended period of time but did not develop further. However, when placed to the aquatic conditions, they promptly moulted to the third developmental stage and progressed normally. Our study revealed an ability of marbled crayfish to undergo terminal phases of embryogenesis, including hatching, as well as early postembryonic development in high air humidity only. This unprecedented live history trait is crucial for inhabiting ecosystems with high water level fluctuation where many other taxa of aquatic biota fail.

Application of geostatistical modelling in predicting the spatial distribution of invasive and expansive plant species

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For predicting potential distribution of the invasive and expansive plant species geostatistical methods can be applied. They allow modeling of their spread and may be applicable tool for effective monitoring and control of those species in the future.

This study aimed at estimating the spatial distribution for *Heracleum sosnowskyi* and *Cirsium arvense* using geostatistical methods supplemented by field data set and image classification techniques. Semivariogram maps, for identifying anisotropy directions, were generated for data transformed with the Gaussian anamorphosis. Performing Sequential Gaussian Simulation resulted in the generation of prediction models for species distributions in places where they are likely to occur. In order to verify the correctness of the conducted modeling, the following prediction errors were calculated: mean absolute error (MAE) and mean percentage error (MPE). The prediction errors for *H. sosnowskyi* were as follows: MAE=3.30–4.69, MPE=0–0.01%, in case of *C. arvense*: MAE=3.51–4.73, and MPE=0–0.02%. The errors values indicate a well-conducted models evaluation. MAE with a value close to 0 informs about small errors computed for the prediction model, while MPE indicates a slight underestimation or overestimation of the obtained model. Models for both species at different scales were also compared and the coefficient of variation (V) for each of them was calculated: *H. sosnowskyi* V=0.14–1.11%, and for *C. arvense* V=0.15–0.92%. The results indicated that the models for predicting the spatial distribution of species are accurate.

Using geostatistical tools in conjunction with environmental parameters (e.g. species cover) allows to assess the future distribution of invasive and expansive plant species at different spatial scales.

A comprehensive screening program to prioritize management and prevent introductions of non-native plants and their cultivars in Florida's natural areas

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The detrimental ecological and economic effects of non-native invasive species are especially evident in the natural areas of Florida. Preventing high-risk species from being introduced into natural areas and managing invasive species early in the invasion process can reduce these effects. To identify species most likely to invade Florida's natural areas, the University of Florida's (UF) Institute of Food and Agricultural Sciences (IFAS) developed the UF/IFAS Assessment of Non-Native Plants in Florida's Natural Areas. The IFAS Assessment utilizes protocols to evaluate the status of non-native species either present in the state or prior to introduction. Approximately 60% of the 880 species evaluated by the UF/IFAS Assessment are considered low risk for invasion or have not escaped into natural areas, 14% are listed as caution species, and 26% are prohibited, invasive, or high risk for invasion into natural areas. A unique component of the IFAS Assessment is a cultivar assessment tool used to determine if the recommendations of a cultivar, sub-species, variety, or hybrid differ from those of invasive parent species. This tool has been valuable in the assessment of presumably sterile cultivars of invasive horticulture species such as *Ruellia simplex* and *Lantana camara* that have demonstrated ecological harm to natural ecosystems, but also provide economic benefits to Florida's US$890M per year horticulture industry. The IFAS Assessment provides reliable, comprehensive recommendations for the use of non-native plant species. Results are accessible through an interactive, searchable website that can be filtered by conclusion type, origin, and growth habit. The IFAS Assessment contributes to management and conservation efforts of our valuable natural resources by helping to reduce the introduction and spread of plant invaders.

Characterizing recovery strategies after fire in pine forests susceptible to invasion by Acacia longifolia

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Among the Mediterranean countries, Portugal registers the highest records of forest fires in recent years. Maritime pine (Pinus pinaster) forests, dominant in coastal areas of Central Region of Portugal, are not only considered highly vulnerable to fire, but they are also identified as highly susceptible to invasion. After the big fires of last year (2017) we selected a study area (Marinha Grande) in sand dune pine forests in order to assess which recovery strategy is dominant after fire, considering different types of understory and different stages of invasion by A. longifolia.

In the study area we selected parcels (10x10m) according fire disturbance, where assessments will take place every year: i) in parcels not disturbed by fire, we describe floristic composition and, based on cover degree, prevalence of recovery strategy (seeders, sprouters),regarding different understory conditions (low and tall native shrub communities, invaded understory), ii) in the case of parcels disturbed by fire, located near non-disturbed parcels, and considering sub-parcels of 1m2, we recorded: number of seedlings per species, number of stems per species and per sprouter, average height per sprouter.

In both type of parcels soil samples at different depths (5, 10, 40cm) were collected to characterize soil conditions.

In terms of preliminary results, we observed that in low native shrub communities there is a prevalence of seeders, while in tall native shrub communities there is a prevalence of sprouters. In invaded communities there is a prevalence of seeders, and, despite the stage of invasion, the number of seedlings is higher for Acacia longifolia, even if the presence of native seeders is recorded, which is significantly lower. However, in tall native shrub communities invanded, the biomass for the majority of sprouters is significantlly higher than for seeders. Will be A. longifolia able to overcome native tall shrubs adapted to fire?

Illegal plant imports: A pathway for plant pest invasions

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Worldwide, thousands of species of herbivorous insects and plant pathogens have accidentally been transported and established outside of their native ranges. Many of these species have had catastrophic impacts, killing large numbers of host plants resulting in damage to both agricultural and natural ecosystems. Previous analyses have identified live plants as the dominant pathway by which plant pests are accidentally moved among world regions. Policies have been developed at national and international levels to regulate imports of live plants in order to mitigate the live plant invasion pathway. However, there is considerable evidence that in addition to the international transport of plants through legal, regulated channels, live plants are also transported illegally among countries. These illegal movements include commercial plant growers who choose to circumvent regulations, rogue importers of forbidden live plant food products, importers serving hobby gardeners and tourists who transport live plants in their baggage for propagation in their gardens. Illegally imported plants are likely to harbor insects and plant pathogens that are often not discovered through border inspection and potentially could establish outside their native range. We analyzed records of insects on illegally imported live plants discovered during inspection of mail, parcel post and air passenger baggage entering the USA from 2010-2015. The most frequently intercepted plant genera infested with pests discovered in passenger baggage and mail were *Citrus, Ipomoea, Magnoliophyta , Dendrobium* and *Pinus*; insects were the most common plant pests and Hemiptera was the most common insect order encountered. We conclude that illegal imports of live plants currently serve as an important pathway for invasions by plant pests. Prevention of arrival of plant pests on this pathway represents a serious challenge to regulators.

Comparing the main drivers of species turnover between native and alien birds: the relative role of propagule pressure, environmental suitability and human connectivity

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Aim. Understanding the importance of main drivers shaping alien species turnover can provide important insights into the processes driving species' invasiveness and their management. Propagule pressure and environmental suitability may facilitate the settlement of such species, while road and railway networks may facilitate their dispersal, either by easing the movement of animals through the infrastructure corridor or by human mediated transportation. Here, we examine the relative role of these three drivers on turnover patterns for alien and native bird species.

Location. Iberian Peninsula.

Methods. We assessed the relationship between species turnover across main cities (n=39), as measured by zeta diversity, and the biophysical drivers related to propagule pressure, environmental suitability, whilst considering the distance between cities, either Euclidean or the effective distance through transportation corridors (roads and railroads; hereafter DRR). We used as focal groups alien passeriformes and psittaciformes, and compared the outputs with those obtained from native passeriformes.

Results. Turnover of native passeriformes followed the expected pattern of increasing pairwise dissimilarity with increasing distance (both Euclidean and DRR), while the other alien birds showed weaker signs of such relation. For alien passeriformes, the models of zeta diversity including the DRR distance had in general higher support. The opposite was found for native passeriformes, and mixed results for psittaciformes. The results highlight key environmental drivers shaping species turnover, namely Temperature and Aridity. For alien passeriformes, the Distance to ports was also high ranked.

Main conclusions. Species turnover of the three focal groups are differently influenced by human connectivity, environmental suitability and propagule pressure drivers. These birds seem to have a complex relationship with distance between cities, probably denoting the variable effects of natural dispersal, and scattered introductions and active transportation by humans. Our results can be used for better control and management of alien species and to predict their invasiveness.

Understanding the naturalizaton-invasion process: when ornamentals fail to establish?

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Our understanding of the naturalization-invasion process is limited due to the bias towards successful species, as failed introductions are rarely recorded. It is known that propagule pressure and residence time may overcome the biotic and abiotic barriers in the invasion process. Unfortunately real data that would elucidate the role of such biases are rarely available.

A group of organisms whose participation in invasion process can be captured in greater detail than most other taxa are ornamental plants. In our study we made use of the fact that in the Czech Republic, many villages and urban areas near state borders were abandoned after WW II, and mostly remained uninhabited until now. With the spontaneous succession progressing for 70 years, it is insightful to explore how species grown private gardens, persisted over such a long period. This was made possible due to existence of the inventories from the 1960s of alien and native species growing in those abandoned villages. The villages were revisited in 2016–17, to answer the following questions: (i) which alien and native species have survived, (ii) are there any specific traits to separate planted species that survived from those that failed, and (iii) can the actual species diversity be better explained by site environmental conditions, or the traits of surviving species?

The found that the number of recorded species and their survival does not depend on site environmemtal conditions. Among traits that best explain individual species' survival are niche breadth and height. The most frequent species that were found in recent survey were apophytes, utility plants and trees. Some currently very common species were quite scarce at the time of the first inventory, indicating that there was a significant lag phase. Other species such as geophytes were disappearing despite their former popularity reflected in frequent cultivation.

Factors influencing forest invasions by exotic plant species at multiple scales

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Intact forests were long thought to be resistant to invasion by exotic plant species. However, evidence has mounted in recent years that some plant species are able to invade even undisturbed forest. Nevertheless, not all undisturbed forests are invaded and questions remain about what forest characteristics may enable or prevent successful invasion. Forest age, landscape position, soil characteristics and land use history are all factors that may influence the degree to which forests are invasible, and different factors may be important at different spatial scales. In this study, I sampled the distribution of invasive species within three large natural areas in southeastern Connecticut, USA and compared the distribution with a range of factors including forest age, basal area, distance to forest edge, and distance to nearest road or trail.

These natural areas are covered by forests that have regenerated after the abandonment of agriculture 50-150 years ago, but have been largely undisturbed for the past 50 years. I also collected soils from paired plots with and without invasive species and analyzed organic matter content, pH, water content and nutrient levels. Results were similar among all sites. Within sites, invasion was highest in younger forests, but did not vary with forest basal area. Invasion was also higher closer to roads, trails and forest edges. Paired plots showed higher invasion in areas with higher soil nutrient levels over small distances. However, younger forests (which were more invaded) had lower overall nutrient levels. Thus, soil nutrient levels may impact invasion at small scales, but are not likely the primary drivers of the effect of forest age on larger scale patterns in this area. Understanding the factors that influence the invasibilty of forested natural areas at a variety of scales is critical for monitoring and management of invasions in these areas.

Stage-based trait identification by placing model systems on the unified framework for biological invasions

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Invasive plant species could be considered as model systems to gain insights into evolutionary, biogeographic, and ecological processes that drive and/or facilitate introduced species' expansion in novel, heterogeneous environments. It is important to understand the attributes and mechanisms at play during species' invasion and/or range expansion in heterogeneous environments for potential management of the invaders. The study intends to place a few species, at different stages of range expansion, on the unified framework for biological invasions to assess the performance strategies which facilitate a species to breach/overcome the environmental barrier and expand its range in heterogeneous environments. Two study species were selected for the present study; *Lantana camara* L. (*sensu lato*), an established invader and *Ricinus communis* L. represented an

aggressive colonizer in India. *Lantana camara*, an ornamental escapee has spread extensively and continues to expand in India. While an aggressive colonizer, *R. communis* has inadvertently escaped the cultivated croplands to anthropic habitats and beholds immense potential of proliferating and being invasive in India. The unified framework enabled categorizing and comparing the performance strategies of the study species. Interestingly, the results of the study affirmed the hypothetical placement of the two species on the unified framework. In view of the results, *L. camara* is an established invader, expanding its range in shaded habitats and *R. communis*, an aggressive colonizer exhibits boom and bust cycles, but may pose a significant invasion risk in near future through breach of environmental barrier. The study enabled us to understand how plant performance-related traits and species' trait modulation potential assist the species in breaching/overcoming barriers to colonize, invade and/or expand. The emerging pattern will help us to appraise the prospects for research on stage-based trait identification which assists the species to overcome a gamut of barriers along the invasion continuum.

A new metric to assess relative impact potential (RIP) under climate change scenarios

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Predicting invader impact without prior invasion history is a challenge that urgently needs to be addressed. This is a problem exacerbated by our rapidly changing climate and increasing connectivity. Functional Responses (FR) have been utilised as a proxy for invader impact and successfully predict ecologically damaging invaders. FRs can be combined with abundance data and used to calculate the Relative Impact Potential (RIP) of an invader over a native. We demonstrate how the RIP can be used to assess a single species under current and predicted climatic scenarios and make it more informative by the addition of a Resource Reproduction Qualifier (RRQ). By adapting the RIP metric to refer to climatic change we provide a way to rapidly quantify ecological impact on prey populations, which can be applied to

many trophic groups. The addition of the RRQ takes into account expected thermally driven changes to prey populations and incorporates these to represent their effect (or lack of effect) upon the RIP score. Using temperature change as a key variable we quantify the impact of a tropical invasive species (*Pterois volitans*; red lionfish) in its native and invaded range, and a temperate native species (*Sycliorhinus canicula*; lesser spotted dogfish) under current and predicted temperatures. Lionfish ecological impact was constrained by the lower temperature treatment through the mediation of both feeding rate and lower abundance despite a higher resource reproduction rate. Dogfish exhibited a substantial increase of predatory impact under the raised temperature treatment, driven by an increased feeding rate and abundance with no mitigating effect of resource reproduction. This suggests that they may exhibit invader like impacts in the near future. Thus, we provide a prediction metric that accounts for (1) predator abundance; (2) resource availability; (3) empirical quantification of species interaction strength that can be assessed prior to invasion history.

Invasion of the Ponto-Caspian species of Gobiidae in the Eastern European region

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The molecular genetic analysis was performed by cytochrome B gene sequencing on 37 individuals of the monkey goby (Neogobius fluviatillis) fish caught in the waters of Ukraine and Belarus (the Dnieper and Pripyat rivers). The site was analyzed from 36 to 674 nucleotides of a full-length gene (1142 bp). The analysis was carried out with original sequences and sequences obtained from Genbank. Generally 165 sequences were analyzed. There were found 84 haplotype of a monkey goby hibernate, In the course of the molecular-genetic analysis. The total number of variable sites was 102. The individuals which were caught in Belarus, belong to the same haplotype, which also owns a specimen in Poland (the Vistula River). During the analysis of individuals caught in Belarus, no single nucleotide substitution was detected. Extremely low genetic diversity, belonging to the same haplotype, and the absence of nucleotide substitutions established during the molecular genetic analysis of a monkey goby, suggesting the passage of a population recently, the "bottleneck" in the process of advancement of invasive corridors, due to which almost all the ancestral polymorphism was lost. However, the data requires clarification and the research will continue.

Horizon scanning for Invasive Alien Species on Cyprus

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Horizon-scanning for invasive alien species can lead to prioritisation and so inform decision-making and action. The scale and scope of horizon-scanning for IAS can be defined depending on the need. Here we report on horizon-scanning for IAS likely to arrive, establish and affect biodiversity and human health on a Mediterranean island, Cyprus. We used a two-step consensus-building process in which experts reviewed and scored lists of relevant alien species on their likelihood of arrival, establishment and potential to affect biodiversity and / or human health in the next ten years.The information collated provides an evidence base for preventive actions such as pathway control and contingency planning. Our study focused on Cyprus, with particular attention to its British Sovereign Base Areas, and is the first systematic horizon-scan for alien species relevant to the Mediterranean.

A survey of pathogenic fungi on invasive plant *Cytisus scoparius* in Lithuania

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Cytisus scoparius (L.) Link (Fabaceae) is native to Western, Southern and Central Europe. In Eastern Europe, it occurs as a naturalized alien or invasive species. In Lithuania, *Cytisus scoparius* was introduced at the end of the 19th century. During the 20th century it has spread widely because of the human activity. Now this species is recognized as invasive species in Lithuania.

Impact of invasive plant species on the native plant species and ecosystems is widely studied and well documented, however, the diversity of fungi, bacteria and other microorganisms associated with invasive species is much less studied and their impact on both invasive and native species is insufficiently understood. Some microorganisms may facilitate the spread and augment the negative impact of an invasive species, whereas others may suppress their growth and could be used for population control. The aim of this study was to study the diversity of pathogenic fungi and other microorganisms associated with *Cytisus scoparius*.

Samples of *Cytisus scoparius* living tissues (stems, branches and leaves) with signs of certain injuries or necrosis (discoloration of the xylem, spots on branches and leaves, etc.) were collected in four regions of Lithuania. Sampling of plant material was performed in summer and autumn 2017 in large populations of *Cytisus scoparius*. A total of 57 cultures of microscopic fungi were obtained from the samples. Cultures of fungi were grouped based on their morphology, and their representatives were tested applying molecular methods. Pathogenic and antagonism tests with the identified microorganism species were performed.

Status and distribution of crayfish within England - an update

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The anthropogenic spread of invasive species continues to be a key driver for the loss of native biodiversity. White-clawed crayfish (*Austropotamobius pallipes*, Lereboullet) are the only crayfish species native to the UK. In compliance with Article 17 of the Habitats Directive, the UK must report on white-clawed crayfish with respect to Favourable Conservation Status (FCS), measured against specific targets. The previous overall assessment of conservation status for white-clawed crayfish was stated to be bad and deteriorating.

The primary contemporary cause of this decline is the invasive non-native signal crayfish, *Pacifastacus leniusculus* (Dana), and associated 'crayfish plague' *Aphanomyces astaci* (Schikora). Signal crayfish are vectors of crayfish plague, which causes 100% mortality in native populations. In the absence of plague, signal crayfish can outcompete native populations in 6-7 years.

Here we provide an updated distribution map for England, utilising new data from collaborations with the Environment Agency, Natural England, and local experts. These maps are presented both at a regional and country scale.

White-clawed crayfish continue to show significant declines within England at the sub-catchment and 10-km grid square scale, whilst signal crayfish continue to expand and consolidate their range. Several key populations of white-clawed crayfish were lost due to plague outbreaks, without signal crayfish being subsequently identified. We also present analysis of Special Areas of Conservation (SACs) that were partially or specifically designated for white-clawed crayfish, in the context of localised distributions.

A key focus for management is to determine if sub-catchments containing no crayfish records are truly without crayfish populations, for example due to habitat suitability, or are data deficient. Additional consideration should be given to 'conflict zones', where frontiers of red or blue sub-catchments meet. As with all invasive species, prevention in the first instance is the best biosecurity.

Assessing phenological change in the morphological characteristics of Impatiens glandulifera since its early invasion days within the U.K.

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There is increasing interest in biological invasions and the threat they pose to ecosystems worldwide. Along with habitat destruction, non-native species invasions are thought to be the leading cause of species extinction in recent times. Until now, the main focus of research has been on the impact of invasive plant species on local-scale habitats; there has been relatively little research on phenological changes in invasive plant species since they were first introduced. The aim of this research project is to assess phenological changes in the highly invasive plant species *Impatiens glandulifera*, which is spreading rapidly within Wales and England and having a detrimental effect on local ecosystems. Over

350 herbarium specimens were used to determine if there have been any changes in morphological characteristics of the species, including leaf area, leaf width, leaf length, stomatal density, flower length, guard cell size. The research is based on both present-day populations and herbarium specimens. The oldest herbaria records of *I. glandulifera* used in this study date back 130 years, soon after its introduction to the UK. 190 herbarium specimens were studied from the herbaria at National Museum Wales, the Royal Botanic Garden, Kew and the Natural History Museum. For present-day populations, 160 specimens were collected in 2017 from various locations around South Wales. Preliminary results suggest that mean leaf area, width and length fluctuate between decades. Further investigations into stomatal density, guard cell size, flower length are ongoing. Other factors that affect changes in the characteristics of the species, such as habitat and weather were also considered in this study.

Phytotoxicity of the invasive *Hedychium coronarium* j. König (Zingiberaceae) on the germination and radicle growth of a dominant native tree species from Brazilian riparian forests

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The production and release of allelochemical compounds in the environment is one mechanism to increase the success of invasive plants. Riparian forests are important to the maintenance of ecosystem functions and biodiversity conservation, but especially vulnerable to dominant and invasive species. However, little is known about the impact of invasive plants on native tree species from these habitats. Here, we tested the influence of the invasive *Hedychium coronarium* J. Koënig (Zingiberaceae) oil, extracted from the rhizomes, on the speed germination index, percentage

of germination and on the radicle growth of *Sesbania virgata* (Cav.) (Fabaceae). This native tree species is dominant in Brazilian wetlands and its seeds produce allelochemicals that can inhibit the establishment of other native and invasive plants. Germination bioassays were performed using essential oil concentrations of 0.01%, 0.1% and 1%, distillate water and Tween 80 (1%) as controls. None of the treatments inhibited the percentage of germination of *S. virgata* (Kruskal-Wallis test, KW = 4.000, df = 4, p = 0.406), but the 1% concentration reduced the germination speed (KW = 13.174, df = 4, p <0.001) and the radicle growth (KW = 45.666, df = 4, p <0.001). These results demonstrate that the phytotoxicity of *H. coronarium* chemical compounds may have a negative influence on the performance of a strong native competitor which can negatively affect the local regeneration and the succession process on invaded riparian areas.

