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15th International Conference on Ecology and Management of Alien Plant invasions

EMAPi 2019

Integrating research, management and policy

Book of abstracts

Edited by P. Pyšek, J. Pergl & D. Moodley

INSTITUTE OF BOTANY CAS

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

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CONFERENCE PROGRAMME

MONDAY 9 September 2019

15.00 registration opens

18:00–19.00
(KEYNOTE 1) Marc Cadotte: Dissecting the success and impact of urban invasions

Welcome party & poster session

TUESDAY 10 September 2019

8.30 conference opening

(Chair: Cristina Maguás)

9.00–9.40 (KEYNOTE 2)
Jane Catford: Unravelling context dependency in invasion science

SECTION 1 – SPECIES INVASIVENESS: INTRODUCTION, NATURALIZATION SPREAD & MONITORING

9.40–10.00	John Wilson: Invasion frameworks: an assessment of usage and options for improvement
10.00–10.20	Yan Sun: When and how does "origin" matter: from macro-ecology back to experimental ecology to elucidate drivers of invasion success?
10.20–10.40	Thomas Carlin: Plant invasions in non-analogue climates reflect phenotypic plasticity rather than contemporary adaptation

coffee break 10.40–11.10

11.10–11.30	Marco Brendel: Does time heal wounds? Effects of climatic dissimilarity on population dynamics of invasive plants revealed by residence time
11.30–11.50	Heidi Hirsch: A global assessment of the introduction history and population genetic characteristics of the commercially important invasive tree *Acacia dealbata* Link.
11.50–12.10	Luís González: An Atlantic Odissey: the fate of invading propagules across the coastline of the Iberian Peninsula
12.10–12.30	(flash talks) Mauricio Mantoani: Surviving the cold: impacts of an extreme weather event on the growth and phenology of *Gunnera tinctoria* Andrei Costan: Reduced herbivory does not increase competitive ability or shift chemical defences in alien *Rumex* Francesco Guarino: Epigenetic aspects involved in plant invasiveness Sandra Savinen: Applications of bioinformatics to identify genotypic differentiation in alien plants

lunch 12.30–14.00

(Chair: Mark van Kleunen)

14.00–14.40 (KEYNOTE 3)
Franz Essl: The big picture: a macroecological perspective on the global state of plant invasions

14.40–15.00 Jaco Le Roux: Invasive plant-soil feedbacks: insights from Australian acacias in South Africa's fynbos biome
15.00–15.20 Wen-Yong Guo: The role of adaptive strategies in plant invasion
15.20–15.40 Luke Flory: Drivers of the long-term dynamics and impacts of plant invasions

coffee break 15.40–16.10

16.10–16.30 Becky Kerns: Ecosystem change and a novel invasive annual grass in North American interior ecosystems
16.30–16.50 Peter Raal: The ongoing development and evolution of a control and detection system for scattered wilding conifers at the landscape scale in New Zealand
16.50–17.10 Ryan Perroy: Increasing the availability and utility of high-resolution imagery for invasive species detection in Hawai'i
17.10–17.30 Gonzalo Rivas-Torres: Use of drone and satellite images to classify and map native and invasive vegetation in island systems: the Galapagos example
17.30–18.00 (flash talks)
Staci Warrington: Do co-introduced exotic rhizobia facilitate Australian acacia invasion success?
Jennifer Bufford: Homeostatic fitness is key to understanding the role of plasticity in invasions
Margherita Gioria: Plant species forming a persistent soil seed bank have a higher probability of becoming naturalized
Kyle Hemming: Using the distribution of Australia's native grasses to predict the spread potential of exotic grasses
Josef Brůna: Detection and modelling of spread of *Ailanthus altissima* using UAV data
Joseph Fennell: From handheld-device to satellite: A toolkit of remote sensing and machine learning techniques for measuring the spread of invasive plants

18.00 poster session

WEDNESDAY 11 September 2019

(Chair: Montserrat Vilà)

8.30–9.10 (KEYNOTE 4)
Milan Chytrý: The role of habitats in plant invasions: combining the source-area and invaded-area approaches

SECTION 2 – INVADED COMMUNITIES: FROM SPECIES RELATIONSHIPS TO MACROECOLOGY

9.10–9.30 Ben Gooden: Impacts of alien plant invasion on forest vegetation are modulated by landscape configuration and native plant functional group
9.30–9.50 Anikó Csecserits: Trait-based evaluation of a perennial alien species (*Asclepias syriaca*) in the invaded community
9.50–10.10 Emily Jones: A global assessment of terrestrial alien ferns (Polypodiophyta): species' traits as drivers of naturalisation and invasion
10.10–10.30 (flash talks)
Maia Raymundo: Mechanisms limiting seed recruitment in an invaded community

Emily Waddell: Plant invasions are related to disturbance and native sapling diversity in tropical rainforest fragments
Pablo González-Moreno: Understanding hierarchical patterns of plant invasions impacting agriculture: the study case of Parthenium weed in Pakistan
Isabel Pérez Postigo: Which environmental factors affect the diversity of alien herbs in the ruderal flora in western Mexico?

(Chair: Bruce Osborne)

coffee break 10.30–11.00

11.00–11.20 Anna Schertler: The "Global Database of Alien Pathogenic Fungi"
11.20–11.40 Marina Golivets: Neighbour tolerance, not suppression, provides competitive advantage to non-native plants
11.40–12.00 Kateřina Štajerová: Community assembly rules of arbuscular mycorrhizal fungi in plant invasions: comparison between ranges
12.00–12.20 Zarah Pattison: The freshwater biodiversity crisis: what role do plant invasions play?
12.20–12.40 (flash talks)
Tomasz Szymura: Joined effect of anthropogenic factors, landscape structure, landrelief, soil and climate on alien plant invasion risk at regional scale
Natalie West: Flood dynamics dictate distributions of invasive trees on floodplains
Dorjee: Developing an inventory of the alien flora for data deficient country like Bhutan
Alessandra Kortz: Increases in local richness (α-diversity) following invasion are offset by biotic homogenization in a biodiversity hotspot

lunch 12.40–14.00

14.00–14.20 Christine Sheppard: Relative performance of co-occurring alien plant invaders depends on traits related to competitive ability more than niche differences
14.20–14.40 Marija Milanovic: Trait-environment relationships in native versus non-native plant species
14.40–15.00 Montserrat Vilà: Functional and phylogenetic consequences of plant invasions

15.00 excursion/poster session

THURSDAY 12 September 2019

(Chair: Max Wade)

8.30–9.10 (KEYNOTE 5)
Doria Gordon: Does weed risk assessment predict timing rather than probability of invasion?

SECTION 3 – ASSESSING RISKS & RAISING PUBLIC AWARENESS

9.10–9.30 Anja Bindewald: Linking theory and practice: a site-specific risk assessment for introduced tree species in European forests based on inventory data
9.30–9.50 Ingo Kowarik: A plea for multiple responses to invasive plant species exemplified by the case of *Ailanthus altissima*
9.50–10.10 Phil Hulme: Does awareness of invasive freshwater plants mitigate the dispersal risk posed by lake users?
10.10–10.30 Ivan Jaric: The role of species charisma in biological invasions

10.30–10.40 (flash talks)
Sandra Skowronek: Who's next? How species distribution models can and should support the identification of new invasive plant species.
Laura Jones: Driving up standards of invasive weed management through training and assessment: a United Kingdom success story

coffee break 10.40–11.10

SECTION 4 – IMPACT & MANAGEMENT

11.10–11.30 Pilar Castro-Diez: Impacts of four common non-native tree species on regulating ecosystem services
11.30–11.50 Katharina Dehnen-Schmutz: Impacts of alien plants at regional levels
11.50–12.10 Joaquim Silva: Fire hazard and plant invasions – the cases of *Hakea sericea* and *Acacia dealbata* in Portugal
12.10–12.30 Tomos Jones: Ornamental plants: a threat to the environment due to climate change?
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Sjirk Geerts: The absence of keystone indigenous trees inhibits bird recovery up to a decade after invasive tree removal from riparian habitats
Barbara Tokarska-Guzik: Evaluation of invasive plant species in Poland - methods adopted and results of their application as a basis for practical action

lunch 12.40–14.00

(Chair: Phil Hulme)

14.00–14.40 (KEYNOTE 6)
Melodie McGeoch: From data to decision for policy on biological invasions

14.40–15.00 Qiang Yang: Global homogenization of flowering plants by naturalized species
15.00–15.20 Thomas Wohlgemuth: Comparative effects of non-native tree species on forest ecosystems in Europe
15.20–15.40 Urs Schaffner: Integrating ecological and socio-economic impacts of *Prosopis*, a woody invasive alien species, to inform management
15.40–16.00 (flash talks)
Jacob Cowan: Invasive and native grasses exert negative plant-soil feedback effects on *Artemisia tridentata* whereas conspecific effects are neutral.
Iris Stiers: Removal of alien plants: any effect on native macrophyte recovery and pollinator services?
Ramya Ravi: Plural realities of plant invasions: *Prosopis juliflora* in the Banni grassland, India
Bruce Osborne: Plant invasions and greenhouse gas emissions

coffee break 16.00–16.20

16.20–16.40 Florencia Yannelli: Soil legacy effects of Acacia invasions and their implications for restoration in South Africa's Cape Floristic Region
16.40–17.00 Heinz Müller-Schärer: Predicting benefits and risks of biological control of the invasive common ragweed in Europe: from ecological to evolutionary studies
17.00–17.20 Jael Palhas: Modelling the biocontrol of an invasive tree by a bud-galling wasp, *Trichilogaster acaciaelongifoliae*

17.20–17.35 (flash talks)
Catherine Baso: The future of biological control in South Africa: Effects of elevated CO2
Jean-Marc Dufour-Dror: Control of *Acacia saligna* with aminopyralid direct application: New perspectives in the control management of one of the most widespread invasive wattle species
Magdalena Szymura: How to establish grassland on site invaded by *Solidago* – results of a five-year experiment

conference dinner

FRIDAY 13 September 2019

(Chair: David Richardson)

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Heinke Jäger: Conservation and management in plant invasions in biodiversity hotspots

SECTION 5 – CONSERVATION, PROTECTED AREAS & POLICY

9.10–9.30 Llewellyn Foxcroft: Patterns and implications of alien plant invasions at multiple scales
9.30–9.50 Ross Shackleton: Assessing biological invasions in protected areas
9.50–10.10 Liliana Duarte: Sustainable management of Acacia spp: an applied perspective of natural control and other methodologies to improve habitat recovery in Protected Areas
10.10–10.30 Hillary Cherry: Plant risk assessment tools to reduce invasive plant use in ornamental plant industries

coffee break 10.30–11.00

11.00–11.20 Katelyn Faulkner: Stronger regional biosecurity is essential to prevent hundreds of harmful biological invasions
11.20–11.40 Spyridon Flevaris: European Union policy on invasive alien species: latest developments and next steps
11.40–12.00 Mark Fennell: How Japanese Knotweed stopped me from selling my house: the history of Japanese Knotweed in the United Kingdom, 1981 to 2019
12.00–12.20 Elisabeth Pötzelsberger: Different strategies in national and subnational legal frameworks on non-native forest tree species in Europe
12.20–12.30 Aníbal Pauchard: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) thematic assessment of invasive alien species and their control

12.30–13.00 closing

13.00 lunch

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Aksoy N. Current status of alien ornamental flora in Turkey

AlOtaibi S. A new suggested model of a semi-regional plant protection organization for the Gulf Cooperation Council (GCC countries) in order to enhance The Pest monitoring and Control Strategy including transboundary pests