Impact of the EU Guideline on zoological parks and how zoos can be used to educate general public about invasive species: Vienna Zoo (Tiergarten Schönbrunn)

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With the implementation of the Invasive Species EU Guideline (1143/2014) a big step was made to protect native wildlife. However, the execution inaccuracy of the guideline raises more questions on how to deal with existing and potential affected species in zoos than it answers. As a result the Austrian government has still not established any management plans. Article 8 of the guideline clearly allows ex-situ conservation in zoos, but the lack of expertise and the absence of clear structures and regulations make it hard for all involved to follow the guideline. Zoos not only struggle to receive permits to keep or transport existing invasive species, but are publically condemned when drawing the conclusions and humanly cull the individuals as the law states.

Vienna Zoo has a long tradition of educating people about animals. Only a few years after its foundation in 1752, adults and school children visited to experience and learn about exotic and native animals. More than 265 years later education is the main part of its mission and is anchored in the EU Zoo, WAZA and EAZA guidelines. Complimentary education programs at Vienna Zoo alone are used by nearly 1,300 school classes with about 26,500 participants annually. To raise awareness about conservation including invasive species among as many people as possible, Vienna Zoo (2.3 million visitors yearly) applies different methods as e.g. specific information boards, daily interpretations, various guided tours, special information days, conservation days, and many more. Especially overtaxed pet owners are looking for information and guidance and it is particularly important to reach them before they release invasive species into the wild due to the lack of direction. In this context zoos can not only make people aware of the problems of invasive species, but can provide and display various possible solutions.

Presence and distribution of invasive alien plant species of Union concern in Italy: Insights into the national application of the Regulation (EU) No. 1143/2014

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The Regulation (EU) No. 1143/2014 on invasive alien species entered into force on 1 January 2015, fulfilling Action 16 of Target 5 of the EU 2020 Biodiversity Strategy. It provides with a set of measures to be implemented across the European Union, in relation to species included on a list of Invasive Alien Species of Union concern. Consequently, the Commission Implementing Regulation (EU) 2016/1141 and (EU) 2017/1263, respectively, established and amended a list of 49 invasive alien species, which will be updated regularly, in accordance with Article 4(2) of the Regulation. Within 18 months after the adoption of the Union list, Member States shall establish a surveillance system that should collect and record data on the occurrence in the environment of invasive alien species by surveying and monitoring or other procedures.

A total of 33 out of 49 Invasive Alien Species of Union concern, including 14 plants, are present in Italy. As requested by the Italian Ministry of Environment, under the supervision of ISPRA, a large task force of Botanists from the *Società Botanica Italiana* dealt with the inventory and geographical distribution for all the invasive alien plants of Union concern on the Italian territory.

We present herewith the specific aims of this project, the applied methodology and the results of the survey. As a result, it seems feasible to effectively prevent the introduction of those few alien plant species not yet present in Italy and to eradicate those found at an early stage of invasion. On the other hand, a significant number of alien plants of Union concern, such as *Elodea nuttallii* (Planch.) H.St.John and *Cenchrus setaceus* (Forssk.) Morrone (☐ *Pennisetum setaceum* (Forssk.) Chiov.) are already quite widespread throughout the Country. Those widespread species will require the set-up of dedicated and very likely costly management measures.

Pueraria lobata in Europe: current and future potential spread of an alien species of union concern

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Pueraria lobata (Fabaceae), so-called "kudzu", is one of the 100 worst invasive species in the world. It is a perennial, semi-woody climber and crawling vine native to Asia and some western Pacific Islands. Kudzu has been exported all over the world with dietary, pharmaceutical, foraging, ornamental and habitat-restoring purposes. The downside is that kudzu, when uncontrolled, can be highly destructive for ecosystems and human activities. Its invasive range includes all continents, but the severity of its impact varies among countries. In USA, kudzu is the most devastating alien plant. In Europe, kudzu is considered a serious pest in Switzerland and Italy. The widest "hotspot" of presence of kudzu lies at the border between Italy and Switzerland (Maggiore and Lugano lakes). Kudzu is a species of European Union concern (Regulation (EU) No. 1143/2014), and Member Countries have the obligation to prevent its spread, to manage and, if possible, to eradicate it.

In order to understand the potential spread of kudzu in Europe and contribute to an effective management of the species, we investigated the climatic niche dynamics in its invasive range (niche expansion, stability and unfilling) and modelled its current and future potential distribution (Maxent). Analysis in the environmental space highlighted a low niche overlap between native and all invasive ranges, in line with high unfilling values, suggesting that kudzu could fill a widest niche. Currently niche filling seems to be affected by dispersal mechanism (natural and human mediated) and residence time. Also preliminary results in geographical space showed that kudzu occurs only in a limited part of its European present potential range. Future projections suggest a further potential expansion of kudzu throughout Europe. Then, in the future the role of Regulation (EU) No. 1143/2014, weakening the main dispersal vectors, will be fundamental in reducing its spreading favoured by climate change.

An assessment of the impacts of invasive alien plants on habitats in Italy: first results from the ISPRA-SISV convention

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The EU Regulation 1143/2014 sets out rules to tackle the adverse impacts on biodiversity of invasive alien species within the Union. The regulation, *inter alia*, includes the possibility for the member state to establish a national list of invasive alien species. Toward the aim of a correct and effective implementation of legislation regarding the management of alien species on the national territory the Ministry of Environment, under the supervision of ISPRA, developed a large survey, conducted by botanist members of the Italian Society of Vegetation Science (SISV) and involving about 50 contributors from all Italian regions. The survey was aimed to the assessment of the impacts of invasive alien plants on habitats and vegetation in Italy, including information concerning the main mechanisms of impact and impact outcomes, given at the regional scale. The resulted data allows to pinpoint the current state of art concerning this topic, to highlight the main knowledge gaps and provide future hot topics to be further investigate.

Particularly the survey covered more than 230 species considered to be invasive in Italy, underlining competition as the main impact mechanism. Particularly *Ailanthus altissima* (Mill.) Swingle was assessed to exert impacts in all Italian regions, while other 20 species were reported to exert impacts on up to ten regions. As to the habitat worthy of conservation 83 out of 132 Habitat listed in the "Habitats" Directive (Dir. 92/43/EEC) are subjected to some degree of impact by alien plants. Forests resulted the most threatened habitat, followed by freshwater habitats, marine coastal habitats, dunal ecosystems and open grasslands.

Rapid responses against invasive species on islands: lessons from the introduced Barbary ground squirrels in the Canary Islands

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Despite efforts to combat invasive species, further measures are still required to prevent their arrival and translocation, especially into island ecosystems, one of the most important biodiversity hotspots. Although governments worldwide have already set up full protocols to control alien species, the European outermost regions are still far from implementing effective prevention or rapid response procedures. The numerous translocations of the invasive Barbary ground squirrel (Atlantoxerus getulus) between the Canary Islands illustrate this situation. From 1996 to 2016, at least 2.1 individuals per year have been moved from Fuerteventura to other islands. If movements of these medium-sized vertebrates are taking place regularly, the number of smaller species transported within the archipelago could be much greater. We argue that it is urgent to implement stricter strategies in most of these remote biodiversity-rich islands to carry out effective invasive species prevention, early detection and rapid response to minimize their impact on native biodiversity

Analysing consistency of habitat suitability models for invasive plants across different sample sizes and spatial resolutions of data

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Chorological data on invasive plants in Croatia are quite heterogeneous with respect to their spatial accuracy. Habitat suitability models are nowadays widely used for assessing the potential spread of invasive species. However, spatial precision and/or resolution can significantly influence the model output. Here, we have analysed consistency of habitat suitability models across different sample sizes and spatial resolutions of species (dependent variables) and environmental (independent variables) data. Data on 15 invasive species, and 5 natives that share similar environmental envelopes as a control were used, as well as 15 environmental variables (climatic, topographic, proxies for disturbance) for habitat suitability models development using MaxEnt. For species with sufficient amount of data within different spatial resolution classes (e.g. *Erigeron anuus* (L.) Pers., *Robinia pseudoacacia* L.), models were developed across different spatial resolution, using environmental data on three spatial resolutions (300-meters, 1-km and 5-km), separately. Using a conservative threshold value of 0.5, we reclassified MaxEnt models output grids into habitat suitability maps, and compared consistencies (i.e. overlapping) of their spatial coverage across combinations of different data sets. In general, models developed with lower spatial resolution of species data, smallest sample size and lower spatial resolution of environmental data tends to predict larger areas as suitable habitats. Habitat suitability models were more consistent with respect to spatial precision of chorological data, then to their sample sizes. Higher spatial resolution of the environmental data (i.e. 300-meters grids) yielded results that are more consistent across different combinations of sample size and spatial precision of species data, than those with 1-km and 5-km environmental grids. Obtained results suggests that we should focus more on spatial precision of our data then sample size in order to decrease uncertainty of our predictive models, and conclusions we yield based on those models.

Towards global scenarios of biological invasions in the 21st century

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Biological invasions substantially affect ecosystems, ecosystem services and human livelihoods alike, and the impacts of species invasions will rise in the future as the rate of establishment of alien species has increased strongly during the last decades with no sign of saturation. Further, they drive species extinctions worldwide and especially in phylogenetically rich regions such as island systems that contribute strongly to global biodiversity, causing high mitigation and adaptation costs.

Consequently, different international initiatives and agreements such as the United Nations Sustainable Development Goals (SDG), the Convention on Biological Diversity (CBD) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) consider the assessment and control of biological invasions as a crucial step to sustain global biodiversity, ecosystem services and human livelihoods. The rising numbers and impacts of alien species, the de facto irreversibility and often limited manageability of alien species introductions, and the substantial time lags associated with different stages of biological invasions underpin the need for understanding the long-term trajectories – scenarios - of biological invasions.

Here, we present a conceptual framework and a roadmap for the development of scenarios and models on how alien species richness and impact might change in the 21st century. This includes the establishment of qualitative scenario narratives and the quantification of pressures and impacts for these narratives. The recent advances in data availability of biological invasions for the first time allows addressing this task appropriately. We believe that the biological invasion scenarios concept proposed here provides an important contribution for understanding – and pro-actively managing – the future of biological invasions.

Cost-benefit analysis for control of invasive greater Canada goose *Branta canadensis* in Flanders (northern Belgium)

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Sound decisions on control actions for established invasive alien species (IAS) require information on ecological as well as socio-economic impact of the species and of their management. We apply a bio-economic model in a cost-benefit analysis framework to greater Canada goose *Branta canadensis*, an IAS with documented social, economic and ecological impacts in Belgium. We compared a business as usual (BAU) scenario which involved non-coordinated hunting and egg destruction with an enhanced scenario based on a continuation of these activities but supplemented with coordinated capture of moulting birds. To assess population growth under the BAU scenario we fitted a logistic growth model to the observed pre-moult capture population. Projected damage costs included water eutrophication and damage to cultivated grasslands and were calculated for all scenarios. Management costs of the moult captures were based on a representative average of the actual cost of planning and executing moult captures. Comparing the scenarios with different capture rates, different costs for eutrophication and various discount rates, showed avoided damage costs by 2050 were in the range of 21.15 M€ to 45.82 M€ under the moult capture scenario. The lowest value for the avoided costs applied to the scenario where we lowered the capture rate by 10%. The highest value occurred in the scenario where we lowered the real discount rate from 4% to 2.5%. The reduction in damage costs always outweighed the additional management costs of moult captures. Therefore, additional coordinated moult captures could be applied to limit the negative economic impact of greater Canada goose at a regional scale.

Reyns N, Casaer J, De Smet L, Devos K, Huysentruyt F, Robertson PA, Verbeke T, Adriaens T. (2018) Cost-benefit analysis for invasive species control: the case of greater Canada goose *Branta canadensis* in Flanders (northern Belgium) PeerJ6:e4283 https://doi.org/10.7717/peerj.4283

Improving our understanding and management of biological invasions by engaging with the social dimensions in the field

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Research in invasion science has exploded over the last three decades, but contributions on the social and human aspects lag behind those from the ecological domain. Humans and biological invasions are closely coupled and further studies on the social domain is essential for improving our understanding of biological invasions and for facilitating more effective management and policy formulation.

This presentation discusses key developments covered in contributions to a special issue in the *Journal of Environmental Management* on the topic of "Social dimensions in invasion science" that will be published late in 2018. The talk focusses on (1) impacts of invasive species on society - including aspects on the positive and negative impacts of invasive species on ecosystem services, human well-being, local livelihoods, and social-ecological transformation; (2) actions and understanding relating to the factors that influence people's perceptions, knowledge, awareness, behaviour and practices surrounding invasive species; and (3) social aspects of management, such as stakeholder engagement, collaboration, prioritisation and conflicts-of-interest. Guidelines are proposed to improve the uptake and contributions from the social sciences in the future and also how contributions from this domain can aid more effective management of invasive alien species.

Prevention, monitoring and management of biological invasions in the Port of Gijon, Bay of Biscay.

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Invasions of marine non-indigenous species (NIS) are one of the greatest threats to biodiversity worldwide. Ports are main gates of exotic marine biota worldwide, principally through biofouling and ballast water. Since management is more difficult in late than in early invasion stages, new strategies are needed for effective prevention and early detection of nuisance organisms. The main objective of this work is directly related to reinforce environmental safety policies in industrial ports. This information

is crucial for the development of a protocol for the prevention of unwanted introduction of alien species as a result of industrial activity seaports. Nine sampling points from four different areas were sampled within Port of Gijon in 2016 and 2017 as well as 3 different boats docked in the port. We genetically identified more than 40 different green, brown and red seaweeds and 522 marine invertebrates belonging to 85 different species. We found 5% to 17% of exotics species and an increase in the number of NIS from 2016 to 2017. Furthermore, new NIS not previously reported or found in our sampling in port structures were found adhered in the surface of vessels docked in the port. This work allows to identify and assess the risk of NIS introduction through a particular gateway (port and vessels) and timely detect a new incursion, in order to enable efficient response measures.

Residence time will tell: temporal dynamics of invader performance revealed by abiotic and biotic dissimilarity

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Plant invasions are a major threat to biodiversity by decreasing abundance and diversity of native species. After the introduction of a new species, eco-evolutionary processes may lead to rapid changes in the invader and the invaded community. However, temporal dynamics of these processes have been greatly neglected in studies on invasion success, although invader performance depends on its residence time in a new area. Particularly, we hypothesize that increasing biotic resistance of the native community will counteract positive effects of local abiotic adaptation, resulting in a unimodal response of invader performance with residence time. Based on a species-for-time approach, we investigated performance of 48 annual Asteraceae along an alien-native continuum (neophytes, archaeophytes, natives), thereby covering a wide range of residence times in Germany. In a common garden experiment with 1250 mesocosms, we compared establishment success and fitness with or without

native communities over two years. We determined abiotic dissimilarity (temperature distance) between the native and invaded range and measured biotic dissimilarity (functional trait distance) between the invader and native communities. We used two "native" communities, a Central European and a congeneric North American, the latter never co-existed with the focal species, to disentangle temporal from species-specific effects. In the Central European community, establishment, growth, and reproduction decreased with abiotic dissimilarity, whereas increasing biotic dissimilarity led to higher establishment rates and fitness. These two counteracting effects were stronger for Asteraceae with short compared to long residence times and thus resulted in our hypothesized unimodal performance pattern along the alien-native continuum. As additional support for such temporal dynamics, we never found biotic dissimilarity to interact with German residence time in the North American community. Our results, which showed that initial invader advantages are a temporary phenomenon, will help understanding the mechanisms behind eco-evolutionary constraints of population growth and spread of invaders.

Exporting skies and stars: extensive transportation of skylarks and starlings within New Zealand in late 19th century

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New Zealand is now home to 34 alien bird species, but many more were introduced in the 19th century and failed to establish. As most of these introductions were deliberate and documented in detail by the acclimatisation societies responsible for them, New Zealand bird invasions are often used as a model system to unravel what determines the outcome of introduction events, with special emphasis on the role of propagule pressure. However, the credibility of these data was challenged recently, as different authors have reported different numbers of liberated birds. This discrepancy has several causes. For introductions of European skylark (*Alauda arvensis*) and starling (*Sturnus vulgaris*) the most important issue is that not all liberated birds were imported from overseas. In fact, the majority were redistributed within New Zealand from regions where they had already established. This may have implications for analyses of propagule pressure. The birds that were retransported were not a random subset but came from populations that were already pre-filtered. As a result, a lower number may have been needed to establish populations in recipient regions. Some regions, in which the acclimatisation activities started later, relied principally only on such "second-hand" birds, likely for reasons of cost.

Genetic variation of the invasive *Ambrosia psilostachya* (Asteraceae) in Europe

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Western Ragweed (*Ambrosia psilostachya* DC.) is native to North America and naturalized to Europe. This perennial species is reproducing highly clonal by root sprouts which enable the species invading a wide range of climatic regions in Europe – from southern Italy to Scandinavia and Scotland, and from Southwestern Spain to Russia. However, the process and patterns of spreading, the mutual relationship of the various populations as well as the structure of the invasive populations is still unexplored.

Therefore, we sampled more than 60 populations throughout Europe and analysed genetic diversity and population genetic structure based on 15 microsatellite loci.

Preliminary results indicate clear genetic differentiation among populations of *A. psilostachya*. Allelic richness (Na) within populations varied between 3.27 and 5.0. With a populational Fst-value of 0.11 the genetic differentiation among populations was moderate, whereas the genetic diversity within populations, based on Shannon-Index (I) was very high. This was confirmed by the results of the non- hierachical AMOVA indicating that approx. 81 % of genetic variation lay within populations. We found significant deviation from Hardy-Weinberg-Equilibrium indicating high homozygosity levels. Populations originating from the same region showed reduced genetic distance compared to populations from remote regions. Significant clonal structures were detected from genetic data in more than 50 % of all populations studied.

Golden jackal (Canis aureus) in Europe: embraced enrichment of biodiversity or unwanted alien species?

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Ongoing global change is bringing about shifts in species distributions that include both the spread of populations of invading species and range expansions or contractions of native biota, most often in response to increasing temperatures that allow organisms to colonize areas previously unsuitable. Examples cover a range of plants and animals; one species that has received much attention because of its range expansion in recent decades is the golden jackal (*Canis aureus*). In the Czech Republic, we observed the first living individual of golden jackal in 2015 ~40 km east of Prague; up to then several individuals have been recorded but all of them were either shot or killed by a vehicle. The observed animal and its behaviour was documented in detail by camera traps set up for research of carnivore diversity in different habitats in the study area. It was first photographed on 19 June 2015, and in total there were 57 records made by 12 traps until 24 March 2016. Forty-nine of the 57 records were made in a shrubby grassland over an area of ~100 ha, 39% of sightings were during the day and 61% in the night. There were two distinct peaks in the circadian activity of the animal, from 4 to 10 a.m., and from 6 p.m. to midnight. This observation represents the first evidence of a persisting occurrence in Europe of the same overwintering golden jackal individual northwest of Hungarian-Austrian border where the population has been known to reproduce. Additional observation from 2017 indicate that golden jackal has reproduced in the area where we made our observation. The results are discussed with respect to the status of golden jackal in Europe; the species is embraced as enrichment of biodiversity in some countries while in others it is considered as invasive alien species.

Climatic niche shifts in a coastal invaded plant community in Southern Spain

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The climatic niche of invasive species in their native range determines their success in new areas. It has been shown that invasive species may occupy different climatic niches from native species. Nevertheless, they could also compete with native species leading to changes in the structure of the community. We explore the changes in the climatic space of a plant community after the arrival of invasive species, a key issue regarding the vulnerability of the community to climate change (e.g. if the aggregated community climatic niche is reduced). We expect that the invasive species will occupy a wider climatic range than the native species, causing also a potential negative effect on the breadth of the community climatic niche. The community under study was located in the southwestern coast of Spain, and consisted of 106 species native to Europe and 4 non-native species. Data on the presences of the species, necessary to know their climatic niche breadths, were collected at two spatial scales, plot scale -in 2191 paired plots established during an intensive fieldwork- and global scale -gathered from GBIF-. Data on 19 bioclimatic variables, solar radiation and wind speed were downloaded from WorldClim2.0. The original database was filtered to exclude records without coordinates and to reduce spatial autocorrelation. In addition, Pearson's correlation coefficients and a VIF analysis were carried out to avoid multi-collinearity among variables. Using ordination techniques, we assessed niche changes at both spatial scales by means of overlap, expansion and stability indices. The results help prevent future invasions by detecting the invasive species that cause a greater impact on the resilience of the community and the native species that are more vulnerable to extinction.

Distribution models for the invasive mud snail *Potamopyrgus antipodarum:* the role of the scale of analysis

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Invasive species generate important disruptions in aquatic ecosystems and have become a great concern in nature conservation. To manage invasive species efficiently, we need tools to optimize the allocation of resources for species prevention and management. Thus, there is a growing interest in establishing the suitable areas for the expansion of invasive species, as this knowledge helps establish early-alert programs. Some aquatic invertebrates such as the New Zealand mud snail (*Potampyrgus antipodarum*), are not well known despite the impact they generate in many ecosystems. *P. antipodarum* is an aquatic gastropod mollusc which has spread in many parts of the world. It was found in Spain at the beginning of the 20th century and now it is included in the current Spanish catalogue of invasive alien species. This implies the need for a better understanding of any aspect related to its possible expansion and impacts. Here we used Species Distribution Models (SDMs) to identify the most suitable areas and determine the environmental conditions that favour the presence of *P. antipodarum* at two scales, i.e. the Iberian Peninsula and drainage basin. This information will contribute to the prevention and early detection in fluvial stretches with a high risk of invasion and expansion of this snail.

Marine exotic isopods from the Iberian Peninsula: new arrivals and patterns of introduction

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Effective management of marine bioinvasions starts with prevention, communication among the scientific community and comprehensive updated data on distribution range of exotic species. Despite being a hotspot for introduction due to numerous shipping routes converging at the Strait of Gibraltar, knowledge of marine exotics in the Iberian Peninsula is scarce, especially of abundant but small-size and taxonomically challenging taxa such as the Order Isopoda. To fill this gap, we conducted several sampling surveys in 44 marinas and provide the first comprehensive study of marine exotic isopods from the Iberian Peninsula, southern side of the Strait of Gibraltar (northern Africa) and Balearic Islands. Exotic species included *Ianiropsis serricaudis* (first record for the Iberian Peninsula and Lusitanian marine province), *Paracerceis sculpta* (first record for the Alboran Sea ecoregion), *Paradella dianae*, *Paranthura japonica* (earliest record for the Iberian Peninsula) and *Sphaeroma walkeri*. We report an expansion in the distribution range of all species, especially at the Strait of Gibraltar and nearby areas. *Ianiropsis serricaudis* and *Paranthura japonica* are polyvectic, with shellfish trade and recreational boating being most probable vectors for their introduction and secondary spread. The subsequent finding of the studied species in additional marinas over the years points at recreational boating as vector and indicate a future spread. We call for attention to reduce lags in detection and report of small-size exotics, which usually remain overlooked or underestimated until the invasion process is at advanced stage.

Key words: Exotic Isopoda, Marine bioinvasions, Neglected taxa, Recreational boating, Iberian Peninsula, Strait of Gibraltar

Application of chemical risk assessment in invasive species research: the role of pollution as a modulator of invasion success

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The interactive effects of myrad of chemicals in aquatic environments on invasion rates and success are currently poorly understood. There is little empirical evidence of long-term effects of contaminants at environmental concentrations on behavioral and physiological responses in key aquatic invaders such as the signal crayfish. We applied chemical risk assessment approaches and tools to study potential impacts of contaminants on aquatic invaders. We applied the adverse outcome pathway framework (AOP) that organizes knowledge about mechanistic relationships between initial chemical-biological interactions (e.g. serotonin transporter inhibition), intermediary key events (e.g. increased serotonin receptor stimulation), and adverse outcomes (e.g. changes in activity or aggression). We used the AOP framework to prioritize chemicals of emerging concern (CEC) to further test for their potential effects on behavioral traits (aggression) in invasive signal crayfish.

For this, we analyzed 34 water samples from 13 sites along the whole Sava River section in Croatia for the presence of 549 organic contaminants (OCs). Out of the 184 OCs detected in our samples, we querried those with modes of action related to serotonergic system as it has well described connections with crayfish behavior/aggression. By using available databases (ToxCast), we identified those chemicals which target either serotonine receptors or serotonine transporters. We further predicted the expected biological activity of the identified chemicals based on exposure-activity ratios (EARs), which integrate chemical occurence with toxicity data from the ToxCast database. For the final prioritization list, the results of all querries were overlaped with ECOTOXicology knowledgebase to identify whether selected chemicals have established effects on crayfsh/crustacean behavior. Based on these analyses, we identified citalopram, an antidepressant drug, and BPA, used in polycarbonate plastics production, for further testing on behavioral responses in key aquatic invaders. We discuss the opportunities and challenges for using ecotoxicological tools in invasion biology research.

Molecular diversity of *Phalaris arundinacea* populations in relation to river regulation (Merkys case study)

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Within Baltic States it is unknown about genetic diversity of populations of *Phalaris arundinacea* and how they might be affected by anthropogenic activities such as river regulation. Within 50s-60s of the former century Merkys river basin underwent severe anthropogenic regulations. It is the largest protected area of Lithuania. The objectives of the study were to compare SSR loci based molecular parameters of populations from natural river fragments with populations from regulated river parts. The index of Nei's gene diversity was not very high. Selected for the study populations have bigger part of the genetic diversity within,

rather than among populations. Upstream part of the Merkys basin populations had lower gene diversity compared to downstream part. The mean number of polymorphic SSR loci was lower for populations from regulated parts of the river basin compared to natural ones. Main principle coordinate analysis revealed populations of regulated rivers at marginal positions. Bayesian clustering suggested that current populations are admixtures of at least three formerly distinct genetic groups. Structure analysis allowed geographical subdivision of populations into upper part of the river basin and lower part also separation of populations belonging to natural parts of the river basin and two out of four populations from regulated parts. Pilot study suggests that river regulation might be impaired in changes of genetic diversity of *P. arundinacea* populations. This work was carried out within framework of National Program titled under Sustainability of Agro-, Forest and Water Ecosystems (Project No. SIT-2/2015).

Modelling *Acacia saligna* in Mediterranean islands, using high resolution topographic and climatic data

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Invasion by non-native tree species is an environmental challenge requiring adequate predictive tools to assess invasion dynamics. Thus, the identification of the areas exposed to the risk of invasion represents a priority for management. The frequent scale discrepancy between informative thematic layers might limit modeling and invasion management. This study aims to assess species distribution models (SDMs) with high-resolution thematic layers (HRTLs) for invasion mapping for the invasive tree *Acacia saligna*. SDMs at two scales were developed and resulting niches and spatial distributions were compared. At the larger scale (Mediterranean bioclimatic regions) Worldclim data and presence records from the GBIF database and literature were used. Such model integrates over all currently occupied

environmental conditions, for native and non-native populations of *A. saligna*. At the local scale, climate data was supplemented with high resolution topographic variables of 10 m resolution. This local model considered the specific conditions of the island of Sardinia and is expected to be more informative about local-scale habitat and micro-climate requirements. Appropriate geostatistical techniques allow the correct interpolation of thermal data considering latitude, distance from the sea, distance from the valley floor, altitude and exposure of the slope of the land. We present the range of projected distributions that result from the effects of choice of variables at different scales and climate models. We argue that a combination of models at different scale may help to overcome their limitations, namely a coarse-spatial resolution at global scale, and a low current range filling and a strong influence of the available habitat and microclimate on the modeled niche at the local scale. Fine-scale spatial-explicit estimation of invasion success combining SDM predictions with high resolution invasion mapping, might mitigate scale discrepancy between predictions of invasion dynamics and help conservation decision making for invasion management.

Australia 2.0? The beginning of an invasion and the preliminary assessment of the factors influencing its spread

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An invasive population of the Asian common toad (*Duttaphrynus melanostictus*) was reported in 2014 in Toamasina (Eastern Madagascar), where it was accidentally introduced a few years earlier and thrived taking advantage of the suitable climate and its marked adaptive natural history traits. This species is toxic, has a varied opportunistic diet, and it can lay up to 10000 eggs per breeding event. Due to its ecological similarities with the Cane toad (*Rhynella marina*) in Australia, fears arose that this could evolve in a similar ecological disaster. The most dreaded negative effects of this invasion include the predation of the toxic toads by naive predators, and negative interactions with native amphibians species (i.e.,including the transmission of pathogens, competition for feeding resources and breeding sites).

In this study we document the expansion of the distribution range of the invasive population of the Asian common toad in Madagascar, calculating the invasion spreading rate, and estimating its abundances across different habitats. Updates of the distribution range revealed a five-fold increase of the invaded area in the last three years, and a two-fold increase of the spread rate, showing a significant shift of the invasion towards North-West, most probably because of the absence of ecological barriers. To estimate species abundances we used N-mixture models based on repeated counts data collected at six sites (both within Toamasina and in its countryside). Our results showed that the species has a patchy distribution and an estimated average abundance of 184 toads ha^{-1} (95% CI, 132–263). The use of N-mixture models also enabled to highlight that human disturbance have a positive effect on toad abundances across different habitats.

Characterization of the bacteria community of the invasive Asian Toad (*Duttaphrynus melanostictus*) in Madagascar and comparison with a native species

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Biological invasions can pose multiple threats to native species through competition for natural resources, predation or transmission of diseases, among others. The success of invasive species has been attributed to habitat plasticity, high reproduction rates or generalist life traits. While there have been several studies assessing the beneficial role of the bacteria community aiding in distinct physiological traits in amphibian hosts (e.g., improving digestion, protecting against diseases), the potential benefits of this community within an invasion scenario remains widely unexplored. In Madagascar, the Asian common toad (*Duttaphrynus melanostictus*) has recently (2010) been accidentally introduced and is now facing a fast expansion. The current known distribution is centered in humanized areas around the sea-port city of Toamasina, and recent studies suggest that the species is suitable to colonize large portion of the country. Given the high level of endemism among amphibians it is worth investigating how the amphibian-associates bacteria of the expanding toad population are interacting with the ones of the native communities. We characterized the bacterial community of *D. melanostictus* from three different sites and compared their composition with the one of a widespread native and syntopic species (*Ptychadena mascareniensis*). The specific aims were to i) characterize the bacteria community from the skin and gut of the invasive and native species; ii) understand if the communities are changing across different sampling sites representing different stages of the invasion (where the invasive species first arrived, where the population recently established and where the invasive species is expanding); iii) assess if the older population of *D. melanostictus* has a bacteria community more similar to the one of the sympatric *P. mascareniensis*. Preliminary data suggest that skin and gut bacteria communities differ between the invasive and native species, with site collection also affecting bacteria diversity in both species.

A biosecurity hazard perception assessment: the effect of training on the ability to identify biosecurity hazards

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Preventing the spread of invasive species in the environment is imperative to limiting their environmental, economic and social impact. Vectors such as equipment and transport can mediate the accidental spread of invasive species. Biosecurity protocols aims to remove invasives from vectors and therefore reduce the risk of potential spread. However, the question remains, are fieldworkers able to identify these important vectors (here termed 'biosecurity hazards') and does training improve their 'hazard perception'? As a scientific approach, hazard perception is well utilised in driving safety assessments to assess an individual ability to identify clear hazards and therefore mitigate against the risk. The ability of an individual to identify hazards does not necessarily translate into mitigation action, in this case, employing biosecurity, but the inability to identify hazards is likely to result in no action taken, therefore creating a biosecurity risk. This research aimed to identify the impact of training on participants' ability to identify biosecurity hazards and if certain hazards were less frequently identified than others. University students whose studies likely involve fieldwork, were recruited and completed a biosecurity hazard assessment before and immediately after biosecurity training. The biosecurity hazard assessment consisted of still-images of different environmental scenes with a range of 'biosecurity hazards' present, to be identified by participants. Certain hazards were frequently not identified, illustrating the need to highlight these vectors in future training and communications. Training enhanced the ability of participants to detect biosecurity hazards, as did familiarity of working in most of the environments. This approach could be used with a range of stakeholders and can create an informed method of assessing an individual's understanding of biosecurity vectors as well as potentially being transferrable to training itself. Further work aims to assess if participants' ability to identify biosecurity hazards is retained after a prolonged period after training.

Dynamics of alien and native understorey plants following variable retention harvesting in *Nothofagus* temperate forests

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Disturbances have frequently been shown to increase invasibility of communities by alien plants. Logging, the most common and severe anthropogenic disturbance in forests, enhances resource availability for alien plants. However, it is unclear whether and to which extant these initial changes are permanent or just temporary. Using annually surveyed permanent plots, we analyzed temporal changes of understory composition of Patagonian *Nothofagus pumilio* forests during 12 years under three site conditions created by variable retention harvesting: retained forest patches of 30m radius in a density of 1 patch ha^{-1} (AR), edges of such retained patches (DRI), retained dispersed single trees (DR); and old-growth primary forests as control (PF). Most interesting trends include that (a) AR supported a high cover of forest species in the top layer that, however, declined during the 12 years and increasing alien species became dominant at 9 years after harvesting (YAH), (b) DR and DRI supported much higher cover of aliens in the top layer and aliens became dominant at 2 to 3 YAH, but started to decline after a maximum at 8 YAH; (c) in the bottom layer, the cover of forest species was high at the beginning but aliens surpassed them in DR and DRI after 4 and 7 years, respectively. Tree regeneration had significant relationships with understory dynamics, i.e. (a) in DR, a negative relationship with alien species cover and a positive relationship with native colonizers from other habitats; (b) in DR and in DRI negative relationships with alien species richness; (c) in DRI, a positive relationship with native colonizers (cover and richness). We conclude that alien plants invade Patagonian forests after logging, but decline with succession and increasing tree regeneration. Our results highlight the role of harvesting on facilitating plant invasions in southern temperate forests, and how this depends on treatments.

Unconventional seed lots as contaminant pathway

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The accidental introduction of alien plants through contaminated seed lots, can cause economic losses in agriculture and forestry and be the starting phase for the invasion of natural habitats. The knowledge of the pathways of introduction is important to apply precautionary methods and tailored strategies against invasive plant species. Among them, the seed contaminants pathway is among the primary sources of accidental introductions for terrestrial plant species. While seed lots for agricultural crops are usually carefully controlled, the trade of many other types of seeds is less regulated. This study aims to evaluate the risk of "unconventional" commercial seed lot trade as a pathway for invasive alien plant species in Sardinia (Italy) identifying which species can be introduced and assessing their germination and viability. A random sample of 39 seed packages were screened to check the presence and the diversity of contaminants. The sample was composed by novel forage crops under testing (Fc), flower mixtures (Fm), recreational lawn mixtures (Lm) and pet feeds (Pf). Germination and viability were analyzed, on the seed commodity of Pf, following conditions retrieved from Seed Information Database. Number of seedlings, the day of scoring and presence of molds were recorded. Importantly, we found among the contaminants *Amaranthus* sp.pl. and *Echinochloa oryzoides*, i.e., respectively, a group of agricultural alien weed species and one invasive weeds in rice fields in Sardinia. Our results showed that a considerable quantity of imported and traded seed commodities are a source of associated contaminants, increasing the risk of invasive plant entry and establishment in Sardinia.

Genetic diversity of Lithuanian populations of *Impatiens parviflora* DC. at amplified fragment length polymorphism loci

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Impatiens parviflora is an invasive annual herbaceous plant species which was introduced to Europe from Central Asia. In Lithuania this species is attributed to the most rapidly spreading and highly invasive alien plants. The objective of the study was to evaluate molecular diversity of Lithuanian populations of *I. parviflora* according to amplified fragment length polymorphism (AFLP) markers. Twenty one Lithuanian population of *I. parviflora* was chosen to cover all the territory of the country. Five *I. parviflora* individuals from each sampling site, in total 105 individuals, were chosen for AFLP analyses by capillary electrophoresis performed using ABI 3130 genetic analyser. Eight amplified fragment length polymorphism primer combinations were selected. Molecular studies revealed much higher genetic diversity within populations than among populations. Among studied populations the highest index of Nei's gene diversity and percentage of polymorphic loci of *I. parviflora* were observed in the Central part of Lithuania and the same parameters were the lowest in the Western part of the country. The pairs of populations which were the most distinct according to the genetic distances were not the most geographically distant populations. AFLP makers based UPGMA dendrogram and principal coordinate analyses did not clearly differentiate *I. parviflora* populations into groups according to the geographic location. Bayesian analysis of AFLP data suggested that populations split into thirteen clusters. Based on the obtained results, spread of *I. parvilfora* was occurring as very complex process of multiple introductions. High genetic diversity in the Central and the Eastern parts of Lithuania suggest that introduction of *I. parviflora* might have happened firstly in these regions and later species has spread into the other parts of the country.

Tracking the occurrences of invasive and non-indigenous fishes in the eastern Adriatic sea: which methods yield best results?

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There is a growing discussion on the means of detection of invasive fish species in the marine realm, especially in the Mediterranean Sea. It seems that regular fish sampling activities are not as adequate as citizen science and similar activities such as Local Ecological Knowledge surveys. Adriatic sea, being the northernmost and coldest part of the Mediterranean Sea, still shows resilience toward significant impact of invasive species and such species are still very rare. However, there is always a possibility of sudden outbursts of such species and keeping track of their occurrence is essential. To tackle this issue, we use all possible means to get information about their occurrence and distribution extensions. Here we present the outcomes of a decade of fishery monitoring programmes, LEK survey, social-network screening and information spreading activities in the context of detection of invasive and other non-indigenous species in the eastern Adriatic Sea (Croatian coast). Our results suggest that information spreading activites and citizen science provide the best approach in detection of reliable records in the case when such species are very scarce.

Records of three fish Lessepsian migrants: an overview and status

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Fish community changes are mainly evident in the Mediterranean basin considered one of the main hotspots of marine bioinvasion on the planet. This is partly due to many fish species reached the Mediterranean Sea after the opening of the Suez Canal, while other newcomers arrived through the Gibraltar Strait. Continuous arrival of new species has been confirmed, although in less quantity, in the Adriatic Sea.

The first sighting of the *Lagocephalus sceleratus* for the Adriatic Sea was in 2012. Since then, 7 additional specimens have been recorded (TL range 478-663 mm) on the eastern Adriatic coast. One specimen (TL=587 mm) was caught on the western coast (Puglia, Italy). Although there is no strong evidence of a permanent population in the study area, these captures are an indication of an expansion of the distribution of the silver-cheeked toadfish in recent years in the Adriatic Sea. It has probably extended its distribution from populations established in the Ionian Sea.

The first record of the *Siganus luridus* was in the northern Adriatic Sea in 2010. A second record occurred in the eastern Adriatic in the very same year. Juveniles were observed for the first time in the same area in 2011. Three years later, one specimen was caught on Montenegrin coast. Last records in 2016 were in the area of southern Adriatic showing a presence of large schools of this species clearly indicating an established population in the area.

Fistularia commersonii was recorded in the Adriatic Sea for the first time in 2006 in the southern Adriatic. There are also new additional records in Montenegro in 2008 and the Island of Šipan (two juvenile specimens) in 2011. Based on additional records of juveniles, the existence of a self-sustaining population in the Adriatic is possible.

INVASIVESNET: International association for open knowledge on invasive alien species

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In a world where invasive alien species (IAS) are recognised as one of the major threats to biodiversity, leading invasion biology scientists from five continents have created INVASIVESNET: an international association for open knowledge and open data on IAS (https://www.invasivesnet.org). This new association will develop a sustainable network of networks on IAS.

The increasing ecological, social and economic impacts associated with IAS have driven the need for greater co-operation and information flow among scientists, management and the community of practice.

INVASIVESNET links networks of all interested stakeholders including scientists, citizens, international and national expert working groups and initiatives, database managers, thematic open access journals, environmental agencies, practitioners, managers, industry, non-government organisations and educational bodies. The association will promote networking opportunities, knowledge sharing and learning and provide resources via high quality communication, information, publication and education services.

Membership in INVASIVESNET is open to individuals and organizations wishing to participate in promoting the objectives of the association. The benefits of INVASIVESNET membership are:

1. Unique networking opportunities: Share your knowledge on invasive species and collaborate with scientists and environmental managers from your field of expertise or interest. 2.

2. Eligibility to support from the INVASIVESNET Open Access Publishing Fund: Associate individual members are eligible for discounted article processing charges for their publications in the official open access journals of the Association. Regular individual members are eligible to publish in these journals free of charge.

3. Unrestricted access to the INVASIVESNET webpages: Benefit from unlimited access via membership login to your INVASIVESNET Workspace. Here you can edit your personal profile or profile of your organization, find other people and organizations, and access our online network services.

4. Eligibility to place news items in INVASIVESNET media: Make your organization, its achievements and events visible on the INVASIVESNET website and via our social media platforms.

Niche conservatism as a key factor in exotic mammal global invasion

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Biological invasions are among the main causes of biodiversity decline in the Anthropocene. Invasive species eradication and control could be difficult and require great efforts, particularly for charismatic species such as many exotic mammals. They can cause local extinction and decline of native species through predation, competition and ecosystem alteration. Predicting their establishment is therefore pivotal to prevent their environmental and economic impacts. Niche conservatism, i.e. the conservation of species environmental requirements between native and exotic range, is a crucial assumption in biological invasion prediction, as current methods heavily rely on what is currently know about species ecology. To date no studies have quantified the observed niche shift in exotic mammals worldwide, a fundamental piece of information to develop forecasts of their future range expansions. We used the IUCN distribution mapping method to build a new exotic range database for the 209 currently established and free-ranging mammals worldwide. From these distribution data, IUCN native ranges and 19 Worldclim bioclimatic variables, we analysed the conservatism of exotic mammals climatic niche using the Ecospat R package. We assessed whether niche changes could be ascribed to a partial filling of the native niche in the new range, niche unfilling, or a niche expansion into novel environments. The realized climatic niche of alien mammals is globally generally conserved across species. On average, niche unfilling was predominant over niche expansion, suggesting a possible ongoing colonization in the exotic ranges. Our results therefore support the use of species distribution models based on current observed bioclimatic niche to generate predictions of mammal invasion risk in present and future climates.

DNA in a drop: Using eDNA to detect and monitor aquatic invasive species

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Environmental DNA (eDNA) is increasingly being used to monitor rare native and aquatic invasive species, as well as associated pathogens. We have developed two novel eDNA qPCR assays to detect 1: the UK endangered native crayfish (Austropotamobius pallipes), the highly invasive signal crayfish (Pacifastacus leniusculus) and their dominant pathogen, Aphanomyces astaci, (causative agent of crayfish plague) using a multiplex approach and 2: the topmouth gudgeon (Pseudorasbora parva) using high-resolution melt curve analysis (HRM) for both assays. We tested the assays by analysing field samples in areas with known presence or absence of target species. Our multiplex assay confirmed the presence of infected signal crayfish further upstream than previously detected, despite previous intensive eradication attempts in the area, and the coexistence of both species in plague free catchments. We also detected the endangered native crayfish, in spite of its very low abundance, in an area where trapping had failed. In addition, our highly sensitive novel qPCR topmouth gudgeon assay confirmed presence of this species in all four ponds which were previously eradicated and DNA was detected in a significantly greater proportion of sites (77.5%) using our qPCR assay compared to eDNA detection methods based on conventional PCR (35%) and highlights the difficulties of eradicating invasive fish. Early detection of AIS and their associated pathogens is critical for the prevention of negative impacts on the ecosystem, and our assays provide a rapid, cost effective and highly sensitive method for assessing eradication attempts and reliably estimating the distribution of both native and invasive species.