Alvarez M. Modelling potential dispersal of *Prosopis juliflora* in East Africa: scaling and assembling correlations

Anđelković A. The influence of hydromorphological characteristics of riparian areas on the presence of invasive alien plants

Aravind PS. Long term impacts of *Lantana camara* invasion in a heterogeneous landscape of a biodiversity hotspot

Axmanová I. Levels of alien plant invasions in European grasslands

Bąba W. Mechanisms of adaptation of photosynthetic apparatus in invasive plant *Euthamia graminifolia* to drought stresses

Balogianni V. Long-term impacts of two herbaceous invasive species on the standing and below-ground vegetation

Berchová-Bímová K. GEO-BI – new GEOportal for Biological Invasions

Bjedov I. Polyphenolic profiles of invasive *Sorghum halepense* within the Belgrade urban and suburban area

Brock JH. Ecology and management of alien annual grasses in the deserts of southwest North America

Bzdęga K. The application of the spatio-temporal geostatistical modelling in predicting distribution of invasive plant species

Canavan S. Assessing the invasion risk of industrial hemp

Castro K. An updated status of introduced and invasive plants in Canada

Chapman DS. Invasion of freshwater ecosystems is promoted by network connectivity to hotspots of human activity

Cowie B. Feasible or foolish: restoration of *Parthenium hysterophorus* invaded landscapes with native grass seed

Čuda J. Regeneration of *Phragmites australis* from rhizome and stem fragments: testing the effects of environment, population origin and status

Dajdok Z. *Veronica peregrina* as a potentially invasive species in European temporarily flooded habitats: a case study from Lower Silesia (SW Poland)

Dehnen-Schmutz K. Plant Alert: a new tool for the submission of records of potentially invasive ornamental garden plants

Deschamps Schmidt A. Biotic and abiotic changes in subtropical Seasonal Deciduous Forest associated with invasion by a non-native tree

Divíšek J. Functional trait differences between native and alien plant species in local communities of different habitat types

Dommanget F. Novel ecosystem functioning: from invasion to restoration of knotweed-invaded areas – a bee perspective

Fenollosa E. Physiological and ecological niche differentiation between invasive and native *Carpobrotus* species: the key of its invasion in Europe?

Fletcher RA. Invasive plants negatively impact native, but not exotic, animals

Freudenreich M. National management strategy for *Heracleum mantegazzianum*, an example of how France wants to control widely spread IAP

Fu W. Effects of different alternative plants on the control of *Mikania micrantha*

Galkina M. *Bidens decipiens* Warnst. (= *B. connata* Muehl. ex Willd.) in Eastern Europe: new information about hybrid origin

Giulio S. Alien flora across European sand dunes

Hall RM. Know your enemy: are biochemical substances the secret weapon of common ragweed (*Ambrosia artemisiifolia*) in the fierce competition with crops and native plant species?
Hall RM. Regional adjustment of management options of common ragweed (*Ambrosia artemisiifolia*) along roadside verges in Bavaria
Hanczaruk R. Impact of land use on the distribution of invasive plants in urban river ecosystems: a case study from the Kłodnica Valley (Silesian Upland, Poland)
Hay DJ. How does *Arundo donax* grow?
Hirata M. Which traits explain the distribution patterns of alien *Lolium* species in Japan?
Hiremath A. Managing invasive species in a complex social-ecological system: a system dynamics based insight-building tool for the Banni grasslands, India
Holec J. *Ammi majus* as a new arable weed in the Czech Republic
Holec J. *Rosa multiflora* in Prague 6 district: cultivated ornamental and escaping invader
Indjai B. Siam weed (*Chromolaena odorata*) invasion in Guinea-Bissau, West Africa
Jakaityte I. Induced damage effect on *Rhododendron ponticum* chemistry composition
Jesus J. Establishment of early symbiosis in *Acacia longifolia*: does fire play a role?
Jogan N. Can archaeophytes' distribution patterns help us understand the neophytes?
Jones GL. Shrub establishment favoured and grass dominance reduced in acid heath grassland systems cleared of invasive *Rhododendron ponticum*
Jubase N. *Asphodelus fistulous*, a newly discovered plant invader in South Africa: assessing the risk of invasion and potential for eradication
Kaczmarek-Derda W. Survival time of rhizomes of invasive *Reynoutria* taxa when above-ground shoot production is prevented by covering with geotextile
Karrer G. Genetic variation of the invasive *Ambrosia psilostachya* in Europe is biased by clonal propagation
Karrer G. JOINT AMBROSIA ACTION: Interreg-Project V-A Austria-Hungary to fight common ragweed (*Ambrosia artemisiifolia*)
Klinger Y. Germination of *Lupinus polyphyllus* depends on cutting date and seed morphology
Kompała-Bąba A. The role of alien species in plant communities that developed in the ruderal habitats of the Silesian Uplands (Southern Poland)
Kutlvašr J. Perennial ornamental plantations as a source of plant invasion: long-term trends in species compositions
Langdon B. Optimising the long-term management of invasive species affecting biodiversity and the rural economy using adaptive management
Langdon B. The invasive potential of forestry species in South Central Chile: first steps towards management planning
Lapin K. The impact of invasive alien plant species on the regeneration of European temperate broadleaf and mixed forests
Latombe G. AlienScenarios: developing and applying scenarios of biological invasions for the 21st century
Leostrin A. Towards a better understanding of plant invasions in the boreal zone of European Russia: the inventory of Kostroma alien flora
Linders TEW. An integrative approach to assess how invasive plants affect ecosystem service multifunctionality
Lozano V. Mapping and monitoring water hyacinth (*Eichhornia crassipes*) in Sardinia (Italy) based on color-morphology features using Unmanned Aerial Vehicles
Lozano V. Native and not-native weeds in globe artichoke fields under diverse cropping systems in Sardinia (Italy)
Luoma MO. Mapping *Anthriscus sylvestris* and *Myrrhis odorata* in Reykjavík, Iceland
Mehta N. Making friends with mad trees: sustainable management of an invasive species in the Banni grasslands
Miashike RL. What explains higher invasion success among three alien pines in Southeastern Brazil?
Minuti G. A first step towards the biological control of *Iris pseudacorus*
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Moodley D. Gatecrashers at the doorstep: towards a global inventory of alien plants in protected areas
Moravcová L. Differences in short-term seed-bank dynamics between alien species and their native congeners
Moser B. Invasiveness of Douglas fir in temperate European mixed forests during the seedling stage
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Mottet M. Risk assessment and management strategy of giant ragweed and western ragweed in France
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Novoa A. Additive effect of urbanization and invasion by *Carpobrotus edulis* on the soil ecology in coastal areas
Nuske S. Advancing the understanding of invasion ecology with pines
Obratov-Petković D. Predicting the distribution of invasive plants using climate and habitat suitability models
Oliveira-Costa JLP. Australian *Acacia longifolia* invasibility: geographic, climate and taxonomic scales in invaded ranges
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Paul TSH. Detecting and mapping invasive Pinaceae remotely in the South Island High Country of New Zealand
Pergl J. Ecological impacts of dominant alien and native plants on vegetation and soil: does origin matter?
Pergl J. Parks as sources of invasion and refugia for threatened native species
Pertierra LR. Examination of the global invasive relatedness among Poaceae alien species
Pertierra LR. Examining traits related to invasiveness in polar regions
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Rivas-Torres G. Invasive species impacts on the Galapagos flora, the *Cedrela odorata* case
Rodríguez J. Do changes in plant-herbivore interactions determine the biotic resistance against *Carpobrotus edulis*?
Rolando CA. Improving herbicide application efficiency and efficacy for control of wilding conifers
Rozman S. Action plan for invasive alien species management in the Landscape park Tivoli, Rožnik and Šišenski hrib near Ljubljana, Slovenia
Sainepo B. *Parthenium hysterophorus* in East Africa: a numerical review
Sampaio C. Influence of abiotic factors on growth and nodulation of *Acacia longifolia*
Sarat E. A National Resource Center to improve knowledge and management of IAS in France
Sheppard AW. The potential for gene technologies for management of alien plants
Sheppard CS. Biotic resistance or introduction bias? Immigrant plant performance decreases with residence times over millennia
Shevera M. *Grindelia squarrosa*: economically useful or an invasive plant in Europe?
Shimono Y. Invasion of alien species through weed seed contaminants in grain commodities strongly affect local vegetation at international trading ports
Sitzia T. Combined effects on plant trait composition and soil properties by an alien tree species: perspectives from a black locust case study
Skálová H. Effect of growing conditions on the germination of native and invasive *Impatiens* species
Skálová H. In search of traits driving plant invasion: growth, tissue chemistry and genome size of invasive and native *Phragmites australis* populations
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Sychrová M. Effects of past land-use on invasions by alien plants in the Czech Republic

Szczęśniak E. Expansion of halophilic and pseudo-halophilic alien species in Lower Silesia (SW Poland) as reaction for co-impact of salt deicing and climate changes

Šipek M. Alien species diversity and composition in periurban and urban forest islands is affected by adjacent land use

Šoln K. Rhizome extracts of invasive *Fallopia japonica* and *F. ×bohemica* inhibit root growth and modify root tip ultrastructure of radish

Tamayo M. Native insect herbivory on Nootka lupine in Iceland

Thibaudon M. IRS (International Ragweed Society) an international tool to help *Ambrosia* management

Tortorelli C. *Ventenata dubia*: invasion potential and impact on native communities in North America's Inland Pacific Northwest

Trouvé R. Predictive propagule pressure reduction from biosecurity inspection

Ulm F. Using an invasive legume to engineer healthy agricultural soil: from mechanisms to models of a potential win-win situation

van Loo M. Genetic diversity and geographic origin of *Ailanthus altissima*: Europe versus Vienna (Austria)

van Valkenburg J. A natural hybrid of *Impatiens* in the introduced range: *Impatiens balfourii* × *parviflora* in Ticino canton in Switzerland

Varia S. The use of the Australian mite, *Aculus crassulae*, as a biocontrol agent for *Crassula helmsii* in Europe

Vítková M. How vulnerable to plant invasions is an arctic-alpine tundra under long-term human impact in the Krkonoše Mts, Czech Republic?

Vojík M. Two shades of grey: xerophytes from garden beds as invaders of native vegetation?

Yaacoby T. Control of the invading species *Ambrosia confertiflora* and *Parthenium hysterophorus* with Aminopyralid herbicide

Zhang T. Effects of invasive *Cenchrus spinifex* on nitrogen pools in sandy grassland

Key note talks

Dissecting the success and impact of urban invasions

Marc W. Cadotte

University of Toronto-Scarborough, 1265 Military Trail, Toronto, ON, M1C1A4, Canada
e-mail: mcadotee@utsc.utoronto.ca

Urban environments are often seen as unique or degraded habitats that present both hardships for some sensitive species and provide opportunities for others. How non-indigenous species (NIS) respond to urban environments is not well understood. I ask a simple question: do NIS benefit from urbanization? I answer this based on a literature review and meta-analysis where I show that the available evidence supports the proposition that NIS benefit from urbanization, with NIS obtaining higher abundances and greater diversity in more urbanized habitats. The NIS that benefit from urbanization for establishment can then go on to spread and impact native habitats. One approach to understanding NIS success and impact is to assess how their functional traits influence their spread and impact. I will use the example of the invasive plant *Vincetoxicum rossicum* (Kleopow) Borhidi which has established itself as one of the dominant urban invaders in the northeastern United States and southeastern Canada. To examine the mechanisms underpinning the success and impacts of *V. rossicum*, I will discuss trait-based insights, using trait data for seven different functional traits (i.e. height, stem width, specific leaf area, leaf percent nitrogen and leaf percent carbon) from 500 1x1 m plots across a gradient of invasion in the Rouge National Urban Park located in suburban Toronto, Canada. *V. rossicum* occupies unique niche space, possessing trait combinations not found in the native flora, and its impact comes from its ability to alter the niche space for other species.