P201

Functional responses of lionfish (*Pterois volitans*): effects of prey densities under different light intensities

Monica McCard

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The lionfish invasion over the Western Atlantic and Caribbean continues to expand and with it an increasing demand to understand their foraging behaviour. Their high fecundity, growth rates, and success in varying habitats has allowed them to rapidly spread in extensive geographic and depth ranges, reaching over 300m (Darling *et al.*, 2011). Functional response (FR) methodology is used as a proxy to define impacts on prey populations (Hollings, 1965), where the curves produced show changes in predator-prey relationships, comparing how predator impacts change under different conditions. The purpose of the study was to investigate the FR and behaviour of *Pterois volitans* under different light treatments that simulate diurnal and nocturnal conditions. The greatest differences in FR came from the dark nocturnal trials in which the consumption of prey was significantly lower than during day or moonlight light simulations. Similarly, lionfish behaviour changed from actively hunting when there was light (day and moonlight) to a slow movement in the dark, feeding only over long periods of time. The results show that light levels have significant effects on the FR of *P. volitans*, suggesting that their impact at depths where no light reaches could be less than in shallow habitats. The increasing rate in which the ocean is warming along with the impacts of climate change could cause bigger problems for lionfish when used in the context of this study where feeding rates will be reduced.

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P202

Conservation detection dogs protecting Irish biodiversity - dogs saving wildlife

Helga Heylen

Conservation Dogs Ireland, Clare, Ireland

Introduced by Ireland - NEW in Europe

Conservation Dogs Ireland uses dogs to ensure the earliest possible detection of INVASIVE WEEDS. Problems spread quickly, so we prioritize species that are causing problems around Europe.

1 of the world's worst invasive weeds is 'Fallopia Japonica', Japanese Knotweed (JK).

This weed now terrorizes cities, construction sites, homes and private gardens. JK pushes through concrete and bends steel. When left unaddressed, it is a threat to ecosystems, crops, man-made structures like bridges and roads. It can wipe out the entire value of a house when it shows up in a survey.

Banks refuse mortgages on infested sites and solicitors need the official box ticked declaring the weed's presence. With JK present, a home becomes impossible to sell and insurance won't pay out. New developments are at particular risk, with excavations and moving soil being key factors in the weed's spread. A fragment in topsoil, wheels or spread underfoot is enough to create a new population as JK grows up to 10cm a day.

In Ireland, it's estimated that it causes €300M of damage annually.

No single method to eradicate JK is 100% successful, nor appropriate for all sites, and involves harsh chemicals over a 3-5 year program. It has so far been a costly, complex and time-consuming exercise, relying on visuals. To contain the spread and cost, early detection is key, and this is where detection dogs are unsurpassed.

Adapted from Conservation Dogs successfully detecting invasive weeds before they break the surface in New Zealand and the USA, Conservation Dogs Ireland are now in training to detect any part of JK - including underground and invisible to humans - in soil down to 1.5m, in any season.

Our training methods can be adapted to other invasive weeds e.g. Himalayan Balsam and Giant Hogweed.

P203

Don't move a mussel! Conservation dogs saving Irish waters

Helga Heylen

Conservation Dogs Ireland, Clare, Ireland

A critical issue in biodiversity is that of invasive species like the ZEBRA and QUAGGA mussel in waters worldwide, referred to as the 'most troublesome freshwater bio-fouling organisms'.

Zebra and Quagga mussels out-compete Irish native fish for food causing wide-spread decline. They also cause algae outbreaks because of increased water clarity. A further result is bird die-off.

These mussels quickly colonize and clog water pipes, causing extensive and often irreparable damage to hydro turbines and reservoirs, agricultural irrigation, drinking water systems and boat engines. Once a colony of Zebra and Quagga mussels is established, it is nearly impossible to prevent them from spreading elsewhere - further accelerated by watercraft and other vessels. Once boats are infected by infested waters, lengthy quarantine is almost always required - at a great economic loss. Through learning from countries that have tackled this before Ireland, we can assist with setting up detection dog check-points to inspect boats and other watercraft, and give boat owners clearance ID.

Year after year, the cost of fighting these invasive mussels is staggering and an almost futile, ongoing exercise, with bio-pesticides giving disappointing results.

In managing invasive species, early detection is key. Zebra and Quagga mussels live up to 3 years and release close to 1 million eggs each year. Conservation Dogs Ireland are trained to sniff out Zebra and Quagga mussels at the earliest possible larvae stage - which is still invisible to the human eye.

At Conservation Dogs Ireland, we take pride in our research and learning from the best in the world. Governments and organizations in Canada and New Zealand have been successfully employing conservation detection dogs for this purpose.

No other method is as cost-effective, environmentally friendly, thorough and efficient as detection dogs, with them covering areas 40 times faster than humans and their efficiency impossible to quantify.

Detection dogs saving trees from widespread disease in Ireland

Helga Heylen

Conservation Dogs Ireland, Clare, Ireland

NEW in Ireland - pilot adapted from Austria

Early detection of **invasive wood boring insects** by conservation detection dogs - in particular **Citrus Longhorn Beetle**

Origin: Native to China and Japan, Citrus Longhorn Beetles have been moving around the world in ornamental trees from Asia. They pose a serious threat to horticulture, forestry and native trees in Europe.

Impacts: This species kills many species of broad-leaved trees, including alder, apple, ash, cherry, elm, horse chestnut, maples, mulberry, poplars and willows. Adult beetles feed on twigs, leaf petioles and primary leaf veins. Their larvae destroy the tree's vascular system which disrupts sap flow. Trees are slowly killed over a 3-5 year period.

How might it get to Europe? Nursery trade, sea freight, in solid wood packing material such as pallets and containers and infected firewood.

How to address the problem: Relying on visual inspection comes too late, and access to carry out inspections is not always possible.

Detection dogs smell an infestation early where visual inspection is impossible.

Conservation detection dogs have been used since 1890 in New Zealand with unrivalled success.

Method development started in Austria Federal Research and Training Centre for Forests, Natural Hazards and Landscape and has been very successfully implemented in Austria, France, Germany, France, Italy, the Netherlands and Switzerland.

Dogs are trained to detect the Citrus Longhorn Beetle in all development stages (egg, larva, pupa, adult) alive and dead, as well as larval galleries, pupa chambers, exit holes, frass and wood shavings.

Detection sites are commonly wood or living plants/trees at import locations, storage places, in the vicinity of high risk spots or in outbreak areas.

This method can be adapted to address other invasive beetles in Ireland and Europe, e.g. Emerald Ash Borer, Large Pine Weevil but needs further research.

Intermediate consumer naïveté and sex-specific vulnerability to an invasive higher predator in aquatic systems

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Freshwater systems are particularly at risk of invasions due to multiple pathways and vectors for introductions, compounded with high interconnectedness and thus potential for rapid dispersal. Understanding both the trait-mediated and density-mediated effects of invaders is integral to robust quantifications of impact on native communities. Here, we employ functional response (FRs; resource use as a function of resource density) and prey switching (frequency-dependence of predation) experiments to examine the trait-mediated and density-mediated impacts of the invasive mosquitofish, *Gambusia affinis* on the open-water mesopredator *Lovenula raynerae* (Copepoda), using larvae of the mosquito *Culex pipiens* as a basal prey. *Lovenula raynerae* exhibited a destabilising Type II FR towards mosquito prey irrespective of either chemical or visual mosquitofish cues. Further, FR parameters (attack rates and handling times) were similar under the addition of cues, illustrating naïveté of the copepod to higher-order fish predation. When female and male copepods were presented together to the invader at varying proportions, the invader did not exhibit a prey switching propensity, and consistently displayed a preference for female copepods. We thus demonstrate a lack of risk-reduction activity in the presence of invasive fish cues by copepods and, in turn, vulnerability of intermediate trophic groups to predation by an invasive higher-order fish. Further, we show that *G. affinis* will readily target and consume intermediate predators of mosquito larvae, which may, perversely, result in increased proliferations of mosquitoes in the field, given the widespread introductions of *G. affinis* for vector control. The lack of intraspecific prey switching may additionally foster sex-skewed ratios within zooplankton communities, and accordingly affect the reproductive success and potential longevity of zooplankton assemblages. We advocate that the use of FRs and prey switching designs in combination provides a robust tool to elucidate both the trait-mediated and density-mediated impacts of introduced predators on recipient ecosystems.

Global threats and management of nonindigenous species in marine protected areas

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Marine nonindigenous species (NIS) can have severe impacts on native species, habitats, and ecosystems, yet there is minimal knowledge of the prevalence of NIS and their impacts in marine protected areas (MPAs). The degree to which NIS may be hindering protection efforts in MPAs is a critical oversight during a time of heightened awareness and expansion of MPAs, stimulated by the goals of the Convention on Biological Diversity. We are distributing questionnaires on NIS to MPA researchers and managers around the world and pairing this with online database information to answer the following questions: Does awareness of NIS in MPAs reflect the reported distributions of NIS in these areas? Are there observed impacts of NIS in MPAs? How do NIS rank among priority issues in MPAs? What characteristics of NIS lead to recognition of a management issue and what management actions (if any) are taken? The results of this study will indicate the magnitude and recognition of the issue of NIS in MPAs, and will provide insight towards how to better protect the ecosystems we have committed to conserve.

Current situation and future prospects of three invasive carnivores in France: Raccoon, Raccoon dog and American mink

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Introduction of exotic species is one of the major threat to biodiversity. Raccoon, Raccoon dog and American mink are three alien carnivores introduced in Europe in the last century for fur production purposes or as pets. Some individuals escaped or released and then established self-sustaining populations, still expanding through Europe and in France. The main problems caused by those alien carnivores are the threat they represent to native wildlife by predation, competition, transmission of pathogens and parasites. Reducing populations of those alien carnivores and preventing their spread is a big challenge when detected into the wild.

In France, Raccoon, Raccoon dog and American mink are game and pest species and may be culled through the year. Nevertheless, their expansion still progresses and new populations are created due to accidental releases. In particular, American mink is a serious threat to the European mink (*Mustela lutreola*), one of the most endangered mammals in Europe still living in few spots in the South West of France. To assess their distribution, the monitoring of those species in France is led by the French National Agency for Wildlife (ONCFS) compiling trapping, hunting, road killing, living observation data.

This poster will present the current situation of those three carnivores in France and some results of the management scheme that has already been in place. It will also presents the control of those carnivores in captivity due to the new EU regulation n°1143/2014 on prevention and management of introduction and spread of invasive alien species.

Assessing potential allelopathic effects of invasive *Acacia* species on germination of native and invasive species

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Allelopathy, defined as the disruption of the metabolism of surrounding plants caused by phytotoxins, has been put forward for explaining the success of some invasive alien species. The novel weapons hypothesis suggests that alien plants' phytotoxins can excert a negative effect on the germination and establishment of native species that have not been historically exposed to them. Such inhibitory allelopathic effect is suspected to mediate the invasion of several invasive Australian *Acacia* species. We examine whether invasive *Acacia* species have allelopathic effects on the germination of native species as well as on other co-

ocurring invasive acacias in South Africa (SA) and Spain. For this, we collected leachates in both countries under the canopies of invasive acacia species and co-ocurring vegetation in uninvaded areas. In a multifactorial germination experiment, invasive acacias (SA: *A. saligna*, *A. dealbata*, *A. mearnsii*, *A. cyclops*, *A.elata*; Spain: *A. dealbata*, *A. melanoxylon*, *A. mearnsii*), native species (SA: *A. karroo*, *Protea repens*; Spain: *Cytisus striatus*, *Plantago lanceolata*) and the model species *Lactuca sativa* were germinated under all types of leachates collected with a control of destilled water. We measured total germination and the comulative germination rate under controlled conditions in temperature chambers. Preliminary results from SA show that the invasive *Acacia elata* had a lower germination rate when treated with the leachate collected under *Acacia dealbata*. Also, the native *Acacia karroo* and invasive *Acacia saligna* had a higher total and cumulative rate of germination when exposed to leachates collected in uninvaded fynbos compared to the other treatments. Though we found no overall pattern in total germination, results indicate an interspecific and intraspecific allelopathic effect on early growth kinetics for some of the species selected. Comparing the results from South Africa and Spain should tear apart if these effects are site specific or intrisic to the invasive species considered.

Monitoring the impact of some alien invasive species in the south-east zone of Romania

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Located in the central-eastern area of Europe, Romania is at the crossroads of important European roads and, at the same time, on the main directions of the invasion of insect species that once entered the country can have a consistent economic impact on native, local biodiversity. In the last decade, a series of species from different taxonomic families have entered by the Balkan way and are expected to penetrate others through various ways: roads, vegetal imports, tourism, etc. From the east, from the Asian area, a number of other species have also penetrated and would penetrated, some of which have produced real disasters in

the invasion areas. Invasive species monitoring activity is a major component of the prevention system for invasive alien species included in the first objective of this system, namely that of rapid detection and control in order to prevent, as far as possible, the prevention of accidental intrusion of such invasive species. An effective prevention and monitoring system works, for example, in Italy, with which it has managed to stop the penetration of the invasive species Diabrotica virgifera virgifera LeConte in Italy. The paper presents a series of data on the situation of the monitoring of invasive species already on the Romanian territory, such as the alien species list, the spreading area, host attacked plants in case of insects, the degree of attack on the frequently attacked hosts and the estimation of a possible economic impact. It also presents the current situation of the invasion of dangerous species on the territory of Europe and near the borders of Romania.

Effects of two invasive plant species on soil biogeochemistry: a comparison between invaded and native vegetation

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Plant invasions are often associated with significant changes in the structure and composition of native plant communities including drastic reductions in plant species diversity. Whilst previous studies have reported on a number of eco-physiological and functional traits that may increase plant species invasiveness and which plant communities might be more vulnerable to invasion, it remains less clear how plant invasions will actually affect soil ecosystems in the long-term and how invasive species might influence soil nutrient cycling or soil organic carbon accumulation. Key questions remain about whether and how soil chemical, physical and biological properties might change between invaded and adjacent uninvaded native plant communities under similar environmental conditions.

Here we specifically addressed how the presence of two contrasting plant invaders, *Impatiens glandulifera* (Himalayan Balsam) and *Gunnera tinctoria* (Giant Rhubarb) influence soil biogeochemical properties when comparing monoculture stands of these invasive species with neighbouring native plant communities.

Overall we show that soil responses to plant invasion can be very different between *Impatiens* and *Gunnera* and that the impact of these species can be strongly site-dependent. Soil biogeochemical properties (i.e. soil pH, soil nutrient availability, soil carbon content, soil microbial composition etc.) showed differences between plant invaded and native communities but these responses varied depending on location and plant species. We discuss how soil biogeochemical properties may be influenced by the identity of the invasive plant species. Finally, we suggest how further experimental research could help in our understanding of the impact of plant invasive species on soil ecosystem functioning.

Villains in a Half-Shell? Assessing the relative potential ecological impacts and risks of four globally traded turtles

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Invasive alien species (IAS) can cause many negative impacts, such as ecosystem disruption, human health issues, financial cost and even species extinctions. The poorly regulated international pet trade is a major source of IAS, but methods are needed to predict the ecological impacts and risks of emerging and future IAS that lack invasion histories.

This study develops the Relative Impact Potential (RIP) metric, a measure of ecological impact that incorporates functional responses and proxies for numerical responses (RIP = FR x NR_{proxy}). Acknowledging the utility of propagule pressure as a determinant of invasion success, we also bolster RIP with a new measure of pet propagule pressure (PPP), giving the novel Relative Invasion Risk (RIR) metric.

We develop RIP and RIR to assess the potential impacts and risks of four commonly traded pet turtles: *Trachemys scripta scripta*, the yellow-bellied slider; *Trachemys scripta troostii*, the Cumberland slider; *Sternotherus odoratus*, the common musk turtle; and *Kinosternon subrubrum*, the Eastern mud turtle. *T.s. scripta*, with high maximum feeding rate and attack rate combined with high lifespan and fecundity values, had the highest impact potential. It was also the second most readily available according to our Northern Ireland and GB surveys, giving a high invasion risk. *S. odoratus*, despite having the lowest maximum feeding rate and attack rate, was found to have a high invasion risk due to availability, indicating a species worthy of monitoring.

The RIP and RIR metrics are two methods that can assist the prioritisation of emerging, potential and future invaders from the pet trade and elsewhere. These metrics highlight *T.s. scripta* as having high impact and risk, corroborating its position as a species on the EU List of 49 IAS of Union Concern and suggesting that this method has potential to direct future policy decisions.

Success of the Signals: invasion biology and impacts of *Pacifastacus leniusculus* in a rocky headwater stream, North Yorkshire

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The worldwide, human-induced spread of invasive alien species has had severe ecological, social and economic implications, with freshwater systems proving particularly vulnerable to invasion. Freshwater crayfish are exceptionally successful invaders, with 90% of species introduced to Europe becoming established in the wild. As ecosystem engineers, they present a significant threat to aquatic ecosystems. Previous studies have produced inconclusive and conflicting results on the spatio-temporal ecological impact of invasive crayfish on native biota.

Here a case study is presented at an upland headwater in North Yorkshire where signal crayfish, *Pacifastacus leniusculus,* were illegally introduced in the 1990s. Several methods were employed to investigate the invasion biology and ecological impacts of

signal crayfish along a downstream invasion gradient. Results show that as signal crayfish abundance increases, macro-invertebrate abundance significantly decreases. However invertebrate diversity remains consistent between sites. Comparison with historical datasets shows that brown trout and bullhead populations have reduced severely on a spatial and temporal scale between 2011 and 2018. Trapping and hand-search data shows crayfish abundance to vary along the invasion gradient with a distinct peak at one of the upstream sites. A novel draw-down technique revealed that signal crayfish can thrive at densities that far exceed all previous approximations (110.4 individuals / m²). Furthermore, the draw-down provides the best estimate of population size-class distribution, with 90% of individuals falling within the 0-25 mm carapace length category and only 1% of the population could be caught through trapping. This finding emphasizes the biases associated with other survey methods such as trapping and hand-searches. This case study contributes to the current understanding of signal crayfish invasion biology and provides an example of the severe ecological damage suffered at an upland headwater stream following signal crayfish introduction and expansion.

Linking plant traits with ecosystem services and disservices: a conceptual framework for plant invasions

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Invasive alien species (IAS) are of great importance for human well-being as they alter ecosystem properties and their downstream services and can have economic impacts. Alien plants were introduced to improve agriculture and forestry, as ornamentals they are part of many homes and gardens, but they also transformed landscapes. Some introduced species have negative effects on biodiversity, crop and timber production, infrastructure or human health. These impacts occur either by reducing ecosystem services or by creating disservices, i.e. causing genuine negative effects on humans. Impacts of IAS on ecosystems can be mediated by species traits related to service provision – e.g., biomass, flowering patterns or SLA, but the same traits can be associated with disservices, depending on the context or ecosystem. In this paper we present a conceptual framework, which links functional traits of IAS via services (ES) and disservices (EDS) to affected economic sectors. In the framework, benefits equal an increase in ES or a reduction of EDS and impacts equal a reduction of ES or an increase in EDS. The framework is applicable for each trait and species and can include the direction (positive/negative) and strength of impact. Furthermore, we classified six socioeconomic and environmental sectors frequently affected (positively or negatively) by invasive plants, along with the list of ES and EDS relevant in these sectors. Thus, the framework can be used for targeting the affected sectors by invasive plants. Only by analyzing both positive and negative effects of IAS can we maximize ecosystem service provision (or minimize disservices) and guide future management actions particularly with respect to multiple ES and EDS.

Keywords: alien species, impact, functional traits

Impact and risk assessment of the alien North American channel catfish *Ictalurus punctatus* in Central Italian freshwater ecosystems

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The North American Channel Catfish *Ictalurus punctatus* was first observed in Italian rivers about 20 years ago and it has since spread throughout every major Northern and Central Italian river, without having received any scientific attention. Hence, aside of being reported from about 20 European countries, nothing is known about this highly reproductive, opportunistic alien species, which is recognized to exert various impacts on recipient ecosystems.

In an attempt to gain information about this species' impacts and the risks it poses to European freshwater ecosystems, samples were collected over a period of two years. Annuli in extracted spines were used to estimate length-based age boundaries and the age of maturity was estimated based on fecundity. Stomach contents were analyzed according to season, gender, age classes and life stage with multivariate analyses. Additionally, stable isotopes of all aquatic species present in the invaded river Arno were analyzed, not only to get insight into its trophic position, occupied niche, potential competitions and impacts, but also to investigate how the presence of *I. punctatus* has affected the recipient ecosystem. As a result, the adaptation to the European freshwater ecosystems is described and the competition with species like the European catfish *Silurus glanis*, which occupies a similar ecological niche and is of major interest for stakeholders as an invasive species and as a game fish for anglers, has been focused.

Invasion of alien species changes phylogenetic and functional diversity of plant communities

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Species composition of plant communities results from past radiations, migrations, environmental filtering, and interspecific relationships, which resulted in recent phylogenetic (PD) and functional diversity (FD). Biological invasion may have a strong effect on this part of diversity, which is scale-dependent. On the level of species pools the effect of biotic invasion is attributable to environmental filtering, while on the level of plots it is driven also by species interactions. Our aims were to detect the effects of establishment of alien species on PD and FD of plant communities in the Czech Republic on different spatial scales. We used data about composition of plant communities on plots 1-100 m^2 in size, harbouring the total of 2306 vascular plants. Communities were divided into several broadly defined vegetation types and for each type the species pool was defined. PD and FD were quantified using mpd and mntd indices and related to the level of invasion. Different effects of alien species on PD and FD could be detected on the two spatial scales addressed. On the scale of species pools alien species increased the degree of phylogenetic clustering in phylogenetically clustered vegetation types as they tended to be from the same lineages as native species. In phylogenetically diverse vegetation types, alien species even increased PD, despite of the fact that the level of invasion in such vegetation is low. On the small scale of vegetation plots aliens reduced PD and FD across all studied vegetation types. These results suggest that on the plot scale, alien species occupy a phylogenetic and functional space within the range formed by the resident native species in a community. They do so either by filling empty gaps or by excluding natives from the existing phylogenetic and functional space, rather than occupying a phylogenetic and trait space outside of it.