Unravelling context dependency in invasion science

Jane Catford

Department of Geography, King's College London, London, UK
e-mail: jane.catford@kcl.ac.uk

The context of invasion matters: it can determine whether, when and where invaders fail or succeed; which systems are resistant or vulnerable to invasions and when; the impacts that invaders cause and the approaches through which they may be managed. Unravelling this context dependence is a critical challenge in invasion science, and an essential step towards greater generality and predictive ability. Drawing on experimental, observational and theoretical examples from around the world, I will demonstrate how process-based understanding derived from community ecology can help us unpack and understand context dependencies in plant invasions.

The big picture: a macroecological perspective on the global state of plant invasions

Franz Essl

Department of Botany and Biodiversity Research, University Vienna, 1030 Wien, Austria
e-mail: franz.essl@univie.ac.at

Biological invasions have become a defining feature of global environmental change. However, the global patterns and underlying factors that determine variation in invasions worldwide are still insufficiently understood. Similarly, the consequences and future trajectories of biological invasions are not fully appreciated.

Progress in data coverage and availability, supplemented by new tools for data integration and analyses have facilitated the compilation of comprehensive databases of worldwide alien species distributions such as GloNAF for vascular plants (https://glonaf.org; van Kleunen et al. 2015). Similarly, the compilation of the Alien Species First Record-database provides a backbone for analysing spatio-temporal patterns of alien plant species accumulation (Seebens et al. 2017). Further, data on human pressures, the exchange routes of goods and people, and on a large range of environmental factors have increasingly become available. Combined, these novel data sources have substantially advanced the understanding of the (macro)ecology and biogeography of biological invasions, and they provide the foundation for exploring future trends of alien species spread and impacts.

In this talk, I will synthesize key insights into the macroecology of plant invasions. I will highlight likely future consequences of plant invasions and identify gaps in knowledge which have to be addressed as a priority. Finally, I will provide a perspective on priority questions for future macroecological research on plant invasions.

Seebens H. et al. (2017) No saturation of the global accumulation of alien species. Nat. Comm. 9: 14435.
van Kleunen M. et al. (2015) Global exchange and accumulation of non-native plants. Nature 525: 100–103.

The role of habitats in plant invasions: combining the source-area and invaded-area approaches

Milan Chytrý

Department of Botany and Zoology, Masaryk University, Kotlářská 2, CZ-611 37 Brno, Czech Republic
e-mail: chytry@sci.muni.cz

Each plant species evolved in a specific habitat and adapted to its abiotic environment where it co-existed with other species occurring regularly in that habitat. Once a species is introduced to a new area, it will likely spread especially in habitats that are similar to those in which it grows in its native range. Comparative studies of alien floras across multiple habitat types indicate consistent variation in the level of plant invasions across habitats, with some habitats invaded rarely and by few alien species while others are invaded often and heavily. Several processes, both in the source area and in the invaded area, can generate these patterns.

Source-area processes generate habitat-specific species pools of alien species: (1) Some habitats tend to occur more closely to human settlements and transport corridors, therefore their species are more likely to be introduced to a new area. (2) Some habitats are richer in species, therefore there is a higher probability that some of these species will be introduced to a new area and become established. (3) Some habitats have a highly dynamic ecological regime, which selects for traits that facilitate colonization and establishment in new or disturbed areas. Such species are more likely to spread outside their native ranges.

Invaded-area processes act as filters on alien species pools influencing the establishment of species from these pools across different recipient habitats: (1) Some habitats tend to occur closer to human settlements and transport corridors, therefore they are exposed to more incoming propagules of alien species and more likely to be more invaded ("propagule pressure" or "colonization pressure" explanation). (2) Some habitats are poorer in species, therefore they contain empty niches, which are colonized by incoming alien species ("biotic resistance" explanation). (3) Some habitats have a highly dynamic ecological regime, which supports the establishment of new species, of which some can be alien ("fluctuating resources" explanation). (4) If none of these filters are acting, habitats can still differ in the degree to which they are invaded due to different sizes of their alien species pools ("alien species-pool" explanation).

In our research into habitat invasion patterns and processes conducted over the last 15 years, we applied both the source-area approach in studies of intercontinental exchange of alien plants between European habitats and habitats on other continents, as well as the invaded-area approach in fine-scale studies of European habitats. These studies provided support for most of the above-mentioned mechanisms except those involving species richness.

In this talk, I will summarize evidence for each of these mechanisms based on our own work and published literature, and I place the source-area and invaded-area perspectives of habitat invasions into a single framework.

Does the weed risk assessment predict timing rather than probability of invasion?

Doria R. Gordon

Environmental Defense Fund, Washington DC, USA and University of Florida, Department of Biology, Gainesville, Florida, USA
e-mail: dgordon@edf.org

Increasing evidence suggests that many of the species predicted to have a low risk of invasion using trait-based weed risk assessment (WRA) tools will become invasive given sufficient time in the introduced range. However, if minimum residence time and propagule pressure are the ultimate predictors of invasion for casual species, why does WRA have high accuracy in differentiating invaders from non-invaders? I hypothesize that the risk predicted by the WRA may be the risk of more rapid than slower transition from a casual to invasive status. I will examine evidence for this hypothesis from multiple locations and explore the implications.

The WRA was developed for precautionary purposes: to preclude import of species with high probability of becoming harmful invaders. Climate and environmental constraints are included in most WRA tools, but much of the emphasis is on plant traits. While we have limited data on introductions that result in unsuccessful establishment, species are unlikely to naturalize where environmental conditions preclude survival without cultural treatments, regardless of propagule pressure. As the proportion of intentionally introduced species has increased over time, the probability of environmental and climate matching has increased. Repeated purposeful introduction and cultivation increases not only propagule pressure over larger areas, but also the probability of adaptation via greater genetic diversity. Species traits appear to have more influence on timing rather than the probability of invasion, with different types of traits more important at different stages in the invasion process. For example, reproductive traits appear more critical as species move from the casual to the naturalized stage and dispersal traits become more important for transition to the invasive stage. Life history, therefore, should also influence the rate of these transitions.

The relative speed of invasion may be critical for predicting potential impact, control cost and control success. Native species may have a lower probability of persisting with a non-native that becomes invasive rapidly after introduction, where the non-native species has high growth rates and develops high biomass. Area invaded is inversely correlated with eradication success and positively with management cost. As a result, WRA and other efforts developed to identify predictive traits of invaders appear as relevant for screening imports pre-border as well as for post-border regulation and management. Species with traits correlated with invasion, including high WRA scores, have a higher probability of costly environmental and economic impacts on the timeframe of decades, consistent with the regulatory timeframe. While perhaps not predicting the intended risk, pre- and post-border use of WRA for identifying species for noxious designation or management focus likely has the intended management result. As such, we can successfully protect native species and functions through deliberate focus on species likely to be early invaders and on those moving slowly but are likely to be system changers. Accurate identification of the latter may require additional assessment tools.

From data to decision for policy on biological invasions

Melodie A. McGeoch

School of Biological Sciences, Monash University, Clayton 3800, Australia
e-mail: melodie.mcgeoch@monash.edu

As is the case with much of biodiversity, population abundance and distribution data on invasive species is geographically and taxonomically patchy. However, unlike the rest of biodiversity there are differences in the priority associated with generating such data, as well as in the significance of particular species population variables, such as the knowledge of native range limits. There are therefore still a number of key research questions, but also informatics challenges and governance arrangements that need to be addressed to smooth the pipeline of knowledge from data to decision on biological invasions. Some of the solutions include efficient, repeated generation of new data on the presence and distribution of invasive species, capitalizing on the rapidly developing field of biodiversity informatics, and model-generated essential biodiversity variables for invasive species. The recent realization of the *Global Register of Introduced and Invasive Species*, for example, provides a significant step forward in connecting national scale invasive species occurrence information with decision makers, as well as a mechanism that is leveraging higher quality, more comprehensive, harmonized and more accessible information on invasive species.

Conservation and management in plant invasions in biodiversity hotspots

Heinke Jäger

Charles Darwin Foundation, Galapagos, Ecuador, and Department of Ecology, Technische Universität Berlin, Germany
e-mail: heinke.jaeger@fcdarwin.org.ec

Biodiversity hotspots, defined as having high plant endemism and major habitat loss, encompass 35 geographic regions. Together they only cover 15.9% of the global land surface but contain 152,000 plant species (over 50% of the world's total). Oceanic islands comprise one third of global biodiversity hotspots and provide particularly suitable habitats for invasive species. Hundreds of invasive plant species have invaded island ecosystems and threaten native biodiversity worldwide. Although an effective biosecurity system provides the best way to prevent new plant invasions, few oceanic island governments have implemented them to date. Once a non-native species is established, a swift action to eradicate it would be best – but often the establishment goes unseen and subsequently, only control measures can curb the impacts of the species. Control of invasive plant species is carried out on most oceanic islands now with varying success. Invasive species control is all the more important on islands that house many endemic plant species. The unique flora of the Galapagos Islands, with 43% of the plant species being endemic, provides a good example of this situation. Many of these are threatened by invasive species, transported to the islands by multiple vectors. The exceptionally high levels of endemism led to the recognition of the Galapagos Islands as a UNESCO World Heritage site, a Priority Ecoregion for Global Conservation, a 'flagship' area for conservation and one of the 137 'most irreplaceable protected areas in the world'. As such, conservation management in Galapagos is challenged by the dual needs of sustaining native biodiversity while controlling invasive species. Currently, there are 810 introduced plant species in Galapagos (about 60% of the Galapagos flora), with about 6% of these having become invasive. The most infamous are blackberry (*Rubus niveus*), common guava (*Psidium guajava*), Cuban cedar (*Cedrela odorata*) and quinine (*Cinchona pubescens*). While there have been successful eradications of some of the plant species with a limited distribution, manual and chemical control methods are being used by the Galapagos National Park Directorate (GNPD) to tackle the most invasive ones. Our recent study of the efficiency and impacts of blackberry control in a forest of the endemic, threatened tree species *Scalesia pedunculata*, shows that without control, this unique forest will be lost within the next generation. High resolution vegetation mapping using drones indicates that the restoration actions carried out by the GNPD are highly effective. However, this mapping effort also suggests an indirect effect of goat eradication, as blackberry has now become rampant, 10 years after goat removal. While the breeding success of Darwin's finches and the abundance of some invertebrates have been negatively affected by the blackberry control, results also indicate that these effects may be transient. Efforts to find a biological control agent for blackberry are underway and have produced promising results to date. For other invasive species, conservation efforts in Galapagos seem to be getting unforeseen help. For example, our 21-year long monitoring study of the highly invasive quinine tree *C. pubescens* indicates that it is dying off, which has enabled the native vegetation to recover without additional restoration actions. While the reason for this seemingly natural die-off of quinine trees is still under investigation, it is likely caused by a root pathogen. In summary, conservation of the Galapagos biodiversity has been advanced by science-based technical assistance to the GNPD on invasive species control, which advocates a more holistic, management approach.