Assessment of ecological risk of alien species in Norway - method and results

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In June 2018, The Norwegian Biodiversity Information Centre (NBIC) will present the third list of alien species. The list contains risk assessments that quantify the negative ecological impact of each alien species on Norwegian nature.

In Norway, impact of alien species on native species and nature types is assessed by a quantitative method: *Generic Ecological Impact Assessment of Alien Species* (GEIAA). This method is based on nine criteria estimating the species' invasion potential and the species ecological effects. Depending on the scores on each criteria, alien species are assigned to five risk categories. Species classified to the two highest categories, *high impact* and *severe impact*, constitute the Norwegian Black List. The method is quantitative since the set of criteria uses numerically defined threshold values. The criteria are also generic, i.e. they are applicable to all group of organisms.

Researchers from the Centre for Biodiversity Dynamics (CBD) at the Norwegian University of Technology and Science (NTNU) developed the method in cooperation with The Norwegian Biodiversity Information Centre (NBIC). The method is not specific for Norwegian nature, and other countries have shown interest in the method. Swedish authorities are now using the method.

Twelve expert groups with totally 54 scientists from different institutions conducted the assessments. The assessments are based exclusively on ecological effects. The assessment includes all alien species established in Norway per 1800 or later. In addition, *door knockers* and *regionally alien species* could be assessed. Thus, about 1500 alien species are assessed. A brief summary of the results, and method, will be presented at the conference.

How invasive trees influences their own offspring – limitation or facilitation?

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As ecosystem engineers, trees modify availability of resources beneath their crowns. Conditions which earlier allowed for establishment of invaders may change in ways which facilitate or limit their natural regeneration. We hypothesized that although presence of invasive tree species in the canopy decreases survival of individual seedlings by reducing resource acquisition, it may also increase reproductive success by producing numerous seedlings. As model species we used *Prunus serotina*, *Quercus rubra* and *Robinia pseudoacacia*. To test this hypothesis, we used data from a three-year observational study on 378 study plots located in ten forest types in Wielkopolski National Park (Poland). Each year we quantified natural regeneration (up to 50 cm height) by measuring basal diameter and height of each seedling, and we labelled newly germinated seedlings to assess their survival. For example, in 2016 we labelled 2739 seedlings of *P. serotina*, 501 of *Q. rubra* and 2410 of *R. pseudoacacia* and in 2017 we found 182, 92 and 2 one-year-old plants, respectively (total survival of 6.64%, 18.36% and 0.08%). For *P. serotina* gradient boosted modeling (cross-validated AUC=0.744) revealed that the most important predictors of survival were light availability (47.8%) and litter mass (28.6%) and for *Q. rubra* (cross-validated AUC=0.738) – litter mass (31.3%) and light availability (26.0%). The highest survival of these species did not occur beneath parental tree stands, however, they reached the highest densities and biomasses. These results show dual impacts of invasive trees on regeneration: limitation and facilitation by different mechanisms. The study also highlighted indirect effects of alien tree stands by modification of habitat properties – litter production and reaction as well as light availability, which directly influence performance of natural regeneration.

Acknowledgements

Analysis of invasive plant diversity in the territories of three nature protected reserves – example of Southeastern Latvia.

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The research of invasive plant diversity was carried out in three nature reserves in the Southeastern part of Latvia: nature reserve "Eglone", "Sasaļu mežs" and "Pasuliene" during 10 years (2008–2017) in vegetation seasons. The aim of the study is to evaluate invasive vascular plant species in these tree relatively small and isolated protected territories with high percentage of protected habitats and illustrate their influence on the natural plant communities here.

The nature reserve "Eglone" (159 ha) holds significant biodiversity – the large part of territory is covered by protected habitats – 9020 *Fennoscandian hemiboreal natural old broad-leaved forests* (69.8 ha) and 91E0 *Alluvial forests* (9.6 ha). Total number of vascular plant species here - 437, and only 9 of them – alien species.

The Nature Reserve „Sasaļu mežs" (199 ha) is covered by mostly different forest and freshwater protected habitats of European Union importance - 3150 *Natural eutrophic lakes* (30.2 ha) and 9010 *Western taiga* (64.2 ha) The surveys of vascular plant flora revealed 482 species, 26 of them – alien species.

The nature reserve „Pašuliene Forest" is small (106 ha) forest territory with significant biodiversity – the largest part of the territory is covered by protected forest habitats – 9020 (70.70 ha) and 91D0 *Fennoscandian deciduous swamp forests* (19.40 ha). The flora of the nature reserve "Pašuliene Forest" has no significant influence, the majority from 284 vascular plant species known here (278 species) are autochthonous, while only 7of them - alien species.

As a result - flora of nature reserves could be considered as only slightly influenced. Accordingd on national list of invasive plant species, there are only eight plant species, considered as invasive, found here, all with unsignificant impact on natural plant communities - *Acer negundo, Bunias orientalis, Elodea canadensis, Impatiens parviflora, Lupinus polyphyllos, Malus domestica, Rumex confertus* and *Sambucus racemosa*.

Check-list of alien insect species of the Island of Sardinia (Italy)

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Alien species have increasingly spread in recent years due to climate change and global trade, and islands are not immune from such trend. Insects, being the dominant group in all terrestrial ecosystems, often represent the largest group of alien species in a given area. Sardinia is the second widest island in the Mediterranean Basin (near 23,800 kmq) and its fauna is largely endemic. An accurate knowledge of alien insects is essential in order to estimate their impact on natural and agricultural ecosystems and on biodiversity, as well as to investigate their pathways of introduction. The aim of the present study is to depict an updated check-list of alien insect species of Sardinia, which consists of a total of 294 species. The dataset includes species mostly belonging to the following orders: Coleoptera (107 species, 36%), Hemiptera Sternorrhyncha (74 species, 25.2%) and Hymenoptera (42 species, 14%). The present data are being used to evaluate richness and composition of alien insect fauna of the island and explore the local implications of these species on natural and agricultural systems, in order to develop efficient strategies to manage biological invasions.

Marbled crayfish is able to rule over calico crayfish in agonistic interactions

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Biological invasions are considered as a great threat to global biodiversity due to having negative impacts on native biota. In spite of having legislation restricting alien invasive species, including crayfish, aquatic ecosystems are currently facing to multiple-invaders. Research therefore moved from native vs. non-native crayfish interactions to study interactions of non-native species. Invasive non-native crayfish have often similar life strategies, niche preference, or adaptation strategies but their interactions are less understood. The present study aimed to discover the interaction patterns, in presence and absence of strategic resource (shelter), of size-matched couples of calico crayfish Faxonius immunis (well established in Rhine River catchment) and parthenogenetic marbled crayfish, Procambarus virginalis (recently spreading invader across Europe). During agonistic interactions marbled crayfish won significantly higher number of fights in absence of shelter than calico crayfish but in presence of shelter no significant difference between two species. On the other hand, in respect to sex of calico crayfish, marbled crayfish won significantly higher number of fights with female calico crayfish without shelter. Similarly, without shelter, the dominance over female calico crayfish was 83.3 %, in males it reached 60 % and with shelter, it was 100 % and 54.5 % for female and male calico crayfish, respectively. However, fight number, latency to start fight, and mean fight duration does not significantly vary among the groups except time spent in short fights (< 60s) and long fight (> 60s). It could be concluded that the sex and resources availability have effects on agonistic behavior in studied crayfish. Marbled crayfish can be also confirmed as at least comparable or stronger than calico crayfish, which is e.g. dominant over other serious invader, the spiny-cheek crayfish Faxonius limosus. Regardless explored agonistic interactions, situation in sympatric environment may alter through other factors (e.g. size of animals, temperature, predators etc.).

Life after knotweed: long-term, sustainable recovery of invader-dominated habitats following control treatment.

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Introduced to the UK as an ornamental in the 19th century, Japanese knotweed (Fallopia japonica) is infamous for being difficult to control. Throughout their invasive range, knotweeds dominate their recipient non-native habitat and form a novel, species-poor, self-mediated plagioclimax community. The past few decades have seen increased focus on invasive species management, yet knotweed control efforts are still inadequate. Knotweed management programmes are often not correctly set in a long-term context or aligned with plant ecophysiology and ecology. Furthermore, little is done to aid ecosystem recovery following control treatment, and post-treatment monitoring is scarce. Knowledge on the lasting effects of knotweed dominance and treatment, and the extent to which native flora can subsequently recover is therefore limited.

Although reliable knotweed eradication has not yet been achieved using standard control methods, post-treatment habitat recovery is still viable. Focusing on the biology of invaded systems instead of a single, target species is hypothesised to enhance invasive species control and re-establishment of native habitat for biodiversity and stakeholder value. This long-term knotweed management and restoration project consists of three stages: 1. Identification of knotweed dominance and chemical control impacts on plant communities and soil physical, chemical and microbial conditions; 2. Large-scale, long-term field trials assessing integrated control and restoration of invader-dominated habitat using revegetation based on functional trait selection and tailored habitat management; 3. Determination of the viability of a restoration framework across invasive, rhizome-forming species, using knotweed as a model through life cycle analysis and comparative growth assessments.

Round goby impact on native fish assemblages: a meta-analysis approach

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One of the major problems in invasion biology is the lack of reliable data on the impact of non-native species on recipient systems. Ideally, reliable evidence of impact requires long-term monitoring data from multiple sites with different invasion histories; otherwise the impacts observed could be confounded with other biotic or abiotic effects occuring at the same time or merely represent short-term fluctuations. Indeed, a large proportion of present data suggesting non-native species impact may be biased in either of these ways. However, as impact studies are rarely conducted on the same invasion (i.e. they differ in time and place), they are rarely subjected to the same bias and, as such, general invasion patterns may be derived through an impact meta-analysis. Here, we introduce a meta-analysis method for assessing impact of a non-native species, using the round goby (*Neogobius melanostomus*) as a model species. The dataset was based on an extensive literature search addressing any changes in fish assemblages possibly attributable to round goby, with each observation weighted according to a set of pre-determined criteria, scored by two independent evaluators. The dataset obtained was then used to determine inter-taxonomic, inter-guild or inter-continental patterns in round goby impact on native fish assemblages.

The distribution of invasive alien plant species in riparian zones along altitudinal gradients in the Austrian Alps

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Mountainous regions have so far been relatively little affected by biological invasions. However, this situation might change in the coming years due to increasing accessibility of mountains, land use, and climate changes. A number of invasive plant species have already been introduced into warm valley floors of the European Alps. From there, roads have been shown to function as the major gateways for their range expansion into higher elevations. Similarly, we argue that riparian habitats along rivers may serve as another network for the upward spread of alien plants. In this study, we assess the composition of the alien and native flora along the main roads and the main rivers of two valleys (i.e. Isel- and Lech-valleys) in western Austria. We will follow an established protocol for studying plant invasions along roads in mountains from the MIREN-network (http://www.mountaininvasions.org/), and extend this approach to studying invasions along the river network. We will examine the role of environmental factors (e.g. climate), species traits and introduction history (e.g. residence time in Austria) on the altitudinal distribution of invasive alien plant species along roads and rivers, and into the adjacent natural vegetation. Additionally, we will assess the impact of plant invasions on native species richness.

Spatial and temporal variability of soil properties in Black locust stands in secondary range

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Black locust (*Robinia pseudoacacia*), one of the first North American trees introduced to Europe, is now a common part of the landscape both due to long historical tradition of planting and subsequent invasion. The objective of our research was to verify the tolerance of *Robinia* to various soil types and physical-chemical soil properties in the secondary range (Czech Republic, Central Europe). We found that *Robinia* dominates on genetically young soils, such as cambisols, leptosols, arenosols, and fluvisols. The limiting factor is a lack of soil oxygen causing inhibition of nitrogen fixation. The species is able to tolerate a wide range of extremely diverse soil conditions, from extremely acid to strongly alkaline, and from medium to highly base-saturated with a gradient of stoniness. Soil nitrates and mineralization rate vary considerably, whereas the exchangeable phosphorus and ammonium are consistently low. Soil reaction was determined as the most important environmental characteristic explaining the variability of herb layer in *Robinia* forests. We studied in detail the temporal variation of light conditions, soil and litter characteristics during one vegetation season. Samples were taken along a linear transect upslope from the moist nutrient-rich nitrophilous to xerophilous *Robinia* stands to relic pine forest. Seasonal dynamics of soil characteristics were similar in diverse *Robinia* plots, but detected concentrations differed significantly among plots within one season. Nutrient-rich *Robinia* forest harboured a dense herb layer dominated by shade-tolerant nitrophytes, and was characterized by high nitrification rate, base saturation and fast turnover of litter. Xeric plot had the highest plant diversity with dominance of heliophytes, high lignin in litter and related slow mineralization. In comparison with pine forest, *Robinia* soil had a higher pH and greater level of available nitrates. Our results confirm that *Robinia* can colonize a broad range of xeric to mesic habitats, where it creates its specific environment.

Do *Acacia* invasions change the structure of the arthropod communities in invaded areas?

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Plant invasions can alter the composition of native communities through disruption of biotic interactions or changes in abiotic ecosystem characteristics. The arthropod communities are sensitive groups that can be affected by the introduction of invasive exotic plant species, modifying the interactions and changing the environmental scenarios. However, effects of plant invasions on arthropod communities have rarely been studied. We compared the co-occurrence between plants and arthropod species in native and invaded areas by *Acacia dealbata*, *A longifolia* and *A. melanoxylon* in a total of eighteen populations in the NW of the Iberian Peninsula. Yellow sticky traps were placed in branches above ground in randomly selected sites and used to qualify and quantify the number of aerial arthropods. The aim was to assess the impact of those invasive *Acacia* on arthropod biodiversity and to discuss about consequences. Our results showed that abundance, species richness, diversity and dominance of arthropods were higher in non-invaded areas. We found that arthropod communities are negatively affected by *Acacia* invasions, which may have substantial effects on ecosystem dynamics as the food web and habitat heterogeneity. Loss of arthropod diversity is commonly associated with homogeneousness and changes on microhabitat produced by plant invasions. Overall, our findings suggest invasive *Acacia* plants reduce biodiversity of the arthropod communities in invaded areas. The physical dominance of *Acacia* invaders compared with other plant species could be a main driver for this effect, modifying the co-occurrence of other groups and affecting local ecological networks.

Structural and functional consequences of climate change and species invasion in freshwater ecosystems.

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Interaction between climate change stressors, such as warming and drought, and biotic stressors, such as biological invasions, can have detrimental effects on the biodiversity and function of vulnerable ecosystems like freshwaters. An important reason for measuring both biodiversity and function is that changes in biodiversity can occur without detectable changes in function or *vice versa*. One important component of ecosystem function in freshwater ecosystems is the processing of plant material into a more digestible form for other organisms. To study the impacts of multiple stressors on resource processing, we took a mesocosm approach with an established amphipod system. Shredder species such as amphipods play a major role in this process. *Gammarus pulex*, a native species in the UK, has a high leaf shredding efficiency and low tolerance to thermal stress. *Dikerogammarus villosus*, a Ponto-Caspian invader, can survive for days outside a waterbody, has a lower leaf shredding efficiency and shows higher tolerance to thermal stress. We used a mesocosm approach to manipulate abiotic (drought and warming) and biotic (presence of invasive species) stressors to explore the impact on resource processing and biodiversity of freshwater communities. Four measurements of resource processing rates and macroinvertebrate abundance were carried out throughout the experiment, one pre-disturbance, one immediately after treatments to determine resistance, and two further measurements to determine resilience of these communities. There was no significant difference in resource processing between warming and drought treatments, but processing rates were higher in invasive treatments than in native treatments. Warming affected zooplankton and macroinvertebrate communities but not resource processing rates. Therefore, our results suggest that biotic stressors, such as invasive species, may play a larger role in driving functional change than abiotic stressors, while abiotic stressors predominantly affect biodiversity.

Pre and post-invasion: changes in structure and composition across a gradient in sand dune pine forests

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Pre and post-invasion: changes in structure and composition across a gradient in sand dune pine forests

In Portugal, pine forests in sand dunes ecosystems are identified as highly susceptible to invasion, and significant areas are already invaded, mainly by the Australian A. longifolia.

It preferably invades foredune, but is also invading other types of habitats and ecosystems. In Portugal, the process of invasion by acacia longifolia is also detected inland. This work aims to assess if pine forests traits are important to distinguish different levels of susceptibility to invasion by A. longifolia, considering a sea–inland environmental gradient (10 km).

Plots of 10x10m were selected in the Mata Nacional da Marinha Grande, (Central Portugal) using a stratified sampling method according different conditions of pine forest structure and understory: i) dwarf forest ii) secondary dune forest iii) forest with low shrubs iii) forest with tall shrubs iv) invaded and non-invaded plots. In terms of results, it is clear a marked difference in terms of structure and physiognomy between sea-facing and inland forests. While pine cover is low in sea wind-facing communities, and present a dwarfish to tall shrubby shape, the inland pine forest structure ranges from open to closed.

Confirming that diversity can be significantly lower in invaded areas, especially in sea-facing communities, results also show that differences between invaded and non-invaded areas are higher if considering canopy cover and colonization status for each taxon. Moreover, invasion promotes changes in the structure of the pine forest, reducing stratification and creating a taller understory.

The impact of the *Acacia* spp. in *Eucalyptus globulus* stands in Portugal

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Eucalyptus globulus is planted in Portugal and has a great economic importance for the paper industry. *E.globulus* wood production varies substantially according to the availability of resources and may be limited by other plant that co-occur in the plantations. In order to develop sustainable management practices, it is essential to make an assessment of all the factors that contribute growth and biomass production.

Tree invasions cause important ecological problems, such as changes in the plant community composition and landscape structures, as well as vegetative growth and cause an impact on co-occurring species. Indeed, competition for water and nutrients is often related to exotic invasive species.

The Australian *Acacia* spp. have been widely planted worldwide for different purposes. Some species have spread and altered the native ecosystem functions to the extent of being considered economic and ecological threats. *Acacia* were introduced in Portugal for ornamental and soil support purposes. These species are often associated with roads, rivers and disturbed areas, acting as an invader in natural and human-altered landscapes.

This study aims to evaluate the impact of control measures of *Acacia* in management and productivity in Eucalyptus stands, under different climate and soil conditions in Portugal. All this, taking into account the different management strategies used to control invasive plants, which involve manual cutting, herbicide, disk harrowing and/or slashing.

Invaded *E.globulus* stands were evaluated, depending on the type and intensity of control, and tree growth was compared before and after *Acacia* control. The vegetative increment (tree height; stem diameter) of *Eucalyptus* took place during two consecutive years in plantations with different ages.

Results indicated that the impact of *Acacia* on *E.globulus* depends on the control measures used and edaphic-climatic conditions. Moreover, it is clear that an efficient and sustainable forest management requires effective control of exotic invasive species, such *Acacia*.

Predicting the impact of climate change onto invasive crayfish species in Croatia

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Indigenous European freshwater crayfishes (ICS) have undergone significant declines in populations' numbers and sizes across their ranges. Apart from being threatened by climate change and habitat loss and *deterioration*, ICS are endangered by non-indigenous crayfish species (NICS). NICS displace ICS through both competitive exclusion and transmission of diseases such as crayfish plague. In Croatia all 4 ICS species have undergone severe declines in population abundance and numbers, in part due to the spread of the 3 NICS species. In order to protect threatened ICS, and manage fast dispersal and invasion range expansion rates of the two NICS recorded in Croatia (the signal crayfish and the spiny- cheek crayfish), the aim of this study was to predict their potential current and future distribution in continental Croatia. We developed Species distribution models (SDMs) using presence only records of the two NICS species and a set of bioclimatic predictors selected based on their ecological relevance, excluding highly correlated ones. Resulting SDMs enabled us to evaluate the potential contemporary range of the two NICS as well as to predict the impact of ongoing climate change onto their future distribution in Croatia. Obtained results will facilitate prioritisation of locations where NICS will probably establish and where their negative impacts on ICS will be most pronounced. Application of acquired results in the future ICS conservation and NICS management programs is discussed.

Climate change, biological invasions and ecosystem services: the case of the Central European vineyards

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Our work is focused on species composition and ecosystem services and disservices of spontaneous plant stands in various habitats of vineyards in Slovakia. The work builds on previous research of vineyards, biodiversity, ecosystem services, climate change and distribution of non-native plants. Global climate changes are caused by natural processes and macro- and micro-processes generated by human activities. Vines were already grown in Pannonia by Roman times and since the Slavic era, pips of Vitis vinifera represent the most numerous palaeo-botanical material in SW Slovakia. It is difficult to determine whether it was cultivated or imported. The climate (or micro-climate) of vineyards is rather dry and many significant steppe-related plant species are preserved there. The aim of the paper is to evaluate changes in biodiversity of spontaneous plant species in different micro-climate conditions of vineyards and to determine relationships between changing climate and other environmental conditions and current species composition. The data obtained were analyzed by gradient analysis. The relationship with all assessed species was determined for moisture and temperature (and the degree of their influence). The occurrence (share) of Atlantic (oceanic) and continental species also was recorded. An important refuge for a number of important steppe species is the mosaic vegetation of traditional vineyards but it creates habitats for new comers, as well. Based on the results, it can be concluded that the complex mosaic of vineyard habitats foster the expansion of climate-specific species. The ecosystem services (production, regulation, cultural etc.) and disservices (competition, allergy, toxicity etc.) have been identified, as well. However, our findings are preliminary and require a further study. Climate is an important driving force behind the vegetation succession and biological invasions, but also vegetation affects climate, especially local micro-climate.

Know your enemy: A multi-disciplinary approach to determine how the pygmy shrew (*Sorex minutus*) in Ireland succumbs to the invasion of the greater white-toothed shrew (*Crocidura russula*).