Oral presentations

Invasion frameworks: an assessment of usage and options for improvement

J. R. Wilson[1,2], S. Kumschick[1,2], D. M. Richardson[2], T. B. Robinson[2], T. A. Zengeya[2,3] and the CIB plant invasions group

[1]*South African National Biodiversity Institute, South Africa*
[2]*Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, South Africa*
[3]*Centre for Invasion Biology, Department of Zoology and Entomology, University of Pretoria, South Africa*
e-mail: jrwilson@sun.ac.za

The Unified Framework for Biological Invasions, published in 2011 in Trends in Ecology and Evolution, has over a thousand citations on Google Scholar; has been used in practice by policy makers and managers to categorise invasions; and is currently being adapted as an agreed biodiversity data standard as part of the Darwin Core. However, when applying the framework, a number of practical issues have arisen, some of which are fundamental to the field. Similar issues have arisen with other frameworks that seek to simplify or conceptualise complex ecological phenomena. For example, guidelines for interpreting the CBD's scheme for categorizing pathways for the introduction of alien species have recently been published, and impact assessments schemes (e.g. EICAT and SEICAT) are increasingly been put in to practice.

In this presentation we review how the frameworks have been adopted and used; identify key problems of applying the frameworks to different contexts (taxa, environments, socio-political situations); and make some preliminary suggestions for how the frameworks can be improved.

When and how does "origin" matter: from macro-ecology back to experimental ecology to elucidate drivers of invasion success?

Yan Sun[1], Urs Schaffner[2], Ragan M. Callaway[3], John L. Maron[3] and Heinz Müller-Schärer[1]

[1]*Department of Biology, Ecology and Evolution, University of Fribourg, Chemin du Musée 10, 1700 Fribourg, Switzerland*
[2]*CABI, Rue des Grillons 1, 2800 Delémont, Switzerland;* [3]*Division of Biological Sciences, University of Montana, Missoula, Montana, USA*
e-mail: yansun.ecology@gmail.com

The steep rise of research on the causes and consequences of biological invasions over the past decades has led to the emergence of a new discipline within Ecology and Evolution. Due to the distinct Environment × Genotype interactions and thus novel eco-evolutionary associations in the introduced range, studies of invasions have yielded novel insights into key ecological and evolutionary issues. However, invasion science has recently received criticism from academia on its "raison d'être" as a distinct discipline, especially fueled by the debate whether origin matters for invader impact. Here, we explore determinants of abundance and impact of invasive alien plants (IAP), specifically the contribution of evolutionary novelty, and thus, if origin matters. Recent macroecological studies that remained observational found that the size (e.g. height, biomass) and abundance of IAP are generally similar in their native (home) and introduced (away) range, while single species studies often found clear origin effects.

To advance the discussion on when and how does origin matter in invasion ecology, we first argue that it is necessary to address two aspects fundamental to the discussion, i.e. the selection of species in tests for possible origin effects, and the suitability of the methodologies used in informing the 'origin matters' debate. Secondly, we reviewed 125 studies dealing with possible origin effects in plant invasions and indeed found that the research setting and the level of manipulation highly determined whether an origin effect was found or not. Origin effects of invasive alien plants were found more often in experimental (i.e. common garden and growth chamber) settings with less focal species studied, as compared to open field and observational studies with high numbers of focal species. We then contrast this approach to a growing list of studies that have examined one very potent invader, *Centaurea stoebe* (Asteraceae). Here, we found that origin clearly matters for impact, both ecological and evolutionary processes contribute to its invasion success, and, thus patterns and mechanisms of neighbour impacts are not transferable between ranges. This has important consequences for management decisions, since impact is highly context-specific and not an inherent species attribute. Finally, we discuss both the strengths and weaknesses of the "macroecological" versus "single species" approach and propose that more studies are needed at the intermediate level of the spatial setting and environmental control, such as in replicated manipulative open field settings with clearly defined focal species in order to better understand the mechanisms driving invasion success, especially their abundance and impact in novel environmental settings.

Plant invasions in non-analogue climates reflect phenotypic plasticity rather than contemporary adaptation

Thomas F. Carlin, Jennifer Bufford, William Godsoe and Philip E. Hulme

The Bio-Protection Research Centre, PO Box 84, Lincoln University, Christchurch, New Zealand
e-mail: thomas.carlin@lincolnuni.ac.nz

Alien plants can and do establish in climates outside of what is expected from their native range. In New Zealand (NZ), we found that three species: *Rumex obtusifolius, R. crispus, and R. conglomeratus* (Polygonaceae) grow outside the range of climates experienced in their native European distribution. Such a climatic niche shift may reflect an evolutionary response to a non-analogue environment and/or high environmental plasticity. To test these alternatives, we established one of the largest field based approaches to date which compared the performance of native (United Kingdom, UK) and alien (NZ) provenances across a marked rainfall and temperature gradient, including non-analogue climate space. Utilizing three common gardens across NZ, we measured differences in germination, survival, fecundity, and developmental speed. For each provenance, seeds were collected from four populations, spanning 3 regions representing a broad range of available climates. Using data from ~50,000 seeds planted, of which ~1,100 plants survived two growing seasons, we present an in depth analysis of the likelihood of an evolutionary or plastic response. Individuals from the native provenance tended to perform equally as well as plants from NZ, even in non-analogue climates, across multiple growing seasons. Although there was large variation in performance between common gardens, there was little indication of differences between provenances at any site. These species are colonists of open, disturbed environments associated with human activity and thus generally occupy similar habitats across the globe. Thus there is little support for an evolutionary interpretation to the climate shift. Rather, the response reflects considerable plasticity in performance to environmental variation that is not fully expressed across the climate gradient in their native range. This demonstrates that the native range is a poor indicator of the total environments a species can tolerate and thus should not be used to predict potential distribution in non-analogue environments.

Fig. 1. Growth of *Rumex* spp. in a New Zealand climate with no analogue in the species' native range.

Does time heal wounds? Effects of climatic dissimilarity on population dynamics of invasive plants revealed by residence time

Marco R. Brendel, Frank M. Schurr and Christine S. Sheppard

Institute of Landscape and Plant Ecology, University of Hohenheim, 70593 Stuttgart, Germany
e-mail: marco.brendel@uni-hohenheim.de

When introduced into a new area, alien species are exposed to novel climatic conditions, which can have negative effects on their establishment, fitness, and population growth. In this regard, differences in climate between the native and the introduced range (climatic dissimilarity) act as a barrier to invasion. With the time since introduction of an alien species into a new area (residence time), its establishment rate and invasiveness are predicted to increase. This leads to the assumption that alien species possibly cope better with local climatic conditions the longer they are present in a new area, thereby overcoming initial climatic barriers (e.g. through rapid evolutionary changes). However, in studies on invasion success, population dynamics in relation to species' residence times have been greatly neglected so far. To address the question if a negative effect of climatic dissimilarity on invader performance weakens with residence time, we performed a common garden experiment based on a species-for-time approach. Particularly, we compiled a set of 46 annual Asteraceae species (with 115 populations) along an alien-native continuum, thereby covering a wide range of residence times in Germany (7 to 12,000 years). We investigated their population dynamics (initiated at low density) in monoculture mesocosms (preventing seed immigration and emigration) over two years. We tested for the effect of climatic dissimilarity (measured as temperature difference between the species' global distribution and the local conditions) in relation to residence time on five different demographic performance measures. In the first year, temperature difference had a strongly negative effect on the finite rate of increase. Intriguingly, this effect weakened with the residence time of Asteraceae species in Germany. For the demographic components, establishment rate and fecundity, we found similar effects. Population growth and size in the second year showed no clear response to temperature difference depending on residence time but seemed to be driven by density dependence instead. Our results revealed that initially, climatic dissimilarity acts as a barrier to invasion in a new area, however, its effect decreases over eco-evolutionary timescales. This will provide a better understanding of the mechanisms behind constraints on population growth and spread of invaders.

A global assessment of the introduction history and population genetic characteristics of the commercially important invasive tree *Acacia dealbata* Link

Heidi Hirsch[1], David M. Richardson[1], Aníbal Pauchard[2,3] and Johannes J. Le Roux[4]

[1]*Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, Private Bag X1, Matieland, 7602, South Africa*
[2]*Laboratorio de Invasiones Biológicas, Facultad de Ciencias Forestales, Universidad de Concepción, Casilla 160-C, Concepción, Chile*
[3]*Institute of Ecology and Biodiversity (IEB), Las Palmeras 3425, Santiago, Chile*
[4]*Department of Biological Sciences, Macquarie University, Sydney, 2109, Australia*
e-mail: heidihirsch71@gmail.com

Tracing the introduction routes of invasive populations is crucial to gain insight into a species' introduction history, its invasion success, spread, evolutionary processes during the invasion process, and to explore biological control options. *Acacia dealbata* Link, also known as silver wattle or mimosa, is native to southeastern Australia and Tasmania and was introduced to several regions around the globe for multiple purposes (e.g. forestry, horticulture, perfume industry). In many of those regions, the species naturalized or became invasive, making it a globally important invader. In this study, we employed a combination genetic fingerprinting and genetic modelling approaches to compare the genetic diversity and structure between populations sampled across the species' native and non-native ranges in Chile, Madagascar, New Zealand, Portugal, Reunion Island, South Africa and the United States, and to investigate the most likely introduction scenarios. Our comprehensive dataset comprised 1615 samples from 92 populations. Our results revealed that global introductions of *A. dealbata* are complex and cannot be generalized. For example, New Zealand invasions likely originated from a genetic cluster of *A. dealbata* in Tasmania, while Madagascan populations originated from the Australian mainland. South African invasions originated from an unknown ('ghost') source, which was also present in Reunion Island. Invasive populations in other regions, e.g. the United States and Chile, likely originated from multiple sources. We will discuss the implications of our findings in regard to effective management approaches of *A. dealbata* invasions.

An Atlantic Odissey: the fate of invading propagules across the coastline of the Iberian Peninsula

Luís González[1], Yaiza Lechuga-Lago[1], Alejandra Guisande-Collazo[1], Gabriel Rosón[2], Diego Pereiro[2] and Pablo Souza-Alonso[1,3]

[1]*Laboratory of Plant Ecophysiology, Department of Plant Biology and Soil Science. Faculty of Biology. University of Vigo, Vigo, Spain*
[2]*Physical Oceanography Group (Gofuvi), Department of Applied Physics. University of Vigo, Vigo, Spain*
[3]*Center for Functional Ecology – Science for People & the Planet. Department of Life Sciences. Faculty of Sciences and Technology. University of Coimbra. Coimbra, Portugal*
e-mail: luis@uvigo.es

Coastal habitats across the Mediterranean region are suffering an increasing anthropic pressure that allows the expansion of invasive alien plants (IAPs). The coastline represents an ecotone with high ecological pressure, dominated by environmental forces that continuously transform it. The ecosystem engineer *Carpobrotus edulis* represents a threat for habitat conservation, biodiversity preservation and the provision of ecosystem services becoming a highly targeted species for eradication along the Mediterranean basis.

The presence of *C. edulis* in the coastline implies that it becomes the first receptor of high loads of energy. However, the possibility of propagule immersion and dispersion has not yet been explored. With the aim of obtaining a better understanding of the mechanisms driving successful invasion and dispersive potential of C. edulis, we assessed the capacity of plant propagules to survive and grow after increasing periods of seawater immersion (up to 144h). We further simulated the potential advection of propagules through the combined use of an oceanic model (ROMS-AGRIF) with a particle-tracking model based on stochastic dispersal components and environmental variables.

Propagules, previously submerged in seawater, were planted and maintained under greenhouse conditions for 2 months. Fragment survival rate (100%) suggested high tolerance to salinity. In fact, an increase in plant and root length was generally observed and immersed fragments consistently accumulated more biomass than control fragments suggesting that immersion positively affected plant growth. After two months of growth, photosynthetic parameters (i.e. Fv'/Fm', Φ_{NO}, and Φ_{II}) remained stable. In addition, osmolyte and pigment content did not show significant changes. Fragment viability and performance suggests potential viability after longer immersion periods. Based on the capacity to resist seawater immersion, our model forecasted that *C. edulis* propagules may travel variable distances (during the first 144h) maintaining their physiological viability. The model also indicated that short-scale circulation would be the dominant process for propagule transport; however, long-scale circulation may be successfully accomplished. In fact, the model indicated that propagules may travel long distances (250 km from the origin) in less than 6 days under optimal conditions. Although oceanic transport should be considered as a secondary dispersal pattern, it can also be responsible for long-distance movements, increasing the invasive potential of *C. edulis.*

Understanding plant dispersal mechanisms is fundamental to unravel IAPs ecology. Modeling transport processes, combined with the dynamics of introduction and expansion, contribute to a better understanding of the invasive mechanisms of *C. edulis* and, consequently, to identify coastal areas with potential risk of invasion and design preventive strategies to reduce its impact. Our model can also be extended to study the invasion other IAPs across coastal landscapes, alone or in conjunction with species distribution models. The context of current and future climate change scenario remarks the necessity for a better understanding of propagation, resistance and spatiotemporal dynamics of coastal population of IAPs.

Surviving the cold: impacts of an extreme weather event on the growth and phenology of *Gunnera tinctoria*

Mauricio C. Mantoani[1,3], Conor Sweeney[2,3] and Bruce A. Osborne[1,3]

[1]*UCD School of Biology and Environmental Science, University College Dublin, Belfield, Dublin 4, Ireland*
[2] *UCD School of Mathematics and Statistics, University College Dublin, Belfield, Dublin 4, Ireland*
[3] *UCD Earth Institute, University College Dublin, Dublin 4, Belfield, Ireland*
e-mail: mauricio.cruz-mantoani@ucdconnect.ie

Whilst it is often assumed that invasive plant species may benefit more from climate change than native species, there is little information on how they might respond to extreme weather events (EWE), the occurrence and magnitude of which are projected to increase with global warming. Here, we show that the benefits of an increase of two weeks in the length of the growing season were offset by an EWE (i.e. Storm Emma), characterized by low temperature extremes and snowfall. This resulted in a disproportionally greater impact on mature populations of the invasive species *Gunnera tinctoria* compared to native species. The EWE reduced the total leaf area of the invader by 11-fold, significantly delayed canopy development and reduced shoot biomass by > 85%, leading to a four-fold increase in the number of regenerating species in invaded areas. This also resulted in the loss of most of the inflorescences (83%) from mature plants, although it had a much smaller effect on seedlings of *G. tinctoria*, which produced new leaves that rapidly expanded after the EWE had passed. Based on this information an EWE may counteract any early growth benefits associated with established plants, but the longer term impacts will depend on the extent to which this compromises seedling growth and development as well as the ability of mature plants to recover vegetative and reproductive growth.

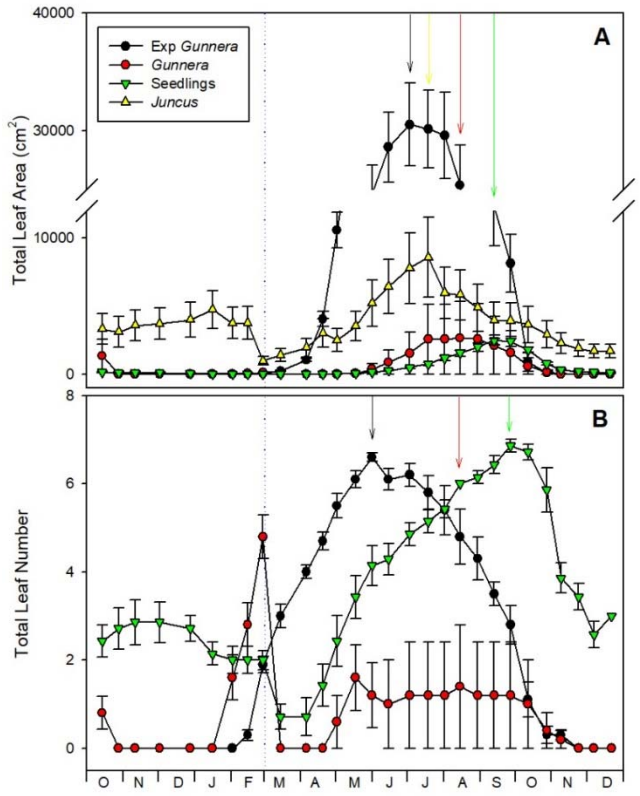


Fig. 1. Seasonal variation in (A) total leaf area (cm^2) and (B) total leaf number, assessed throughout 2017–2018 on Achill Island, Co. Mayo, Ireland (*Juncus* and *Gunnera* n=5, seedlings n=7; mean ± 1SE). Legend: Exp *Gunnera* = the expected total leaf area and number for *G. tinctoria* in 2018, based on 2016–2017; *Gunnera* = mature plants of *Gunnera tinctoria*; Seedlings= *G. tinctoria* seedlings; *Juncus* = *Juncus effusus*. Note: the blue dotted line represents the occurrence of the extreme weather event Storm Emma, in late February early March 2018. The black, red, green and yellow arrows indicate the peak of total leaf area or number for Exp *Gunnera*, *Gunnera*, Seedlings and *Juncus*, respectively.

Reduced herbivory does not increase competitive ability or shift chemical defences in alien *Rumex*

Andrei Costan, Jennifer Bufford, Will Godsoe and Philip E. Hulme

The Bio-Protection Research Centre, PO Box 84, Lincoln University, Christchurch, New Zealand
e-mail: andrei.costan@lincolnuni.ac.nz

Release from natural enemies in the introduced range has often been implicated as one reason for the success of biological invasions, particularly as a result of the evolution of increased competitive ability (EICA). Formal tests of the EICA hypothesis require evidence of shifts in herbivory, competitive ability and chemical defence between native and introduced provenances of the target species. However, many studies only assess competitive ability and are thus not complete tests of EICA. We have previously found that *Rumex obtusifolisus, R. crispus* and *R. conglomeratus* (Polygonaceae) experienced between seven times lower leaf and 22 times lower root herbivory in the introduced range (New Zealand) than their native range (United Kingdom). We therefore examined the consequences of reduced herbivore pressure on the intraspecific competitive ability and plant chemistry of provenances from the native and introduced ranges. A large-scale glasshouse experiment revealed that despite plant biomass of each species being markedly reduced, by as much as 50%, when in competition with a congener from either the same or different provenance, there was no difference in competitive ability between native and introduced provenances for any of the three species. Such a result would be consistent with plants failing to re-allocate anti-herbivore defensive compounds to growth. *Rumex* spp. produce a number of compounds that may have anti-herbivore properties including oxalates, phenols and tannins. We assayed these compounds from plants derived from the same populations as used in the competition experiments. Although oxalates, phenols and tannins were found in high concentrations, in particular oxalic acid (ranging between 12 and 23 g/100g dry weight) and thus potentially represent a significant metabolic cost, there were no differences between native and introduced provenances. These results provide convincing evidence to counter EICA being a mechanism for the success of *Rumex* spp. in New Zealand. Despite the escape from specialist herbivores that have a major impact on the populations of the species in their native range, *Rumex* spp. did not respond by shifting defensive chemistry towards increased growth. This points to limited flexibility in metabolic pathways as a result of compounds playing multiple function in *Rumex* spp and/or selection for these compounds being maintained by generalist herbivores, particularly grazing vertebrates that are widespread in both the native and introduced ranges.

Fig. 1. Experimental setup with study species.

Epigenetic aspects involved in plant invasiveness

F. Guarino[1], A. Cicatelli[1], G. Brundu[2] and S. Castiglione[1]

[1]*University of Salerno, Dept. of Chemistry and Biology "A. Zambelli", Fisciano (SA), Italy*
[2]*University of Sassari, Dept. Agriculture, Sassari (SS), Italy*
e-mail: fguarino@unisa.it

Giant reed *(Arundo donax* L.) has been introduced and grown for local uses in the Mediterranean region since ancient times. Common uses of giant reed include basket work, roofing, trellises, musical instruments and traditional medicine. More recently it has attracted the attention of European researchers and farmers as a potential non-food crop and for energy biomass production. As a result of this human-mediated spread, it is now widely naturalized in many areas of Europe, North and South America, Asia, Africa, Australia, New Zealand and in numerous islands across the Pacific (Mariani et al. 2010). Although well adapted to widely different ecological conditions, giant reed thrives in riparian habitats, where it forms dense monospecific stands. Flowers of its inflorescences are perfect, but neither pollen nor caryopsis have been documented in North America and in other parts of the invaded range (e.g. Europe). For this reason, it is considered a sterile plant, which spreads preferentially asexually through rhizomes at close proximity of the invaded area, and, very rarely, sexually (Bell 1997). Vegetative reproduction is expected to reduce the genetic biodiversity because of absence of meiotic mechanisms and, in particular, of its fundamental steps such as: crossing over, gene recombination and random chromosome assortment. Nevertheless, giant reed thrives very well in a large array of pedo-climatic conditions around the world, showing different phenotypic and phenological features, competing with many native species and displacing native vegetation and arthropod fauna in the invaded sites. This ability to adapt morphologically or physiologically to a broad array of conditions could be attributed to epigenetic mechanisms (Pilu et al. 2014). To shed light on this relevant issue, 96 stems of giant reed from spontaneous populations distributed across the Italian invaded range (island of Sardinia, Northern and Southern Italy) were analysed. Leaf DNAs were extracted and processed through Amplified Fragment Length Polymorphisms (AFLPs) and Methylation Sensitive Amplified Polymorphisms (MSAPs) for defining either genetic or epigenetic profiles, respectively. The AFLP results showed an extremely low genetic biodiversity within and among the studied populations due to vegetative reproduction, whilst, epi-biodiversity, estimated through MSAPs, increased. Our results suggests that the ability of giant reed to invade and thrive in diverse environmental conditions can be attributed, at least in part, to a higher epigenetic variability (Guarino et al. 2019). Moreover, in our opinion, the MSAP technique represents an efficient and cost-effective tool with which is possible to estimate epi-biodiversity of species and populations. As such, the epigenetic profiles should be considered and added to those commonly employed in the framework of the Convention on Biological Diversity. We foresee that epigenetic profiling could be determined in a similar way to genetic profiling, using the same indices, or developing new ones, but by processing DNAs separately based on methylation-sensitive and insensitive profiles. Therefore, we are convinced that the investigation of the DNA methylation status is fundamental for basic ecological and biodiversity studies, particularly in the case of plant species that preferentially propagate vegetatively.

Bell G. P. (1997) Ecology and management of *Arundo donax* and approaches to riparian habitat restoration in southern California. In: J. H. Brock, M. Wade, P. Pyšek & D. Green (eds) Plant invasions. Studies from North America and Europe, p. 104–114, Backhuys Publishers, Leiden, The Netherlands.

Guarino F., Cicatelli A., Brundu G., Improta G., Triassi M. & Castiglione S. (2019) The use of MSAP reveals epigenetic diversity of the invasive clonal populations of *Arundo donax* L. PLoS ONE 14: e0215096.

Mariani C., Cabrini R., Danin A., Piffanelli P., Fricano A., Gomarasca S. et al. (2010) Origin, diffusion and reproduction of the giant reed (*Arundo donax* L.): a promising weedy energy crop. Ann. Appl. Biol. 157: 191–202.

Pilu R., Cassani E., Landoni M., Badone F. C., Passera A., Cantaluppi E. et al. (2014) Genetic characterization of an Italian giant reed (*Arundo donax* L.) clones collection: exploiting clonal selection. Euphytica 196: 169–81.