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Ireland's ecosystem now faces the consequences of yet another accidental arrival from mainland Europe, the greater white-toothed shrew (*Crocidura russula*). Following its discovery in Ireland in 2007, it became evident that the presence of *C. russula* correlates with the rapid disappearance of the Irish population of pygmy shrews (*Sorex minutus*) in newly invaded areas. Considering that these two insectivorous species co-inhabit other regions of Europe, this bears questions of why they cannot co-exist in Ireland. By using various sample sites along the expansion trend of *C. russula*, a valuable opportunity arises to assess multiple contributing factors before, during and after this particular invasion. The French island of Belle Île, an ecologically similar island to Ireland but with both *C. russula* and *S. minutus* co-existing, will be used as a 'natural control' site. Samples collected from Belle Île will be subject to the same analyses, shedding further light on their inability to co-exist in Ireland. DNA metabarcoding is applied to shrew gut contents to determine how the two species compete for local resources/prey. DNA metabarcoding is again applied to the gut contents to detect alterations to the natural composition of symbiotic bacteria (microbiome) of the native *S. minutus* after the onset of *C. russula*. Such alterations to the microbiome can lead to implications to the host's health and fitness. A combination of parasite identification, cell culturing and bacterial genome sequencing are applied to gain insight into the role of vector-borne pathogens in this small mammal invasion-extinction event. Applying modern techniques to determine the role of diet, disease and the microbiome in this *C. russula* invasion will subsequently give an over-all perspective of a common conservation issue and extend our understanding on invasive success of small mammals world-wide, not just in Ireland.

How landscape pattern interacts with IAS presence?

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Anthropogenic pressure on ecosystems varies across regions. Processes such as suburbanisation, agriculture intensification and land abandonment, forest management shape land use/cover spatial distribution in Czechia. Biodiversity conservation at ecosystem level focus on protection of vulnerable and rare habitats including them in protected areas. Depending on their subject of protection, they mostly form an island in open agricultural landscapes. In connection to IAS spread we pose a question: How the immediate surrounding of protected areas influence the presence of selected plant IAS? Within our case study several Sites of Community Importance and their surroundings in Northern, Southern, Western and Central Bohemia regions in Czechia were mapped and local landscape pattern described by chosen landscape metrics at patch, class and landscape levels. Based on presence/absence data on selected neophytes (*Heracleum mantegazzianum*, *Solidago* spp., *Impatiens glandulifera*, *Fallopia* spp.) the relation of invasion level and landscape metrics at different scales were assessed. The scaling of invasive process to landscape level can bring another insight on IAS management.

On the effect of *Fraxinus pennsylvanica* on understory vegetation in hardwood forests

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Fraxinus pennsylvanica is a mostly overlooked but still widespread tree species in Central Europe with invasive characteristics, such as high reproductive potential, the ability for vegetative propagation and the active spread in alluvial ecosystems. Riparian hardwood forests are highly diverse and are very valuable for nature conservation. They are classified as priority habitat types according to the European Habitat Directive, but are also endangered by habitat loss. In order to avoid further potential threats, the neophyte *F. pennsylvanica* has been excluded from use in forestry and is included in national management lists for invasive alien species in several Central European countries. Besides the obvious negative characteristics, the effect of *F. pennsylvanica* on native biodiversity is quite unknown.

We conducted a study to investigate how different relative proportions in the forest of *F. pennsylvanica* affect structural diversity and understory vegetation communities in hardwood forests of Elbe river in Germany. In this case, *F. pennsylvanica* was cultivated since end of the 19th century as part of forestry cultivation experiments. Four levels of relative proportion were differentiated according to the abundance of *F. pennsylvanica* in the overstory: pure stands (>80%), dominant stands (50-80%), mixed stands (<50%) and reference stands (0%) without *F. pennsylvanica*. In total, we collected ground vegetation and environmental data on 120 plots in 20 stands.

First results show that species richness and species diversity along the density gradient are very similar and typical forest plant species occur in all populations. In fact, total number of species is higher in stands dominated by *F. pennsylvanica*. The availability of light and the phosphate content in the soil seem to have a stronger effect on species richness and cover than the presence and abundance of *F. pennsylvanica*. Negative impact on local vegetation cannot be confirmed by the results presented.

The influence of waves and currents on growth rates of native and invasive marine bivalves.

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The ecological impacts of invasive species can be severe and there is an ever increasing number of invasions worldwide. Understanding responses of invasive species to changes in environmental contexts, such as hydrodynamic variability, are therefore key in predicting their success. Along coastlines, animals are exposed to a range of hydrodynamic conditions, including waves and currents. Although water motion can be a key mediator of species distributions, there is little research investigating how these different forms of water motion can affect organisms. Here, a field study was conducted throughout an autumn and winter period to investigate growth and competitive interactions of the native mussel, *Mytilus edulis*, and invasive Pacific oyster, *Magallana gigas*, in four different hydrodynamic conditions (high wave, low wave, high current, low current). Throughout the study period, temperature was measured along with monthly samples assessing water chlorophyll, particulate matter and nutrients. In autumn, both species had higher growth rates in currents compared to waves and both species had highest growth rates at the low current site. Lowest growth for both species occurred at the low wave site. In winter, growth rates of both species were reduced compared to autumn and showed no differences among sites. Growth rates of both species were unaffected by the presence of each other at all sites. Environmental variables were similar among sites suggesting that differences in growth rates were due to hydrodynamic condition. Reduced growth rates in winter are likely linked to reduced temperature and chlorophyll. Here, although growth rates of native *M. edulis* were unaffected by the presence of *M. gigas*, the rapid growth of both species in current dominated areas may lead to space limited competition and are at a higher risk of impacts caused by *M. gigas*. Quantifying such responses can enhance predictions of the success of invasive species.

Ecological impacts of alien and native plants on vegetation: does origin matter?

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There is an ongoing debate on whether alien invasive species impose a greater threat to biodiversity than native species that are spreading in transformed current landscapes. However, quantitative assessment, for a wide range of species, whether the impacts these two groups of contrasting origins have on biodiversity differ does not exist. The presented project is based on combining above- and below-ground characteristics that can be linked to the impact of dominant plant species. We measured the impacts of invasive alien and native expanding plants in the Czech Republic, a representative area of temperate Central Europe, on plant communities (species composition, and diversity) and soil ecosystem (chemical properties, activity of soil biota). Quantifying the difference in impact between the two groups of dominant species makes it possible to express the net impact of invasive aliens. In the project we combine field methods to measure impact at the local scale of individual sites with recording the abundance and distribution of the species in the country, by which we quantify and compare the real magnitude of impacts of native and invasive dominants at the regional scale.

Presence of Ponto-Caspian gobies diminishes predicted fish species diversity

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Negative impacts of non-native, invasive species are often very hard to prove in natural environments. Several authors have tested the consequences of the arrival of the Ponto-Caspian gobies, especially round goby *Neogobius melanostomus*, on the indigenous fish populations in artificial circumstances (e.g. aquaria). However, very few studies exist where in situ effects of these invasive fishes have been proved.

We yearly monitored the fish fauna at six sites of the River Meuse in Belgium over a 7-year time period (starting in 2012), and previous to that, monitoring occurred at 4-year time intervals since 1998. Monitoring was performed using electrofishing gear in the riparian zone of the Belgian part of the river. All caught fish were identified to species level, and individually measured (total length in mm) and weighed (wet weight in g). This large dataset comprises 13,224 specimens belonging to 36 fish species. The dataset was analyzed in R to visualize the effect of the presence of the Ponto-Caspian gobies on typical indigenous river fishes and to calculate the trend in Fisher's alpha (as a measure of species richness).

Where two years earlier, during a preliminary analysis, no impacts on the indigenous fish fauna were visible, the results now show a decreasing trend in predicted values of Fisher's alpha and thus in fish species richness. Also the combined number of typical indigenous river fishes (specimens caught per 100 m electrofishing) tends to decrease in the period during which the number of specimens of Ponto-Caspian gobies exponentially increases.

New data from the monitoring of the fish fauna of the River Meuse in the Summer of 2018 will possibly confirm these recent trends and provide a more solid base for conclusions on the impact of the presence of Ponto-Caspian gobies on the native fish fauna.

A framework for classifying plant communities in invaded habitats along the gradients of human disturbances and accessibility to the public.

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Human made habitats in urbanized environment, including chateau parks, are important sources of newly introduced plants. Although the ornamental and escaping flora of cities and villages is a frequent research subject in invasion ecology, an approach capturing the complexity of human influence as well as natural processes acting in various habitats is missing.

In a project aimed at recording alien plants in chateau and other public parks we need to compare a wide range of habitats that can be characterized by their position along two gradients: (i) the degree of naturalness, and (ii) accessibility to general public. The result of the study is a framework, that enables to describe each habitat in a three-dimensional space defined by the above axes, and tested it by using data on alien plants' occurrence in the parks and their surroundings. The framework for the description of habitats can be visualized as two triangles, one covering cultural and the other social gradient and each plant community is characterized by its position in the triangles. The axes in the first triangle define the character of the environment – natural, cultural, and ruderal. The second triangle makes it possible to place the community with regard to accessibility of the site to public, i.e. space that is public, private and vague (the latter term refers to usually neglected spaces). Our approach displays the invaded community as a centroid of occurrences of plant species that is very close to vertex of "culture" or is located in the "culture–ruderal" area, if it is dominated by ruderal aliens. In the second triangle invasive species are concentrated both in spaces that are publicly accessible (i.e. where the probability of disturbances and diaspore arrival is higher), but also in those that are high on the vagueness axis (such as abandonment areas, wastelands, brownfields).

The round goby *Neogobius melanostomus*: an exploitable resource within an invasive range

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The Ponto-Caspian goby *Neogobius melanostomus*, is probably one of the world's most widespread fish in the wild, now widely occurring in North America and Eurasia and likely to spread further in the future. It was first recorded in the Baltic Sea in the Gulf of Gdansk in 1990 and now occurs on the coasts of all Baltic Sea states, arriving to the south-east Baltic in 2002. It's biomass has been sufficient, despite its size, to result in the development of a seasonal fishery using gill-nets. The abundance has been dependent upon the coastal high densities of the mussel *Mytilus trossulus,* morphologically similar to the zebra mussel *Dressena polymorpha,* a principal food within its home range. Here we look at the population development and how the species is now accepted as part of the commercial catch and processed for export. In Lithuania, this fish is also the subject on an annual festival in spring. The goby-fest, a day's angling from an extended sea-pier, provides an out-of season event for a local town and promotes the species as a culinary speciality. Such innovative approaches to non-indigenous species provides opportunities for local communities which did not previously exist.

Waterlogging and leaf removal effects on greenhouse gases emissions mediated by *Gunnera tinctoria*

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Whilst increasing attention has been directed at the possibility that plant invasions might increase greenhouse gas emissions there is still little or no information on how these are impacted by different environmental conditions or after the removal of above ground parts. One important invasive plant associated with significant negative impacts on ecosystems in Ireland and elsewhere is *Gunnera tinctoria* Molina (Mirb.). To examine how *G. tinctoria* influences greenhouse gas emissions, under different conditions, we subjected 48 plants to the following treatments: (1) CON = control plants subjected to normal watering; (2) WAT = plants subjected to rhizome flooding; (3) CUT = plants that had the leaves removed, but were watered normally; (4) CW = plants where leaves were removed and subjected to rhizome flooding. Both CUT and CW showed higher CO_2 emissions than CON and WAT, due to reductions in photosynthesis, although CW had lower emissions. While WAT was also associated with a reduction in photosynthesis, due to leaf damage caused by anoxic conditions, there was a slower effect under flooded conditions (i.e., after a month). For N_2O, the CUT treatment exhibited higher N_2O emissions that lasted for seven days, while the WAT and CW treatments showed peak N_2O emissions only after seven days of waterlogging. These results show that the removal of leaves/shoots or exposure to flooding can increase short term (i.e., one to seven days) nitrous oxide emissions and longer term (i.e., one month) enhancement of carbon dioxide emissions. Given these results, more attention should be focused on how removal techniques influence greenhouse gas emissions under different environmental conditions as they also might affect carbon budgets.

The evapotranspiration rate is altered by an invasive species, *Hedychium coronarium,* under a greenhouse condition

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Biological invasions may affect several ecosystems processes including primary and secondary productivity, nutrients and water cycling, soil and frequency of disturbance (Vitousek 1986). Invasive plants may entail negative impacts in the water regime since they consume a large amount of water along their life cycle, and maintain a large evaporation rate (Malan & Day 2002). The goal of this work is to compare the evapotranspiration of the invasive species *Hedychium coronarium*, and four different native trees (3) and herbaceous (1) species of riparian forest. Under a greenhouse condition, in 3 replicates of 1000 l box, we simulated three different situations: 1) we planted only *H. coronarium*; 2) we planted the 4 native species; and 3) we planted *H. coronarium* and the native plant species (mixture). Adapted to each of 9 box we have a lysimeter with a diver wich measure the evapotranspiration every 15 minutes. We compare the data using t-test, Mann-Whitney test, and Gribovszki (2008) method to calculate the evapotranspiration. The results were different in the three situations (*H. coronarium* X native plants – t= 1.9888; p= 0.0489 –; *H. coronarium* X mixture – z= 10.8084; p< 0.0001 –; native plants X mixture – z= 13.4302; p< 0.0001). The evapotranspiration's rate of *H. coronarium* plants was higher than native species, probably because of their greater leaf area and because of the superficial roots, compared to the tree species, which may help accumulate water on the soil surface. Our results revealed that the presence of the invasive species *H. coronarium* in riparian forest may be changing the water percolation into the soil.

Allelopathic effects of the invasive plant species *Reynoutria japonica*: what potential consequences in the replacement of native species?

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Many plant species developed biochemical mediators to interact with others. Such allelopathic abilities could play a key role to explain the potential impacts of invasive plant species on local communities. An increasing occurrence of the well-known widespread terrestrial invasive plant species Japanese knotweed, *Reynoutria japonica* Houtt, 1977 (Polygonaceae) has been observed in many European riparian systems. In large river, hydrological constraints as floods modify biological processes, integrating an edge dynamics at the water-riverside interface where many resources in banks are transported into the lotic environment. The terrestrial invasive species, *Reynoutria japonica*, is now usually located on this interface, progressively replacing native plants (Lavoie, 2017). However, biotic effects of the biochemical mediators from *R. japonica* plant leaf litters to limit the growth of native plants are still poorly understood. We studied those effects from *R. japonica* leaf litters on terrestrial and semi-aquatic plant dynamics throughout a long period of decomposition, compared with those of a native plant species, *Rubus fructicosus*. Allelopathic effects of both invasive and native species were assessed through phytotoxicity tests conducted over a six-month period. Major findings showed that (i) biochemical mediators from *R. japonica* and *R. fructicosus* leaf litters induced a root reduction of both terrestrial and semi-aquatic model species, (ii) the root reduction was maintained with *R. fructicosus* leaf litters all over the decomposition period, and (iii) *R. japonica* leaf litters showed a particular pattern with three phases, an initial inhibitory root effects that reduced in April-May and restart in June. This study emphasizes that the replacement of native species may thus enable the emergence of other mechanisms of regulation linked to phenology.

Reference

Lavoie, C. (2017). The impact of invasive knotweed species (*Reynoutria* spp.) on the environment: review and research perspectives. Biological Invasions, 19(8), 2319-2337.

Introduced species that overcome life history tradeoffs can cause native extinctions

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Introduced species threaten native biodiversity, but whether exotic species can competitively displace ecologically similar native species remains contested. Building on theory that predicts multi-species coexistence based on a competition-colonisation tradeoff, we derive a mechanistic basis by which human-mediated species invasions could cause extinctions through competitive displacement. In contrast to past invasions, humans principally introduce modern invaders, repeatedly and in large quantities, and in ways that can facilitate release from enemies and competitors. Associated increases in exotic species' propagule rain, survival and competitive ability could enable some introduced species to overcome the tradeoffs that constrain all other species. Using evidence from metacommunity models, we show how species introductions could disrupt species coexistence, generating extinction debts, especially when combined with other forms of anthropogenic environmental change. Even though competing species have typically coexisted following past biogeographic migrations, the multiplicity and interactive impacts of today's threats could change some exotic species into agents of extinction.

Feeding habitats of invasive gobies in a restored section of the Upper Rhine: potential consequences on macroinvertebrates

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The Upper Rhine River (France, Germany) represents today an incredible melting pot of exotic species. Our study takes place on the biomonitoring of an ambitious restoration program along the Old Rhine River, a 50-km long by-passed reach, located downstream of the Kembs dam. The restoration actions (a controlled bank erosion program achieved in 2013) and the settlement of Ponto-Caspian invasive gobies were concomitant. We investigated the feeding ecology of gobies in this context of restored habitats by gut content analyses. We completed this approach with an environmental DNA analysis of 60 gut contents (18S marker). A sharp increase in *Neogobius melanostomus* (round goby) and *Ponticola kessleri* (bighead goby) in fish assemblages has been observed since 2015 at the expense of native species. *N. melanostomus* was largely more abundant than *P. kessleri*, especially in the restored section. While *P. kessleri* displayed a predatory fish feeding habit, the diet of *N. melanostomus* was dominated by macroinvertebrate species. The monitoring of macroinvertebrate communities provided a prey availability spectrum on the restored- or not restored river sections. The variations of prey availability between locations modified the feeding habits of round gobies, reflecting an opportunistic behaviour. The gut contents were dominated by the most abundant invertebrate species in the river bottom, the invasive Crustacean *Dikerogammarus villosus* and several Diptera Chironomidae. The consumption of insects (Trichoptera, Ephemeroptera) and zooplancton was confirmed by both molecular and macroscopic analyses. We discussed the potential consequences of this pressure by gobies on the changes of macroinvertebrate communities.

Autotoxicity of Ambrosia artemisiifolia allelochemicals

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We have been researching the possibilities of reducing invasive plant species for decades. Among these research studies are of paramount importance for the suppression of common ragweed (*Ambrosia artemisiifolia*). Hungary is considered to be the most infected country in common ragweed in Europe, subject to strict authority measures, but its importance has not diminished.

In the course of our research, we set up an experiment to investigate ragweed autotoxicity. It is known that allelochemicals produced by ragweed, polyacetylene derivatives inhibit the growth of other plant species in their environment. The aim of the present study was to evaluate whether the allelochemicals produced by the *A. artemisiifolia* individuals with advanced foliage in the soil exacerbated the germination of the ragweed seeds in the soil and the growth of hatched ragweed plants. The significance of this experiment is to examine whether the toxicity of ragweed in the soil can play a role in reducing the species in not disturbed areas.

In our experiment, the seeds of ragweed were sown in a soil enriched with the vegetable residue of ragweed and extracted with an aqueous extracts made from the vegetable residues of ragweed and in the irrigated soil and untreated control soil. An experiment was carried out in a greenhouse in 100-division propagation trays, with 4-4 replications per treatment. The results showed that the treated soils did not affect the germination percentage of the discarded ragweed seeds, but in the soil enriched with the plant residues of the ragweed, the ragweed seeds produced prolonged warts compared to the untreated control.

The sterile male release technique approach as a method to control aquatic invasive species: a case study on the American bullfrog (*Lithobates catesbeianus*)

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Widespread populations of the invasive species *Lithobates catesbeianus* (American bullfrog) are present in different parts of the world and are difficult to control. Existing control methods to remove larvae and adults proved to be insufficient to prevent further expansion of these populations.

This study investigated the possibility to sterilize individuals of this species in order to use the sterile male release technique (SMRT) in controlling these invasive populations. The technique can be adopted in aquaculture facilities as well to prevent new introductions by incidental releases or escapes.

In order to produce sterile individuals a cold and pressure shock protocol were used on fertilized eggs to create triploid individuals. The cold shock did not result in triploid individuals while 90% triploids were obtained from a pressure shock, the remaining individuals being aneuploid. The triploid and control larvae were reared for more than one year and the control larvae had a greater length after 7 and 9 months, their weight did not differ. At metamorphosis no difference in length and weight was found between the two groups. The subadult bullfrogs from both groups showed 9 months post metamorphosis a similar scaled body mass index but lower than individuals living in the wild. When the individuals reached sexual maturity they were tagged and released in an enclosure and monitored with a pit-tag antenna system to evaluate their reproductive behavior compared to wild bullfrogs. After making up a detailed population model of the bullfrog this technique can be used to control their widespread populations. Moreover, the technique can be adapted to control other suitable aquatic invasive species.

Who should manage on sites? The second generation element of a legal system to control invasive alien plants

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In 2002 the Conference of the Parties to the Convention on Biological Diversity adopted the Guiding Principles on the control of invasive alien species (decision VI/23), which has short sentence on collaboration for on-site management. On the other hand, in the field of natural resources management and, in some degree, invasive alien species management, the idea of multilevel collaborative management has been developed.

After 2002, several countries such as England, France and Japan have introduced legal systems to control invasive alien species for biodiversity conservation, such as prohibition of introduction and trade. Among those three countries, only England has obliged landowners to manage invasive alien plants and given power to the Environmental Authorities to require landowers to carry out management. Those legal provisions have contributed relatively rapid response to *Ludwigia grandiflora*, invasive aquatic plant native to South and Central America and Southern parts of the USA, which has resulted their local eradication in 10 sites until 2015. France and Japan have not obliged anyone to carry out on-site management. It depends on the discretion of government officials or private landowners. It is difficult to expect rapid response in those situation.

Then we should clarify what is the meaning of "responsibility" of landowners in the reality of implementation. We carried out interviews with government officials, site managers and researchers, and visited management sites in England in September 2016 and September 2017. We found that landowners must not carry out on-site management solely by themselves. The Environment Agency provided technical advices to landowners. In addition, in some case the Environment Agency and the Natural England, executive non-departmental public body, provided financial support for landowners in carrying out on-site management.

We should recognize responsibility of landowners as an important element of multilevel collaborative management.