Applications of bioinformatics to identify genotypic differentiation in alien plants

Sandra Savinen[1], Jeanne Jacobs[2] and Philip E. Hulme[1]

[1]*The Bio-Protection Research Centre, PO Box 84, Lincoln University, Christchurch, New Zealand*
[2]*AgResearch Ltd, Lincoln Science Centre, Private Bag 4749, Christchurch 8140, New Zealand*
e-mail: sandra.savinen@lincolnuni.ac.nz

Admixture is the mixing of alleles between genetically differentiated individuals which can introduce beneficial novel allele combinations to populations. It has been suggested that such gene mixing frequently occurs in the introduction of alien plants where individuals from multiple difference source populations are brought together into a new region. Such genetic variation is often linked to the plants ability to colonize new areas and to adapt to novel conditions. For this reason it has been implicated as a driver of plant invasions, yet the evidence regarding the levels of admixture in alien plant species or about the effect it has on plant invasions remains limited. This is in part due to admixture and population differentiation being studied using microsatellites markers that are often too coarse to distinguish or capture variation, especially for within population comparisons. Genotyping-by-sequencing (GBS) is a reduced representation genotyping method that yields thousands of short sequences with single nucleotide polymorphisms (SNPs). High yield of SNPs makes it possible to differentiate smaller and more subtle changes in the genomes, even between related individuals. However, it has rarely been used to examine population differentiation in alien species. We apply GBS to study population differentiation in the native (United Kingdom, UK) and introduced (New Zealand, NZ) ranges of three *Rumex* species. The three species differ in ploidy and were selected to test the robustness of GBS in discerning population differentiation in polyploids. Our expectation is that when genetic variation is partitioned between the native and introduced ranges, most variation in NZ will be within-populations (due to admixture), while in the UK it will occur between populations (due to isolation and drift). Our results highlight the potential for bioinformatics tools to herald new insights into plant invasions and to look at the partitioning of genetic variation beyond F_{ST} values. The availability of a wide range of bioinformatics methods enables us to dive deep in the population differentiation and patterns of both inter- and intraspecies hybridization.

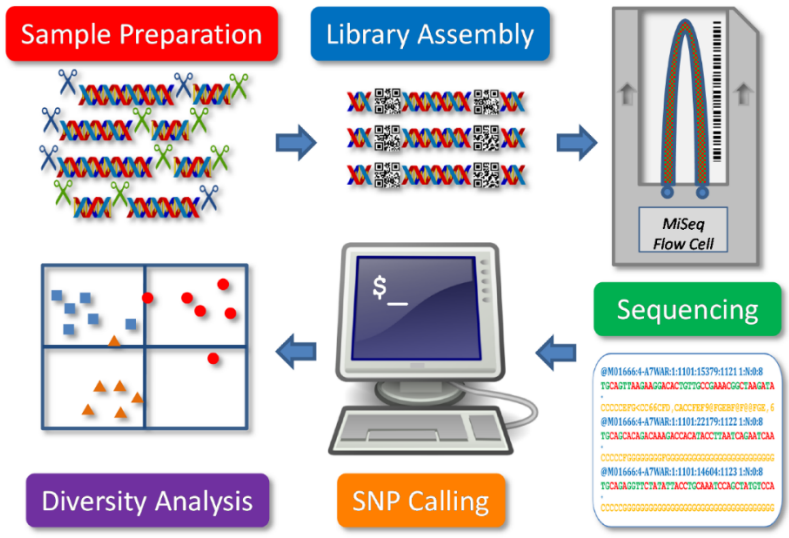


Fig. 1. Picture from (CC BY 4.0): Peterson G., Dong Y., Horbach C. & Fu Y. B. (2014) Genotyping-by-sequencing for plant genetic diversity analysis: a lab guide for SNP genotyping. Diversity 6: 665–680.

Invasive plant-soil feedbacks: insights from Australian acacias in South Africa's fynbos biome

Johannes Le Roux[1,2], Staci Warrington[2], Jan-Hendrik Keet[3], Cang Hui[2] and Allan Ellis[3]

[1]*Department of Biological Sciences, Macquarie University, Sydney, Australia*
[2]*Centre for Invasion Biology, Stellenbosch University, Stellenbosch, South Africa*
[3]*Department of Botany and Zoology, Stellenbosch University, Stellenbosch, South Africa*
e-mail: jaco.leroux@mq.edu.au

Plants interact with many soil microbes. For non-native plants, interactions with both mutualistic and antagonistic soil microbes can significantly impact their invasivesness. This, however, is dependent on the eco-evolutionary experiences of both interacting partners. We will illustrate that invasions by Australian acacias in South Africa's hyper-diverse fynbos biome are often characterized by co-invasions with their nitrogen-fixing rhizobium mutualists from Australia. DNA barcoding and functional analyses of rhizobia revealed that acacias enrich and homogenise invaded soils for these mutualists, leading to positive plant-soil feedbacks. Homogenization of rhizobial communities in invaded soils was, to some degree, mimicked by other bacterial taxa, i.e. whole soil microbiomes. Next generation sequencing data of whole soil microbiomes illustrated that pristine (uninvaded) fynbos soils are characterized by high microbial community turnover, possibly reflecting high turnover in above-ground plant community components. This signal was diluted by the presence of dense monotypic acacia infestations, even over large spatial scales. We will discuss the implications of our findings for the restoration of acacia-invaded fynbos regions.

The role of adaptive strategies in plant invasion

Wen-Yong Guo[1,2] , Milan Chytrý[3], Zdeňka Lososová[3], Jan Divíšek[3,4] and Petr Pyšek[5,6]

[1]*Center for Biodiversity Dynamics in a Changing World (BIOCHANGE), Department of Bioscience, Aarhus University, 8000 Aarhus C, Denmark*
[2]*Section for Ecoinformatics & Biodiversity, Department of Biosciences, Aarhus University, 8000 Aarhus C, Denmark*
[3]*Department of Botany and Zoology, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic*
[4]*Department of Geography, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic*
[5]*Czech Academy of Sciences, Institute of Botany, Department of Invasion Ecology, CZ-252 43 Průhonice, Czech Republic*
[6]*Department of Ecology, Faculty of Science, Charles University, CZ-128 44 Viničná 7, Prague 2, Czech Republic*
e-mail: wenyong.guo@bios.au.dk

As one of the central topics in ecology, efforts to determine the factors associated with alien species' invasions have been rapidly increasing in the last decades. Yet, our ability to generalize and predict the outcome of particular species introductions remains limited. This is partly due to the prevailing focus on individual species traits, an approach that is less suitable to capture the inherent complexity of the naturalization-invasion process. Recently, Guo et al. (2018, 2019) demonstrated the usefulness of Grime's seminal concept of adaptive strategies – competitors, stress-tolerators and ruderals (CSR) – for explaining plant naturalizations worldwide, using a global dataset of >3000 vascular plant species and accounting for phylogenetic relatedness, species' native biomes, native range size and introduction history. They revealed that the C- and R-selection were positively, whilst S-selection negatively, associated with the likelihood of a species becoming naturalized outside its native range. However, due to the limited data availability, these authors did not test the applicability of the scheme for the invasion stage of the process. Here we tested the effects of the CSR adaptive strategies at different stages along the introduction–naturalization–invasion continuum, using the Pladias Database of Czech Flora and Vegetation. Our findings demonstrate the universal utility of the CSR scheme to explain the success of alien plant species in their introduced ranges.

Guo W.-Y., van Kleunen M., Winter M., Weigelt P., Stein A., Pierce S., Pergl J., Moser D., Maurel N., Lenzner B., Kreft H., Essl F., Dawson W. & Pyšek P. (2018) The role of adaptive strategies in plant naturalization. Ecol. Lett. 21: 1380–1389.

Guo W.-Y., van Kleunen M., Pierce S., Dawson W., Essl F., Kreft H., Maurel N., Pergl J., Seebens H., Weigelt P. & Pyšek P. (2019) Domestic gardens play a dominant role in selecting alien species with adaptive strategies that facilitate naturalization. Glob. Ecol. Biogeogr. 28: 628–639.

Drivers of the long-term dynamics and impacts of plant invasions

S. Luke Flory

Agronomy Department, University of Florida, Gainesville, FL 32611, USA
e-mail: flory@ufl.edu

Introduction of species to non-native ranges worldwide shows no sign of decline and many ecosystems are now subject to multiple plant invaders. Meanwhile, funding for management of conservation areas often is inadequate to address even a subset of the problematic invasive species. A better understanding of the long-term dynamics and impacts of plant invasions is needed to distinguish between species that will persist and affect native ecosystems and those that may naturally decline over time. However, most research projects on invasive plant impacts are conducted for only a few years, greatly limiting our ability to measure longer-term changes in populations or their effects. Using examples from studies of *Microstegium vimineum* in Indiana and *Imperata cylindrica* in Florida, I explore the biotic and abiotic drivers underlying the persistence or decline of invaders. For example, *Microstegium* can have profound impacts on native species in eastern deciduous forests, but the results from an eight-year experimental invasion study show that the invader and its effects can decline over successional time and allow native species to return. In other cases, however, *Microstegium, Imperata,* and other invaders persist over the long-term and negatively impact native species and alter ecosystem processes. In addition, fire, the accumulation of pathogens, interactions among multiple invaders, and other factors may determine if, and under what conditions, species may persist or decline. Improving our understanding of how invasions and their effects change over time will require additional monitoring and experiments over multiple years and will help prioritize the efficient and effective use of limited management funds.

Ecosystem change and a novel invasive annual grass in North American interior ecosystems

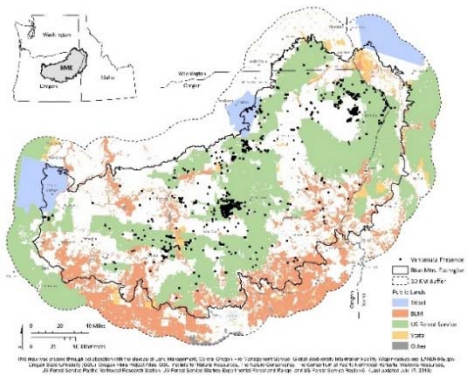
Becky K. Kerns[1], Claire Tortorelli[2], Ty Nietupski[2], Michelle Day[2], Luke Ridder[3], Lila Leatherman[2], Meg Krawchuk[2], Lesley Morris[3], Bridgett Naylor[1] and John Kim[1]

[1]*US Forest Service, Pacific Northwest Research Station, Corvallis, Oregon, USA*
[2]*College of Forestry, Oregon State University, Corvallis, Oregon, USA*
[3]*College of Agricultural Sciences, Oregon State University, La Grande, Oregon, USA*
e-mail: bkerns@fs.fed.us

The transformative ecological and socioeconomic impacts of invasive exotic annual grasses (EAG) have been long recognized in many ecosystems of the Americas, Australia, and Pacific islands. In western North America, EAGs such as *Bromus tectorum* have been highly problematic for decades in the iconic and vast sagebrush-steppe ecosystems. A recent EAG, *Ventenata dubia* or ventenata, has invaded these aridlands, but also threatens a wider range of dry interior North American ecosystems. Like many EAGs, ventenata has the potential to drastically alter biodiversity, livestock forage, fuel conditions and fire regimes, threatening multiple resources and ecosystem functions. We recently launched a series of studies focused on the Blue Mountain Ecoregion (BME), interior Pacific Northwest USA (Fig. 1) to examine how the ventenata invasion is transforming this ecoregion now and in the future.

Our 27 compiled data sources and new field surveys show ventenata is found from 392-1808 m in environments and plant community types ranging from forests, woodlands, shrub-steppes to meadows (Fig. 1). We used these data and leveraged cutting edge spatio-temporal satellite image fusion methods to estimate the species' unique landscape phenology to determine past and present extent across the BME validated with known occurrences. This will allow us to explore multiple aspects of the invasion, understand environmental and disturbance drivers, and provide information to fire managers regarding novel and increasingly hazardous fuel conditions. We also combined this spatially explicit information with other data to feed into the first species distribution model for ventenata in the western USA, allowing us to compare its climate niche to the native range (Europe, North Africa), explore how future climates may alter habitat suitability, and project invasion estimates into the future. We are now simulating how fuels, fire regimes, and fire effects may shift across the region under future climate change.

We have also conducted fine-scale investigations of ventenata dynamics, fire, and biodiversity in the BME's low fuel pyrophobic scablands and native bunchgrass ecosystems. These extensive ecosystems are important landscape components of forests in terms of both their ecology and fuel structure, which are being rapidly altered by the invasion (Fig. 2). Our bunchgrass prairie project explored how ventenata may respond to both prescribed fire and grazing. Newly proposed work will allow investigation into community susceptibility to invasion and delve more deeply into abiotic and biotic interactions.



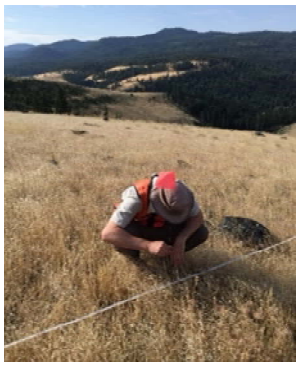


Fig. 1. Known ventenata locations in the BME compiled from numerous sources (left).
Fig. 2. Extensively invaded forest scablands (right).

The ongoing development and evolution of a control and detection system for scattered wilding conifers at the landscape scale in New Zealand

Peter Raal

New Zealand Department of Conservation, Dunedin Office, 265 Princess Street, Dunedin 9016, New Zealand
e-mail: praal@doc.govt.nz

The New Zealand high country has very extensive areas of montane and sub-alpine tussock grasslands that are susceptible to invasion by introduced conifers. However, the detection and control of these small, isolated and low-density infestations prior to seed production is problematic and expensive. Here I describe the development and evolution of a control and detection system for isolated wilding conifers, especially those developments that have led to significant improvements in cost-effectiveness.

The objective of a control operation is to systematically locate, map and destroy all adult and sapling conifers before they can set seed. Because of the large expanses of land involved (usually >30 000 ha) and the relative isolation of the wilding conifers, aerial operations are the only practical methods for finding trees. Initially, using GIS and GPS technology, helicopters carrying 5 - 6 staff used a method called skid-hopping to systematically search the high country for wilding conifers. Each tree found was cut down by a staff member using chainsaws or hand tools who had alighted from the aircraft. Often cut trees would regrow so it became standard practice to use an herbicide gel to poison the cut stumps. This methodology is costly, dangerous and time consuming.

The search and destroy control methodology has been improved through the development of a new and more efficient method called "Aerial Bark Application"**.** This method involves using only one operator to apply an oil-based herbicide from a helicopter **t**o the bark on the lower trunk and branches of the target trees. This single staff member can now cover 5–7 times the area treated with this methodology compared to skid-hopping. Aerial bark treatment has significantly increased productivity, reduced flying costs and eliminated the dangers associated with skid-hopping.

To eliminate unnecessary helicopter flying to search for trees, the detection methodology is being improved using fixed-wing, multispectral remote sensing. Testing very high resolution (VHR) imagery against field data has given us confidence that we now have a robust tool for the accurate detection and classification of small pre-coning sapling wilding conifers in high contrast environments. Approximately 90% of pre-coning conifer saplings that are >30 cm in diameter are able to be detected in tussock grasslands. Analysis of the cost differential between current best practice control (e.g. random search and destroy missions in helicopters) and more directed approaches using remote sensing suggest a significant advantage in using imagery for detection of small trees.

The improvements to the detection and control system was instrumental in the New Zealand Government investing in a three-year National Wilding Conifer Programme (Phase 1 of programme 2016–19), to coordinate control efforts by multiple agencies within the highest priority areas.

Increasing the availability and utility of high-resolution imagery for invasive species detection in Hawai‘i

Ryan Perroy[1], Roberto Rodriguez[2], David Benitez[3], Timo Sullivan[1] and Erica Ta[1]

[1]*Spatial Data Analysis & Visualization Laboratory, University of Hawai‘i at Hilo, Hilo, HI, USA*
[2]*APHIS-PPQ-CPHST Mission Laboratory, United States Department of Agriculture, Edinburg, TX, USA*
[3]*Division of Natural Resources Management, National Park Service, Hawai‘i Volcanoes National Park, HI, USA*
e-mail: rperroy@hawaii.edu

Despite decades of active management and widespread cooperative conservation efforts (Duffy & Martin 2019), native forests and ecosystems across Hawai‘i continue to experience major and growing disruptions from alien plant invasions. These impacts are now compounded by widespread ‘Ōhi‘a (*Metrosideros polymorpha*) mortality on Hawai‘i and Kaua‘i islands due to introduced fungal pathogens associated with rapid 'ōhi'a death (ROD; Keith et al. 2015). Regular monitoring to detect incipient invasions and other forest changes is a basic requirement for effectively managing these challenges (Müllerová et al. 2017). Although Hawai‘i has a great need for this type of monitoring, there is a deficit of available repeat high-resolution (<10 cm) imagery over the islands, even with recent improvements in small unmanned aerial systems (sUAS), manned aviation, and satellite imaging systems. In areas where appropriate imagery datasets are available, bottlenecks associated with tedious manual assessment by trained analysts limit the utility of these data for the detection and identification of targeted plant species over large areas. Here we present work exploring (1) the benefits and challenges of adding consumer-grade (digital single-lens reflex (DSLR) and GoPro) camera systems to acquire useful imagery during conservation helicopter operations in Hawai‘i, and (2) results from the new automated computer vision convolutional neural network (CNN) classifiers for the detection of *Miconia calvescens* DC and other invasive species of interest (Figure 1). Our trained CNN algorithms were applied to directories of raw geotagged sUAS and helicopter imagery to identify targets of interest; real-world coordinates of the identified targets were then estimated from image EXIF and XMP metadata and trigonometric functions. While the deficit of high-resolution imagery in Hawai‘i remains an issue, we can now routinely map thousands of priority hectares across the state and our automated classifiers can analyze hundreds of images per hour, greatly reducing the processing bottleneck and freeing analysts to examine a much smaller number of curated images.

Fig. 1. (Left) Prototype Helicopter-mounted camera mapping system. (Center) Mapping results from helicopter survey of >9,000 hectares on Kaua‘i island. (Right) Plant detection results from convolutional neural network algorithm applied to high-resolution (<5 cm) sUAS imagery.

Duffy D. C. & Martin C. (2019) Cooperative natural resource and invasive species management in Hawai'i. In: Veitch C. R., Clout M. N., Martin A. R., Russell J. C. & West C. J. (eds) Island invasives: scaling up to meet the challenge, p. 497–502. Occasional Paper SSC no. 62. IUCN, Gland, Switzerland.

Keith L. M., Hughes R. F., Sugiyama L. S., Heller W. P., Bushe B. C. & Friday J. B. (2015) First report of Ceratocystis wilt on `Ōhi`a (*Metrosideros polymorpha*). Plant Dis. 99: 1276.

Müllerová J., Brůna J., Bartaloš T., Dvořák P., Vítková M. & Pyšek P. (2017) Timing is important: unmanned aircraft vs. satellite imagery in plant invasion monitoring. Front. Plant Sci. 8: 887.

Use of drone and satellite images to classify and map native and invasive vegetation in island systems: the Galapagos example

Gonzalo Rivas-Torres[1,2,3,4], Lorena Benitez[1], Christian Sevilla[5], Danny Rueda[5] and Carlos Mena[1,3]

[1]*Colegio de Ciencias Biológicas y Ambientales and Galapagos Academic Institute for the Arts and Sciences, Universidad San Francisco de Quito, Diego de Robles S/N e Interoceánica, Quito, Ecuador*
[2]*Department of Wildlife Ecology and Conservation, University of Florida, 110 Newins-Ziegler Hall, Gainesville, FL 32611, USA*
[3]*Department of Geography, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599*
[4]*Galapagos National Park scientific collaborator*
[5]*Galapagos National Park Directorate, Santa Cruz, Ecuador*
e-mail: grivast@usfq.edu.ec

Here we present the results of a mixed, systematic and low-cost methodology to define and map native vegetation and the distribution of pervasive invasive plants that generally affect island resident ecosystems. After obtaining preliminary legends defined by experts: i. Landsat 8/OLI images were used to perform an object classification analysis; ii. high resolution images obtained by drones (UAVs) were taken for mapping validation; and iii. verification was performed in the field and in workshops to obtain the vegetation map of the iconic Galapagos National Park (GNP). This project (which includes species mapping using drones), revealed that 53.6% of the GNP is covered by nine native ecosystems and ~2.2% of this protected land is canopy dominated by invasive species. The so-called “dry” native ecosystems cover 40.8% of the GNP and only 12.8% of this protected area is covered by “wet” and “transitional” native ecosystems. Among the latter, those distributed in the highlands, covered only 4.8% of the protected area and are very threatened by the invasive species mapped here, which predominate in these sites. In addition, three native ecosystems occurring in the GNP were spatially described for the first time including the "Highland deciduous tallgrass", which despite being mainly in the upper parts of the Isabela volcanoes, present a type of vegetation similar to dry coastal forests (due to climatic inversion).

Cedrela odorata, *Pennisetum purpureum*, and *Psidium guajava* were the main invasive plants dominating the GNP canopy. The highly noxious *Rubus niveus* was the only invasive species dominating areas among the five (out of 18) infested islands.

The methodology detailed here proved useful to provide accurate spatially explicit island vegetation data, has a potential for replication in time, and is expected to aid the suitable management of highly endangered and unique biotas in this and other tropical island biomes.

Do co-introduced exotic rhizobia facilitate Australian acacia invasion success?

Staci Warrington[1, 2], Allan G. Ellis[2] and Johannes J. Le Roux[1, 3]

[1]*Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, Matieland 7602, South Africa*
[2]*Department of Botany and Zoology, Stellenbosch University, Matieland 7602, South Africa*
[3]*Department of Biological Sciences, Macquarie University, Sydney, NSW, 2109, Australia*
e-mail: staci_warrington@outlook.com

Australian acacias (genus *Acacia* Mill.) are problematic invasive species in many parts of the world. One of the attributes thought to promote the invasion success of acacias is their mutualistic interactions with nitrogen-fixing bacteria, known as rhizobia. Although rhizobia are cosmopolitan, several researchers have shown that invasive acacias associate with strains of the rhizobial genus *Bradyrhizobium*, which originate from Australia. This suggests that these Australian *Bradyrhizobium* strains were co-introduced to acacia-invaded regions. One such region is South Africa.
Here we report on greenhouse experiments that included two invasive acacias (*A. saligna* and *A. cyclops*) and two native South African legumes (*Psoralea pinnata* and *P. affinis*) grown under various soil, rhizobia, and leaf litter treatments. We investigated how the presence of co-introduced Australian bradyrhizobia may impact acacia performance (growth kinetics and biological nitrogen fixation [BNF] efficiency) at three stages of invasion: introduction, establishment and post-establishment. We found that, under introduction, i.e. when plants were grown in South African soils, acacias inoculated with Australian bradyrhizobia grew faster, accumulated more biomass, and had higher rates of BNF as opposed to those that relied solely on the microbes present within the untreated soils. Similar results were found for the establishment stage. Acacias exposed to Australian bradyrhizobia and acacia leaf litter had higher growth and competitive performances compared to acacias not exposed to these treatments. Lastly, to investigate whether this reliance on Australian bradyrhizobia continued into the post-establishment stage where acacia soils are sufficiently chemically altered to facilitate their growth, acacias were grown in sterilized soils collected from dense invasive acacia populations and either inoculated with Australian bradyrhizobia or not. We found that growth performances were similar between the two treatments, thus demonstrating that the reliance on exotic bradyrhizobia for successful growth/establishment of seedlings in post-establishment acacia soils diminishes due to the facilitatory changes in soil chemistry, such as increases in nitrogen. Overall, we provide evidence that co-invasion between Australian acacias and Australian *Bradyrhizobium* strains enhance invasion success.