Anthropogenic predictors are required to model the distribution of invasive species

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More than one third of invasive species freshwater invasive species cause negative impacts (Vilà et al. 2010) threating the most diverse and endangered ecosystem in the world (Dudgeon et al. 2006). Therefore, studying invasion pathways and placing measures for preventing and managing introductions is an Aichi Target (UNEP 2011). Species Distribution Models have been proven useful to address these requirements; however, most of these studies use bioclimatic predictors obviating the human-induced dispersal (Papeş et al. 2016). We assessed the distribution of eleven non-native invasive species in Great Britain using three SDM algorithms tested with a robust approach based on independent evaluation and TSS, AUC and null models. Our aims were to identify: *i*) what type of predictors better explain the distribution of the species and *ii*) which species traits affected the model predictive performances. Our results indicated that using both, environmental and anthropogenic predictors provide better model performances. Therefore, although environmental variables are important for describing the potential distribution, a more effective management might derive for the use of more focalized actions according to those detected patterns of human-mediated invasion. The distribution of freshwater species that lack economic interest, have arrived recently, and have a restricted distribution range were particularly difficult to predict, and should therefore be a research priority.

Management of invasive alien plants along roadsides

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Roads play a significant role in the spread of invasive alien plants (IAPs) by serving as corridors for dispersal as well as providing habitat for their establishment. Globalization facilitates travel, transport and trade therefore, new species are continually being introduced either intentionally or accidentally into non-native environments. As a consequence, ecosystems that have been heavily modified by humans are more often prone to invasions by IAPs. Transport infrastructure habitats are characterized by harsh growth conditions in regard to soil fertility, sunlight and abiotic stress factors like drought and salt. However, such conditions may provide suitable habitats for IAPs along roadsides. A high disturbance regime caused by road construction and maintenance activities might further promote their introduction and spread. The colonization of road verges by IAPs often enables progressive spread into adjacent environments. Once IAPs have been established along roadsides they may replace native vegetation.

In the project ControlInRoad, (http://www.controlinroad.org; financed by CEDR), we plan to compile a list of IAPs related to traffic, evaluate methods for IAPs management, develop a best practice guide for road construction and maintenance and apply cost-benefit analysis for best practices.

Moreover, current best-practice management techniques will be reviewed and new technologies will be tested on selected IAPs. One of the test methods is based on high voltage electric power. To improve the growth rates of native flora we are also testing seeds inoculated with beneficial bacteria. The results of the first trials will be discussed. As roadsides can play an important role in the introduction and spread of IAPs, the development of effective management procedures is an essential step to ensure a sustainable progression of the infrastructure in the future.

Seasonal variation of invasive and native Codium species assessed using eDNA barcoding.

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Early detection of the invasive algae *Codium fragile* (green sea finger) can help in its control and management. A molecular based approach for invasive species detection, the environmental DNA (eDNA), has proved successful among the aquatic invasive species but its potential use for the early detection of algae and aquatic plants remains understudied. The distribution, abundance and coexistence along the Northwest Atlantic Coast of Iberian peninsula of the invasive and native Codium species (*Codium vermilara*, *Codium tomentosum* and *Codium decorticatum*) is unclear and needs better estimation of invasive processes. We designed species specific barcodes targeting short fragments of coding rbcL gene for the invasive species and elongation factor Tu (tufA) gene for native species, in order to assess spatial and seasonal variations of all the species using quantitative real-time PCR. eDNA samples were collected at four stations, two ports, a beach and at a rocky platform during summer, autumn and winter. We found seasonal differences between invasive and native species with no presence of *C. decorticatum* at any point. There was an obvious dominance of the *C. fragile* in ports which are invasive species hotspots. The species distribution patterns produced through eDNA barcoding coincides with the distribution patterns observed with previous conventional sampling. The fast and accurate detection of *Codium sp.* species provide a solid ground for the use of eDNA for the early detection of invasive algae species.

Mapping of invasive alien *Spiraea tomentosa* L. using airborne imaging spectroscopy and laser scanning data.

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Spiraea tomentosa is one of the invasive alien species posing local threats to transition mires in western Poland. It encroaches on transition mires and quaking bogs protected by the Natura 2000 network (habitat code: 7140) and is particularly expansive on peat bogs degraded as a result of land drainage. This species is now naturalised not only in Poland, but also in several European countries including Denmark and Germany. Due to a considerable threat posed by *Spiraea tomentosa* to valuable ecosystems, attempts are being made in Poland to identify and to control the species at early stages of its invasion. The research focuses on the use of HySpex hyperspectral images and LiDAR data for the identification of the *Spiraea tomentosa*. The study area is located in the range of the Lower Silesian forests in Poland and is protected as a Natura 2000 site. Airborne data were acquired two times in the growing season (August and September 2016) parallel to botanical field measurements. The 1 m resolution HySpex images were corrected atmospherically, radiometrically and geometrically. LiDAR data acquired at 7 points/m^2 were used to generate several products, e.g. Canopy Height Model (CHM). After data fusion, the Random Forest classification was used to identify the species. As a result, high accuracy was obtained: the overall accuracy was about 98%, Kappa coefficients were about 0.8. According to the botanical opinion, slightly better results of species identification were obtained in the second session, which may result from discoloration of the *Spiraea* leaves at the end of the growing season and smaller contribution of herbaceous species. The obtained results have a high application potential and show that while maintaining a high information capacity of hyperspectral data and with a well-scheduled survey flight, it is possible to map this species in the early phases of invasion.

Managing invasive plants in quarry sites: patterns, issues and opportunities

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The environmental conditions generated by quarrying activities often allow the establishment of habitats of high conservation value, e.g. calcareous grasslands. However, disturbances and soil movements in quarries can also enhance plant invasions, which can impede the successful rehabilitation of the area, generate additional management costs and affect the corporate identity.

Here, we report on three complementary studies conducted in collaboration with quarrying companies in different European countries: i) a comprehensive assessment of the occurrence and density of alien plants in active and abandoned quarries, with a focus on the type of habitat invaded; ii) a survey of the perception of the issue by quarry operators; and iii) experimental tests of technically feasible methods to set up prevention, eradication and containment measures.

A total of 45 invasive species were recorded and out of the 51 visited quarry sites, only one was free of invasive plants. Overall, waste soil heaps and extraction pits were the most invaded areas. The species with the highest occurrence rate and density was *Buddleja daviddi*, followed by *Senecio inaequidens* and *Robinia pseudoacacia*. Intentionally planted trees represented a significant part of the total alien plant records. The survey revealed that despite the level of awareness greatly varied among countries, operators were globally aware of the invasion issue but only knew the most established species. Several management actions were already performed, for an estimated cost of 500 to 5000 €/year.site. Among the tested management methods, combining the restoration of calcareous grassland with the containment of invasive plants showed mitigated results. In contrast, the rapid seeding of heaps and bare grounds appeared as one of the most feasible and promising option. Playing on the priority effect and the density of grass (*Lolium multiflorum*) was key to reduce the performance of invaders.

National Plan to prevent, control and monitor wild boar in Brazil

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Wild boars (*Sus scrofa*) are a serious environmental and agricultural pest across Brazil. It was introduced for breeding during the 1960s and occurred an invasion from Uruguay in 1989. In 1995, the problems caused by wild boar in southern Brazil were mounting and the federal environmental agency (Ibama) allowed its management into invaded municipalities. In 1998, Ibama prohibited to import and open new breeders. However, the specie continued to spread throughout the country. From 2005 to 2015, the number of invaded municipalities increased from less than 100 to more than 500. Currently, Brazil has 563 municipalities with wild boar records (652,763 km2) in fifteen states. In 2013, Ibama decreed the wild boar harmfulness in the national territory and instituted the Inter-institutional Committee on management and monitoring of wild boar populations. Ministry of the Environment and Ministry of Agriculture, Livestocks and Supply articulated national actions throughout the country by National Plan to prevent, control and monitor wild boar in Brazil (Wild Boar Plan). The Wild Boar Plan is the first invasive alien species national plan and its elaboration involved several stages: 1) technical meetings between Ibama and researchers, hunters and animal protection associations; 2) seminar about the wild boar invasion; 3) technical document including the invasion diagnosis; 4) public consultation and 5) workshop with all actors involved to elaborate the Plan. Approximately 60 people from governmental, non-governmental institutions, researchers and citizens participated in the Workshop and elaborated objectives and actions that will be executed during five years. The Plan general objective is to contain the territorial and demographic expansion of wild boar in Brazil and reduce its impacts, especially in priority areas of environmental, social and economic interest. It has seven specific objectives and seventy eight actions related to: rules, prevention, monitoring, impact mitigation, population control, research, capacity building and communication.

Use of hyperspectral images in the identification and mapping of annual invasive climbing vine *Echinocystis lobata* (wild cucumber)

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Traditional methods of IAPS identification and monitoring are time- and cost-consuming. Thus, it is necessary to develop new precise technique in order to implement effective strategies for controlling the invasion. The increasing number of studies indicate that remote sensing and GIS techniques are useful and valuable tool. *Echinocystis lobata* is one of the 100 most invasive species in Europe. The objective of the research was to check the effectiveness of the mapping method for *Echinocystis lobata* using airborne hyperspectral imaging data and to analyse the effect of data acquisition time on the possibility of classifying an annual vine. Research was carried out in the Bzura River valley in Central Poland. The georeferenced dataset for classification was compiled on the basis of three field campaigns (C1, C2, C3) carried out during the growing season of 2016. The time of on-ground botanical reference data collection was synchronized with the time of airborne data collection (Hyperspectral images; resolution: 1 m^2). The research schedule was established based on phenological traits, including various stages of the species development: C1 - vegetative growth of juvenile individuals; C2 - peak flowering of generative individuals; C3 - yellowing of plant leaves, senescence of individuals. The results of classification performed using the Random Forest algorithm indicate that the mapping of this species is possible based on hyperspectral data (Kappa accuracy – median 0.86). The best time for data acquisition was the period of mass flowering of the plants and their highest cover-abundance values (July).

Managing Himalayan balsam (*Impatiens glandulifera*) invasion while minimising damage to native plant communities

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Himalayan balsam is a non-native invasive species, that rapidly colonises and dominates riparian habitats due to its rapid vertical growth shading native competitors, compounded by its high seed production and seed bank. Invasion of balsam has led to major environmental and economic costs across Europe. In the UK, annual control costs have been estimated at >£1 million. Therefore, control of this invasive species is a crucial target of local, national and international management plans. However, typical control methods include pulling or cutting/strimming at the plant base. Pulling leads to destabilisation and loss of soils, which increases sedimentation in adjacent waterbodies. Cutting easily physically damages native understory plant communities. Both of these control methods can prevent recovery of native vegetation following balsam control in invaded areas. We tested the efficacy of cutting Himalayan balsam at its base, half-height (approx. 1m) and above the top leaf node, across 3 summer months (June, July and August), to assess the impact of treatment and timing on the number of flowering heads, change in leaf number and leaf area in September, in a field trial in South Wales, UK. Our results showed that cutting balsam plants at half-height in July led to the best overall results, with total loss of flowering heads and leaves by September. July cutting minimised potential regrowth from (earlier) June cutting, or early seed production from (later) August cutting. If repeated across years, to exhaust the seed bank, we hypothesise the half-height treatment will simultaneously control the spread of balsam, while minimising the negative impacts of direct physical damage on native vegetation and soil loss on the wider ecosystem, of alternative control methods.

Use of molecular markers to infer invasion pathways in a marine biodiversity hot spot: the case of two caprellid species (Crustacea: Amphipoda) introduced into the Strait of Gibraltar

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In European waters, approximately 1500 marine non-indigenous species (NIS) have been introduced, some in important biodiversity 'hot spots'. The ever-increasing global maritime trade and rising seawater temperatures, associated with global climatic change, are drastically accelerating the introduction of these species. Therefore, legislation has been adopted. Both the Marine Strategy Framework Directive (MSFD, 2008/56/EC) and the EU Biodiversity Strategy (EU 2011) specifically stress the need to assess the pathways of biological invasions to construct a predictive framework for the prevention of future introductions, risk assessment and design of appropriate management strategies. However, this is not straightforward. Traditional method that relies on morphology is the most widely used approach, which is time-consuming, unable to identify source populations or multiple introductions, and not always able to reach species-level resolution, especially when different life stages (larvae, immature) and cryptic species exist. In this regard, molecular techniques provide powerful and reliable alternatives for detection and monitoring of NIS in marine ecosystems.

The Strait of Gibraltar is a region particularly relevant for monitoring NIS due to its geo-strategic position in Europe. It is subject to extensive national and international shipping traffic, as well as aquaculture activity, being considered as a hot spot for biological invasions. Recently, two non-indigenous caprellid species have been reported in this area: *Caprella scaura* Templeton, 1836, first described in the Indian Ocean; and *Paracaprella pusilla* Mayer, 1890, a tropical species first recorded in Brazil. In this study, direct sequencing of mitochondrial and nuclear markers was used to compare genetic variation in potentially native and introduced populations to infer their introduction pathways in this region. Our results point out the existence of multiple introduction pathways and/or source populations, and support the presence of stepping-stone events, which is consistent with the scenario of transport by small vessels.

Ecophysiology of the invasive aquatic mudsnail *Potamopyrgus antipodarum* under stressful environmental conditions

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Invasive freshwater species, such as the exotic mollusc *Potamopyrgus antipodarum* (New Zealand Mudsnail), can frequently survive under harsh conditions, including brackish and hypoxic environments. We experimentally assessed the effects of salinity (0, 10, 20, 25 and 30 psu) and temperature (environmental water temperature and 20°C) on mortality and physiology of *P. antipodarum* collected at Capitol Lake, Olympia, WA USA. We measured metabolic rates and enzymatic activities (Malate Dehydrogenase, Lactate Dehydrogenase, Alanopine Dehydrogenase, etc.) in snails after different acclimation periods (2, 4, 6 and 10 days). Significantly higher mortalities were observed at 25 and 30 psu than under other salinities, with the strongest effects when snails were collected at the end of winter, and exposed to 30 psu and 20°C (100% mortality in 3 days). These snails lasted 5 days at 30 psu when the environmental water temperature was set at 5°C. When snails were collected during the spring, 100% mortality was observed after 40 days at 30 psu and 20°C, and mortality was much less at 30 psu and 10°C, reaching 74±24% after 105 days. At 0 psu and 10°C, mortality was only 5%. Metabolic rates were significantly lower when snails were exposed to salinities of 25 and 30 psu, even after 10 days of acclimation. Enzymatic activities showed small but significant declines after 10 days at higher salinities, and metabolic rates may be affected at the biochemical level under stressful environmental conditions.

Use of reproductive inhibitors as population control agents for invasive squirrels

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Invasive rodents are frequently targeted for control and eradication programmes, often using poison or direct capture (and subsequent euthanasia). These methods are often ineffective in species whose reproductive capacity enables them to quickly outpace population declines or receive public outcry, especially when charismatic species are involved. Instead, for rodents, the chemical inhibition of reproduction is considered an effective alternative for population control. The Barbary ground squirrel is an invasive rodent species, introduced in the island of Fuerteventura, Canary Islands, Spain in 1965. Since its introduction, the species has spread across the island causing severe ecological disturbances as well as agricultural damage. Nonetheless, no eradication or control programmes have ever been established to minimize the species impacts. We studied the efficacy of 4-vinylcyclohexene (VCD), a highly ovotoxic chemical, as a fertility control agent. We conducted a field experiment with 38 randomly chosen females (22 experimental and 16 control females) starting 2 months before the breeding season. Every time we live-trapped the females, we gave the VCD (mixed with peanut butter 1:1, 500 mg /kg) to the experimental females, or a similar amount of peanut butter without VCD (0,45 ml/kg), to the control ones. Females were euthanized in order to determine pregnancy, litter size and evaluate the impact of VCD on the ovary. All females (VCD treated and control) entered oestrous. Litter sizes did not differ between the VCD-treated and control females. However, our preliminary results suggested VCD could have caused follicular depletion in treated females.

Evaluation of knotweed glyphosate control effectiveness

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Current knowledge shows that invasive alien plants can cause local or complete extinction of indigenous, often valuable, endemic species. The presented work deals with invasive taxons of the genus *Fallopia* (knotweed), which spread in the Czech Republic uncontrollably despite of nature conservation management. Their high regeneration ability from the rhizome systems and production of extremely high amount of biomass are the main reasons of their spreading success. Spraying by systemic herbicide glyphosate is used as the most effective control method but still little is known about its effectiveness. Within this study, series of field and garden experiments were carried out to evaluate the effectiveness of spraying in different periods of vegetation season and application to different physiological stages of plants too. The main aim was to find how the herbicide spraying influence the following regeneration from rhizomes and to compare the reaction among parental taxa and their hybrid. The effectiveness of spraying on above ground biomass is well known, but how are influenced the underground rhizomes and following regeneration from rhizome buds is still not clear. All three invasive taxons from the genus were used for the study: *Fallopia japonica* var. *japonica* (Japanese knotweed), *Fallopia sachalinensis* (giant knotweed) and a hybrid *Fallopia ×bohemica* (Bohemian knotweed). Plants were sprayed by glyphosate and then the regeneration from rhizomes was studied. Main results show strong differences in several aspects of control among taxa and in reaction to spraying in spring/summer and autumn too. The autumn application has stronger effect on above ground biomass but regeneration from rhizome buds was affected less than after spring/summer application. Also the selected herbicide concentration affects the rate of regeneration from rhizomes. All studied taxa regenerate less after spraying by 8% herbicide concentration than by 5%.

From the space to the ground: tackling invasive species impacting agriculture combining earth observation and modelling techniques

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Due to increasing global trade and transport, invasive species impacting agriculture reach new areas, suitable for establishment and growth, at an unprecedented rate. The real and potential negative impact of these emerging invasive species into the agriculture sector is enormous, particularly for low and middle income countries due to the limited resources available and large areas to manage. For example, fall armyworm (*Spodoptera frugiperda*) is a well-established pest in North America which has recently invaded Africa causing large crop losses across the continent. Similar impacts have been caused by the tomato leaf miner (*Tuta absoluta*) across the Mediterranean and East Africa and for gorse (*Ulex europeaus*) in South America. These new invaders provide an opportunity not only to understand invasion processes due to their rapid spread but also to transfer our knowledge on invasive species to mitigate their impact on the agricultural sector. Current developments in Earth Observation and data availability combined with modelling tools can be extremely useful to inform management decisions efficiently for these invasive species. Building on current projects developed by CABI together with UK and in country partners, we will present how Earth Observation and modelling tools can be combined to inform: 1) prevention, by identifying the potential distribution of the species; 2) early warning, by forecasting and monitoring outbreaks; and 3) control, by forecasting the efficacy of putative biocontrol agents. Adoption of these advanced techniques in different cultural setups and complex environments also incurs challenges such as data availability, ownership and information dissemination that need to be carefully identified for effective implementation.

Social perception on invasive cat impacts: learnings from an inhabited islet

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Surveys constitute a very valuable tool that allows planning cat control or eradication campaigns on the inhabited islet (La Graciosa, Canary Island), particularly needed when prevention of a social rejection against these management strategies could detain any conservation action. So, social support represents an indispensable aspect in order to succeed on an eradication program, especially when species affectively linked to humans are involved. Survey was accomplished to 345 residents of the islet (46.43% of the total population) giving a robust idea of the perception about the cat problematic on this islet. Respondents were aware about their problems but beyond their value as pet, useful for the control of rodents. A general consensus was found regarding the priorities when implementing any control/eradication method, being preferred methods to manage cats those that did not involve cats' death or suffering. From obtained results, two different approaches can be carried out controlling cats on La Graciosa. Firstly, feral cat populations must be completely removed and humanely euthanized because it is impossible to adopt them due to their aggressive behaviour. Secondly, stray and unowned domestic cats could be capture, neutered and posterior adoption outside the islet, i.e Lanzarote. It was seemingly supported by a major fraction of the surveyed population, being an effective method to control cats on biodiversity rich areas as oceanic islets are still public acceptance on cats' control methods is known to vary across social groups or when total eradication is undesirable or impossible. This survey and the presented methodology could be extrapolated and adapted to the myriad of inhibited island and islets worldwide whose biological values are actually threatened by cats and where any type of cat management is required. An effective education or social programs are required for increasing the awareness of local communities to conservation problems.

Remote sensing methods as an effective tool for mapping *Solidago gigantea* on alluvial meadows – Natura 2000 habitat.

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Solidago gigantea is one of the most invasive plant species in Central Europe. The species mostly occupies disturbed areas and abandoned fields, but it is also considered as a big threat to valuable semi-natural non-forest communities, including alluvial meadows (Natura 2000 habitat, code 6440). High above-ground biomass and dense root systems of *Solidago gigantea* can quickly dominate original meadow species. Both Polish and European law requires regular monitoring of conservation status of the 6440 habitat, which involves the encroachment of invasive plant species.

Remote sensing methods are continuous, objective and reproducible. They are increasingly used for vegetation and plants mapping. Especially with hyperspectral sensors allowing to detect particular plant species thanks to hundreds of narrow spectral bands they seem to be an effective tool to identify the threat of encroachment of invasive plant species into meadow habitats.

The aim of this study was to analyze the possibility of using remote sensing data for mapping *Solidago gigantea* in the particular patches of the 6440 habitat, depending on the time of data acquisition.

The studies were conducted on the protected Natura 2000 area (PLH180020, Poland). Remote sensing data used in the research included hyperspectral imagery (HySpex VNIR-1800 and SWIR-384 cameras, 451 spectral bands, 1 m spatial resolution) and LiDAR data (Riegl LMS-Q680i scanner, 7 points/m2) acquired simultaneously, three times during the growing season 2017 (spring, summer and autumn). The botanical data were collected during the mass flowering time of *Solidago gigantea*. These data were used as training and validation samples to classification with Random Forest algorithm.

The potential of environmental DNA for monitoring elusive and invasive mammals in the British Isles

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Determining species occurrence, and/or abundance can be particularly challenging when the species exists at low densities and is difficult to observe directly or indirectly by field signs. The use of environmental DNA (eDNA) metabarcoding has become a vital tool for determining the distribution of a wide variety of species, and has been particularly successful in monitoring species in aquatic environments. Mammals have so far been relatively neglected in eDNA studies in aquatic environments but it has the potential to provide data on the distribution and abundance of several elusive mammalian species, particularly priority species such as the water vole (*Arvicola amphibius*), and the otter (*Lutra lutra*). In addition, species like the water shrew (*Neomys fodiens*) could potentially be more readily monitored and it could provide early detection of invasive species such as the American mink (*Neovison vison*). Our primary aim in this pilot study is to test the utility of eDNA to determine the presence/absence of these species in sites in northern Scotland and the Peak District in the UK. We also aim to determine if eDNA data are correlated with actual abundance data from extensive field survey data from the water vole, so that the technique could be used to determine abundances of different species in future studies on a national level.

Comparing the efficiency of selected invasive plant species mapping using airborne remote sensing methods

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Remote sensing methods are increasingly used for invasive species mapping. As compared to the conventional mapping, they are continuous, objective and reproducible. Also, they make it possible to identify the threat in a short time on a very large and often difficult to explore areas. However, one of the basic factors affecting the efficiency of this mapping method is the limitation connected with the detection of the plant species at low cover percentage.

As part of the HabitARS project carried out between 2016 and 2018 we attempted to develop the methodology of invasive alien plant species mapping using remote sensing techniques. One of the main aims of the research was to define the cover percentage threshold at which given species is detected. The research was carried out on chosen plant taxa which are considered invasive in Poland i.e.: Echinocystis lobata, Heracleum spp., Lupinus polyphyllus, Solidago spp., Spiraea tomentosa, Reynoutria spp., Rumex confertus.

The remote sensing data consisted of simultaneous acquisitions of hyperspectral images from HySpex cameras with spatial resolution 1 m and LiDAR data with point cloud density of 7 pts/m^2. Simultaneously with the aerial data, botanical studies were conducted to collect samples for training and validation with cover percentage of the species ranging from 20 to 100%. The set of aerial and field botanical data were used to conduct the supervised classification using the Random Forest algorithm.

The results suggest that the threshold of the minimal cover of a species allowing its detection using multi-sensor data is varied and its differentiation results from the functional traits of the species.

Assessing associations between pathways of alien plant invaders and their impacts in South African protected areas

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Protected areas face mounting pressures, including invasion by alien plant species. Scientifically sound information is required to advise management strategies, where early detection and rapid response is particularly important. The approaches are: (i) determining species that may have the largest potential impact on biodiversity and human livelihoods, and (ii) associating those species with their pathways of introduction, and (iii) based on this information, assessing and prioritising pathways of invasion to be managed. This assessment was based on 139 alien plants that are, based on available literature and expert opinion, most invasive across the South African National Parks (19 national parks, covering ~39,000 km[2]) and reported to have impacts. Nearly 80% of the species with impacts are ornamental plants and about 60% are also be dispersed by rivers, which highlights the importance of managing ornamental species and surveillance along rivers, respectively, in preventing future invasions. As to the impacts, ~95% of the species compete directly with native species and 70% change the physical structure of the environment. The majority of species exert multiple impacts, which is illustrated by 70% of the total number of species assessed to have impact in five or more categories. There was a significant positive relationship, based on generalized linear models, between the number of pathways via which a species can be introduced into an area and the number of potential impacts they can have. This suggests that species using multiple pathways reach a wider range of suitable habitats which increases the potential for different kinds of impacts over a wider area.

Management of invasive parakeet (*Psittacula krameri*) in an insular Biosphere Reserve (La Palma, Canary Islands): combining methods and involving volunteer's networks

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Ring-necked parakeet (*Psittacula krameri*) has become a worldwide invasive species and in La Palma Island Biosphere Reserve was naturalized from different escapes or releases at the end of 1990s. In 2015, a total breeding population of 70 birds was observed in two different localities. Due to the damage provoked in cultivations and land owners complaints, the Island Government decided to manage them. From December 2015 to September 2016, 14 decoy traps were used to capture a total of 116 parakeets (birds bred during this period). In order to set up the traps, land owners were involved by authorizing trapping activities and checking the traps. Any time a parakeet was captured, volunteers called government staff to remove the birds. Due trap shyness development, a rest period was required, closing and removing traps from October 2016 to November 2017. At this stage, 20 parakeets remained in the field. One year later, census showed two breeding populations in the same two different municipalities with about 35 parakeets. In December 2017 traps were set up again, resulting in 12 captured parakeets in a three weeks period. In spite that it has been demonstrated that trapping is a very effective method to capture the main population all year round, breeding season and birds behavioural changes forced to switch methods from trapping to shooting. A volunteer team of local shooters was selected to collaborate within the project, while trained in public and security protocols specifically developed for the project. Up to end of March 2018, a total of 33 birds have been removed by shooting. To avoid social conflicts, public meetings were organized during the entire project to explain the activities involving, stakeholders, technicians, decision makers and animal right associations. Effort continues to remove the remaining three wild parakeets in the environment.

P268

Bridging the gap between invasive species research and management

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The body of scientific literature surrounding invasive species has been rapidly growing concurrently with the introduction and spread of new invasive species. Despite expanding knowledge and technological advances, there continues to be a disconnect between research and management that can hinder the understanding and application of new solutions to invasive species challenges. Additionally, academics are often unaware of the reality faced by invasive species managers on the ground including their information needs and thus their research often does not address these needs. In effort to bridge this gap, New York State has established the New York Invasive Species Research Institute (NYISRI) based at Cornell University in Ithaca, NY. NYISRI has the specific mission to communicate and coordinate invasive species research to help prevent and manage the impact of invasive species in New York State and beyond. Through extensive interactions and surveys of research needs from invasive species managers, the NYISRI has developed strategies and programs to improve the scientific basis of invasive species management. This presentation will highlight what invasive species managers perceive they need from the research community in order to better manage invasive species on the ground and how researcher can improve and guide the decisions made by practioners and policy makers. It will also provide an overview on how invasive species managers and researchers can co-produce valuable information in areas ranging from managing for invasive species in light of climate change to deploying and testing the effectiveness of new control methods. Researchers can benefit from these interactions by designing impactful and actionable research and managers can be an integral part of the development and implementation of research programs.

P269

The European trade ban on wild birds drastically reduced invasion risks

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International wildlife trade is a major source of current biological invasions. However, the power of trade regulations to reduce invasion risks at large, continental scales has not been empirically assessed. We tested whether the European wild-bird trade ban implemented in 2005 to counter the spread of the avian flu reduced invasion risk in two European countries, where 398 non-native bird species were introduced in the wild from 1912 to 2015. The number of newly introduced species per year increased exponentially until 2005 (in parallel with the volume of wild-bird importations), and then sharply decreased in subsequent years. Interestingly, a rapid trade shift from wild-caught to captive-bred birds, with lower invasive potential, allowed the maintenance of bird availability for sale in markets. Our results demonstrate the effectiveness of a regional trade ban for preventing biological invasions without impacting the ability to meet societal demands.

P270

Learning from experience: Spatial and temporal scaling in Invasive Alien Species management

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Costing the removal or suppression of established invasive species is a key factor used by decision makers to assess the feasibility of control. However, predicting the time and effort required to manage Invasive Alien Species remains a challenge, particularly where different strategies need to be employed across different spatial scales and in response to changing population densities. We show how we can improve our ability to predict likely resource requirements for both eradication and ongoing control. Using detailed spatial control data from the EU LIFE and HLF funded Red Squirrels United project as a case study we demonstrate how efficiencies vary at different stages of invasion of the grey squirrel in the UK and Northern Ireland. We explore the effort demands and effectiveness of different detection (active and passive monitoring) and control strategies and how these change across spatial scales. We collate our findings with those of other control programmes and propose standardised measures of control effort to investigate trends across a range of Invasive Alien Species. Understanding these trends will provide decision makers with increased confidence of the magnitude of resource requirements for Invasive Alien Species management.

Marine salt-based method for *Baccharis halimifolia* seedlings and juvenile's elimination. A key stage towards well-established infestations eradication in coastal habitats

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Baccharis halimifolia is an invasive alien plant species of primary concern, especially for European coastal habitats, where it causes serious damage to scarce sensitive and valuable native ecosystems, some *of European Community interest.*

A late social, legislative and scientific response compared to historical pest spread, has led to a point in which management efforts are largely focused on well-established infestations control and containment. However, after mature populations elimination is successfully accomplished, canopy layer shadow removal promotes dormant seed bank activation, leading to an aggressive and quicker than native species re-colonization by *Baccharis halimifolia*. Conventional chemical herbicides spraying cannot be applied to juvenile fields due to its impact on the environment and non-target species, so current best practice is manual removal plant by plant, a drudgery and high-cost technique, difficult or even impossible to implement in large areas.

Aiming to provide an alternative, we have successfully developed an innovative, cost-effective, environmentally friendly and safe for the workers method based on marine salt selective application as herbicide for *Baccharis halimifolia* control at all post-emergence stages of its life cycle. Divided into two main stages, a first stage is focused on mature individual's elimination, whereas a second one, which results are presented here, is focused on seedlings and juvenile´s elimination.

Reproducing sea spray herbicidal action in coastal habitats, different doses of marine salt dissolved in water where sprayed over 588 *Baccharis halimifolia* juveniles of amongst 5 and 56 days of life. Efficacy rates from 80% to 100% where obtained, whereas substrates salinization assessment allowed optimal doses determination according to efficacy and innocuousness under controlled conditions.

In conjunction with our mature population's elimination method successfulness, these results open the door to a more sustainable and ambitious perspective beyond *Baccharis halimifolia* well-established infestations mere control or containment, making practical eradication possible.

Influences of climate variability on the initial stages of pine invasion: Searching tools for cost/effective management strategies in Patagonia

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Pines are one of the biggest invasive plant management problems in the world. Limited resources are available to control for pine invasions in northwestern Patagonia where escaped individuals from plantations are steadily increasing. Thus, there is urgent need to implement cost/effective pine management measures in this region where invasions are still controllable. Furthermore, climate change projections for the area suggest warmer and drier conditions that may affect pine establishment altering the invasion process. Our primary objective was to evaluate responses (germination and survival) of pines (*Pinus ponderosa* and *P. contorta*) to altered temperature and precipitation in a climate change context. We conducted a manipulative experiment planting seeds and 3-year-old seedlings in the field. We implemented a full factorial experimental design with pines growing in warmed (Open Top Chamber), watered, warmed and watered, and control treatments. Water addition had a negative effect on seed germination of both species, and *P. ponderosa* presented less germination than *P. contorta*. The survival of the germinants was not significantly affected by climatic variables, and *P. ponderosa* had mayor survival than *P. contorta* in all treatments. Temperature had a negative effect on the survival of *P. contorta* seedlings but had no significant effect on the survival of *P. ponderosa*. Finally, *P. contorta* seedlings exhibited a higher mortality in all treatments compared to *P. ponderosa*. Our findings suggest that climate variability may be used as a predictive tool for successful pine establishment forecasting but that is key to consider species identity and ontogenetic stage. This may optimize early control measures by focusing control actions on favourable climatic years for pine establishment. More research is needed; however, to refine climate effects on pine establishment and evaluate the influences of other critical factors, such as masting and seed predation.

Author Index

Lieurance, Deah — P116

Linders, Theo — O51

Linnamagi, Merike — W05

Lioy, Simone — O57

Lipinskaya, Tatsiana — P009

Lipták, Boris — P027

Loiola, Priscilla P. — P215

Lonati, Michele — P133

Lorenzo, Paula — P208

Lososová, Zdeňka — P112, P215

Lowe, Andrew — O06

Lozano, Vanessa — P131, P149, P154

Lucchese, Fernando — P133

Lucy, Frances — FP17, O59, P035

Lucy, Frances E. — P158

Luft, Rebecca — O28

Luke, Belinda — P260

López, Heriberto — P015

López-Darias, Marta — P010, P015, P134, P258, P262

Macaya-Caquilpán, Vivian — FP09

MacIsaac, Hugh — O19

Magellan, Kit — P158

Maggiora, Riccardo — O57

Maguire, Ivana — P229

Mahy, Grégory — P110, P251

Maillard, Jean-Francois — P207

Mainetti, Andrea — P131, P133

Makaranka, Andrei — P009

Malamud, Bruce — P033

Manole, Traian — P209

Mantoani, Mauricio — FP14, O10, P239

Mantoani, Mauricio C. — O05

Marchante, Hélia — P005

Marcinkowska-Ochtyra, Adriana — P263

Marhoul, Pavel — P018

Mariani, Stefano — P264

Marin, Julie — O27

Marinangeli, Francesca — P131

Mariotti, Mauro — P133

Marques, Cristina — P228

Marr, Sean — O45

Martinou, Angeliki F. — O48

Martinou, Kelly — P125

Martinovic-Weigelt, Dalma — P147

Martín-Forés, Irene — O06, P109

Martínez Laiz, Gemma — P256

Martínez Pastur, Guillero — P153

Martínez-Laiz, Gemma — P146

Mason, William L. — P005

Maurel, Noëlie — O30

Mazurska, Karolina — W06

McCard, Monica — P201

McCuller, Megan — O21

McDevitt, Allan — P231, P264

McGeoch, Melodie — P266

Mcgillivray, Lesley — P036

McIlroy, John — O10, P210

McKenzie, Maisie — P264

McKnight, Ella — O29

Measey, John — O25, O63, P025

Medina, Félix M. — P134

Medina, Félix Manuel — P015, P262, P267

Meltl, Andreas — O22

Merta, Dorota — P011

Meyerson, Laura — O43

Meyerson, Laura A. — O25

Michalska-Hejduk, Dorota — P250, P263

Milanesio, Daniele — O57

Milanović, Marija — P213

Mill, Aileen — P270

Miller, Jessica — O21

Minchin, Dan — P023, P238

Minissale, Pietro — P133

Miralles, Laura — P139

Mirra, Inês — P228

Moen, Toril Loennechen — P216

Mofu, Lubabalo — O49, P205

Mohanty, Nitya P. — O25

Mohanty, Nitya Prakash — O63

Montagnani, Chiara — P131, P132

Montero-Castaño, Ana — O35

Montes, Marcos — P139

Monteverdi, Maria Cristina — P005

Montgomery, Ian — FP12, O56, P231

Monty, Arnaud — P110, P251

Moodley, Desika — O25, W04

Moore, Charles — FP09

Moreno, Adam — FP07

Moretta-Urdiales, María del Mar — O09

Morin, Randal — O44

Moroz, Michail — P009

Moser, Dietmar — O24, O30

Mucina, Ladislav — O23

Muha, Teja Petra — P249

Mullerová, Jana — P224

Murphy, Sean — P260

Máguas, Cristina — O42, P228

Múrias dos Santos, António — P256

Müller-Schärer, Heinz — O25

Müllerová, Jana — FP18

Münzbergová, Zuzana — P101

Nadasy, Erzsébet — P001

Navarro, Joan — P008

Ndriantsoa, Serge — P151

Nentwig, Wolfgang — O48

Neumann, Stefan — FP07

Nicolescu, Valeriu-Norocel — P005

Niedzielko, Jan — P250

Nigato, Lisanework — O51

Niksirat, Hamid — P027

Nisbet, David — P032

Nogales, Manuel — P010, P015

Novoa, Ana — O15, O25, P138, P208

Noël, Jean — P151

Nunes, Ana Luisa — P036

Nuñez, Martín A. — P272

Nádasy, Erzsébet — P002

O'Farrell, Patrick — FP02

O'Flynn, Colette — P037

O'Neill, James — FP12

O'Rourke, Brian — O40

Obersteiner, Michael — P136

Ocampo-Ariza, Carolina — O14

Oficialdegui, Francisco Javier — O41

Olenin, Sergej — P023, P238

Orazio, Cristophe — P005

Orešković, Anja — P135

Orsenigo, Simone — P131

Ortiz-Sánchez, F. Javier — O35

Rondinini, Carlo	O28	Selvaggi, Alberto	P131, P133	Storch, David	P143
Ros, Macarena	P146, P256	Sendek, Agnieszka	O17	Stout, Jane	O34
Rosalem, Lívia	P240	Setälä, Heikki M.	O16	Stravinskaitė, Kristė	P155
Rosati, Leonardo	P131, P133	Sevilla, José	P015	Strubbe, Diederik	P035
Rosón Porto, Gabriel	P007	Shackleton, Ross	P138	Stuppy, Wolfgang	P154
Rouifed, Soraya	P241	Shackleton, Ross T.	O25	Styles, John	P260
Roura-Pascual, Núria	P136	Shadbolt, Marcus	O01	Sutherland, Chris	P264
Roy, Helen	O46, P125, W05	Sharma, Gyan Prakash	P122	Svensson, Gabriella L.	O20
Roy, Helen E.	O48	Shea, Katriona	O11, Plen02	Szabo, Rita	P001
Ruette, Sandrine	P207	Sheppard, Christine S.	FP06, P140	Szabó, Csaba	P244
Ruiz, Gregory	O21	Shiferaw, Hailu	O51	Szczerkowska-Majchrzak, Eliza	O18
Ruiz, Gregory M.	FP10	Shuttleworth, Craig	P270	Szporak-Wasilewska, Sylwia	P114, P265
Ruland, Florian	O22, P105	Silva Matos, Dalva	P129, P240		
Rumpf, Sabine	P153	Silva S., Joaquim	P005	Sádlo, Jiří	P120, P235, P237
Russo, Laura	O11, Plen02	Silva-Rodríguez, Eduardo A.	O20	Sánchez, Marta I.	O41
Rödel, Mark-Oliver	W01			Sławik, Łukasz	P253, P263, P265
Rūrāne, Ieva	P014	Simpson, David	P036	Tajovský, Karel	P018
Saavedra, Susana	P267	Siniscalco, Maria Consolata	P131	Takacs, Andras	P001
Sabaini, Raquel	P252			Takács, András	P002
Sabat-Tomala, Anita	P250, P263, P265	Sirnic, Teresa	O28	Tanner, Rob	W05
Saccani, Maurice	O57	Skabeikis, Artūras	P238	Taylor, Bryony	P260
Saheed, Dominique	P206	Skowronek, Sandra	O61	Taylor, Jonathan	O65
Saldaña, Asunción	P144, P145	Skuhrovec, Jiří	P018	Team, Consensus	P105
Sales, Naiara	P264	Skukan, Roberta	P030, P139, P249	Teixeira, Amílcar	O54
Samardzic, Natasa	P038	Sladonja, Barbara	P039	Teixeira, Ivan	P252
Sandvik, Hanno	P216	Smith, Annabel	O31	Tella, José L.	P119, P269
Santangelo, Annalisa	P131	Solarz, Wojciech	W06	Temunovic, Martina	P229
Santos, Bàrbara	P151	Soler, Rosina	P153	Thiel, Martin	FP09
Saska, Pavel	P018	Solofo Niaina Fidy, Jean Francois	P151	Thomas, Chris D	Plen01
Saul, Wolf-Christian	FP15, O25, O48			Thuesen, Erik	P257
Sayer, Carl	P127, P212	Sotes, Gastón	O15	Tiedeken, Erin Jo	O34
Saá, Mercedes	P153	Sottovia, Lucio	P133	Tilman, David	P242
Scalera, Riccardo	O48	Sousa, Ronaldo	O54	Tokarska-Guzik, Barbara	P114, P263, P265, W06
Schaffner, Urs	O26, O51	South, Josie	P123		
Schindler, Stefan	P153	Souza-Alonso, Pablo	P007	Tosh, David	O56
Schipflinger, Mirjam	P004	Spampinato, Giovanni	P131, P133	Traveset, Anna	Plen04
Schlaepfer, Martin A.	FP01	Spear, Dian	P266	Treneman, Nancy	O21
Schmidt, Olaf	O05	Srean, Pao	O29	Tricarico, Elena	P026, P111, P158, P214
Schurr, Frank M.	FP06, P140	Staentzel, Cybill	P241, P243		
Scillitani, Laura	FP11, P017	Stanisci, Angela	P133	Trillo, Alejandro	O35
Searle, Jeremy	P231	Starfinger, Uwe	W05	Trognitz, Friederike	P248
Sebesta, Nicole	O65	Stein, Anke	O30	Tsvetkov, Ivaylo	P005
Sedlacek, Norbert	P248	Stellati, Luca	P026	Turbelin, Anna	P033
Seebens, Hanno	O24, P136	Stenzel, Stefanie	O61	Turner, Sophia	P029
Seidl, Miloslav	P018	Stephens, Kirstin	P025	Twining, Joshua	O56
Seidl, Rupert	FP07	Steves, Brian	O21	Tylianakis, Jason	O01
Seitz, Birgit	FP03	Stinca, Adriano	P131, P133	Uludag, Ahmet	P038
		Stipanicev, Drazenka	P147		

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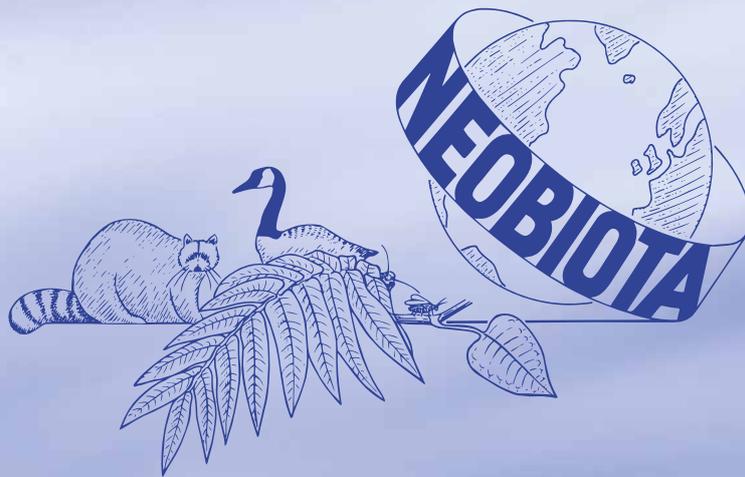PROFESSIONAL
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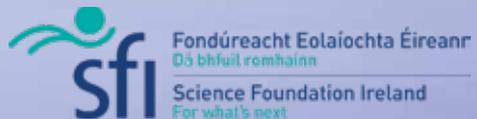
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