Homeostatic fitness is key to understanding the role of plasticity in invasions

Jennifer L. Bufford and Philip E. Hulme

Bio-Protection Research Centre, Lincoln University, PO Box 85084, Lincoln 7647, New Zealand
e-mail: jennifer.bufford@lincoln.ac.nz

Phenotypic plasticity, a change in a plant's expressed phenotype in response to the environment, has the potential to promote alien plant invasions. However, not all trait variation is beneficial for maintaining fitness across environmental gradients and therefore measuring trait change alone can be misleading. We develop a conceptual model of the relationship between trait plasticity and fitness homeostasis to distinguish between adaptive plasticity, which should allow plants to maintain homeostatic fitness across a wide range of environmental conditions, from passive plasticity, which is not beneficial and may reflect ontogenetic or developmental constraints. We suggest that fitness homeostasis, rather than plasticity *per se*, is likely to underpin establishment success and increase spread and range size in alien plants. Therefore, we propose that studies of phenotypic plasticity in invasions need to focus primarily on fitness outcomes and not only on trait change across realistic environmental gradients. We present four scenarios that describe the possible relationships between traits and fitness across an environmental gradient and discuss what each reveals about adaptive and passive plasticity. We demonstrate these scenarios along with an analytical approach to connecting traits and fitness using data on alien plant traits and growth rates from an experimental soil moisture gradient. We also discuss the selection of environmental gradients and traits and argue that our understanding of plasticity will improve with a greater emphasis on multiple points along a relevant environmental gradient, but with analyses limited to traits with clear *a priori* implications for fitness along the gradient considered. By evaluating phenotypic plasticity in the light of fitness homeostasis, we can focus on adaptive plasticity to more clearly and accurately elucidate the role of adaptive trait change and environmental heterogeneity in alien plant establishment and expansion.

Plant species forming a persistent soil seed bank have a higher probability of becoming naturalized

Margherita Gioria[1], Lenka Moravcová[1], Wayne Dawson[2], Franz Essl[3], Holger Kreft[4], Jan Pergl[1], Patrick Weigelt[3], Marten Winter[5], Mark van Kleunen[6] and Petr Pyšek[1,7]

[1]*Institute of Botany, Czech Academy of Sciences, CZ-252 43 Průhonice, Czech Republic*
[2]*Department of Biosciences, Durham University, DH1 3LE Durham, United Kingdom*
[3]*Division of Conservation Biology, Vegetation and Landscape Ecology, University of Vienna, 1030 Vienna, Austria*
[4]*Biodiversity, Macroecology and Biogeography, University of Goettingen, 37077 Goettingen, Germany*
[5]*German Centre for Integrative Biodiversity Research, Halle-Jena-Leipzig, 04103 Leipzig, Germany*
[6]*Ecology, University of Konstanz, 78457 Konstanz, Germany*
[7]*Department of Ecology, Faculty of Science, Charles University in Prague, Viničná 7, CZ-128 44 Praha 2, Czech Republic*
e-mail: margherita.gioria@ibot.cas.cz

Recent evidence indicates that invasive species have a higher probability of forming persistent and denser seed banks compared to their non-invasive but naturalized congeneric species in the native range. This suggests that seed bank persistence is an important determinant of invasive success. Knowledge of the role of the characteristics of seed banks in alien species naturalization is, however, lacking. To address this issue, we tested whether seed bank type (transient vs persistent) and seed bank density (seeds per square meter) play an important role in the naturalization of alien plants at the global scale. To do so, we combined a global seed bank database comprising information on seed bank type and density for over 2000 species from the Global Naturalized Alien Flora database (GloNAF). This included information on naturalization incidence (i.e. whether a species has become naturalized outside its native range) and extent (i.e. number of regions where a species has become naturalized). The combined information on characteristics of the seed bank and naturalization incidence and extent were available for 1917 species in over 11,000 records. Preliminary analyses indicate that the probability of naturalization is higher in species forming persistent seed banks than those only forming transient ones, both in the native and alien ranges. Seed bank density was also positively related with the probability of naturalization but not with naturalization extent, in the native and alien range. These preliminary findings suggest that the capacity to form persistent seed banks is an important predictor of the probability of a species to become naturalized after its introduction in novel ranges, although climatic suitability will affect the number of regions. Knowledge of the characteristics of native seed banks should thus be an important component of risk assessments, although for many species, this information is available from the alien range only, where these species have already become naturalized and invasive.

Using the distribution of Australia's native grasses to predict the spread potential of exotic grasses

Kyle Hemming, Richard Duncan and Elizabeth Wandrag

Institute for Applied Ecology, Faculty of Science and Technology, University of Canberra, Australia
e-mail: kyle.hemming@canberra.edu.au

Determining the drivers of species' distributions is central to predicting the spread potential of exotic species. Most approaches rely on species distribution models, which estimate the potential distribution of an exotic species in a new region based on its distribution elsewhere. We use a new approach to determine the potential distribution of exotic grasses (family Poaceae) in Australia. We used gradients in native grass species richness (estimated using herbarium data) as a template for the potential distribution of exotic grasses across the continent. We identified the environmental variables that best explained native richness gradients and determined whether these also explained exotic richness gradients. If native and exotic grass species respond to environmental variables in similar ways, we would expect regions with high native richness but low exotic richness to be vulnerable to the spread of exotic grasses.

Initially, native and exotic grass species richness gradients and their relationships to environmental variables were dissimilar, suggesting that the native template concept was not supported. Native grasses had higher richness in warmer northern and coastal regions, while exotic grasses had higher richness in cooler temperate regions characterized by high levels of human impact. These differences, however, could be largely explained by photosynthetic pathways. Both exotic and native C_3 grasses responded similarly to the environmental variables, and both groups exhibited higher species richness in southern temperate regions. This match in distributions suggests that exotic C_3 grasses do not have a high spread potential. Conversely, while exotic and native C_4 grasses again responded similarly to environmental variables, there was a large mismatch in their species distributions. Relative to native C_4 grasses, exotic C_4 grasses were underrepresented across much of Central and North-western Australia, suggesting that there is considerable potential for exotic C_4 grasses to colonise these regions where native C_4 richness is high.

Detection and modelling of the spread of *Ailanthus altissima* using UAV data

Josef Brůna[1], Jana Müllerová[1], Tomáš Bartaloš[1] and Petr Dvořák[2]

[1]*Institute of Botany of the Czech Academy of Sciences, Průhonice, Czech Republic*
[2]*Institute of Aerospace Engineering, Brno University of Technology, Brno, Czech Republic*
e-mail: josef.bruna@ibot.cas.cz

Tree of heaven *(Ailanthus altissima)* belongs to the 100 worst European invasive species with further potential to spread due to climate change. *Ailanthus* is particularly limited by late spring frost which damages the buds and young leaves. In the Czech Republic and other Central and Northern European countries, *Ailanthus* is still mostly present in urban areas serving as heat islands. However, with increasing temperatures and enough propagules from already established populations, its invasion is expected to grow rapidly. Means of early detection as well as detailed knowledge on the species potential to spread across Europe are therefore urgently needed. In the Czech Republic, the species is currently on the northern edge of its distribution range, being present only in the warmest parts of the country and in urban areas. Examples of *Ailanthus* escaping into the open landscape are still rather rare here, unlike in neighbouring countries, such as southern Hungary or southern Austria where it has already massively increased in the last decades. But we can expect similar scenarios.
In our study, we focused on possibilities of early detection using custom built fixed wing UAV and identified the best phenology phase for detection. We generated an orthoimage and digital model of the canopy using Structure from Motion method in Agisoft Photoscan. Subsequently, we applied object-oriented image analysis and automatic classification of segments and achieved high accuracies using spring multispectral imagery (RGB+NIR). Our results from several years show that the accuracy also depends on frostwhich can lower the accuracy, especially if the frost appeared only in part of the area (e.g. valley bottoms).

Consequently, we produced a model of the current and potential distribution of *Ailanthus*, using data on species distributions in the Czech Republic and identified environmental and climatic constrains shaping the current distribution, as well as potential spread with regard to expected future climate change.

From handheld device to satellite: a toolkit of remote sensing and machine learning techniques for measuring the spread of invasive plants

Joseph T. Fennell[1], S. M. S. M. Rajib[1], Muhammad Usman[2], Ahtisham Akbar[2], Hamza Khan[2], Saad Khan[2], Tim Beale[4], Julien Lamontagne-Godwin[3], Pablo González-Moreno[3,5], Abdul Rehman[2] and Rene P. Breton[1]

[1]*Jodrell Bank Centre for Astrophysics, School of Physics and Astronomy, The University of Manchester, Manchester M13 9PL, UK*
[2]*CABI Data Gunj Baksh Road, Satellite Town, PO Box 8, Rawalpindi, Pakistan*
[3]*CABI, Bakeham Lane, Egham, Surrey, TW20 9TY, UK*
[4]*CABI, Nosworthy Way, Wallingford, Oxfordshire, OX10 8DE, UK*
[5]*ERSAF. University of Cordoba, 14014, Spain*
e-mail: joseph.fennell@manchester.ac.uk

The use of remote sensing techniques for large-scale monitoring of invasive plant species offers huge promise for better understanding their ecology. A new generation of optical and radar satellites with global coverage and freely available data, combined with increasing computational resource and faster machine learning methods, provide new and exciting opportunities for monitoring and mapping at medium to low spatial resolution. At the same time, consumer and prosumer Unmanned Aerial Vehicles (UAVs) have become more readily available and can carry diverse sensor payloads. Using the spread of *Parthenium hysterophorous* in Pakistan as an exemplar scenario, we present an end-to-end approach for linking ground surveys with remote sensing datasets for monitoring invasive species. First, we designed an extensive ground-survey campaign, capturing 1400 sites across 3 provinces (KPK, Punjab and Sindh) and 22 districts, to provide a representative 'ground truth' dataset of *Parthenium* and similar non-*Parthenium* habitats. We then made high resolution temporal, spectral and spatial measurements using handheld devices and a novel UAV-mounted multispectral imaging sensor to better understand the time-evolution of the *Parthenium* spectral signature. Finally, we trained a probabilistic classifier using optical satellite time-series data, allowing both the quantification of *Parthenium* extent as well as the uncertainty in the prediction. We present the outputs of our exemplar study and discuss the implications for methodological design of future studies and the use of open source tools developed throughout the project.

Impacts of alien plant invasion on forest vegetation are modulated by landscape configuration and native plant functional group

Ben Gooden[1,2], Luke O'Loughlin[1], Dane Panetta[3] and Louise Morin[1]

[1]*Commonwealth Scientific and Industrial Research Organisation, GPO Box 1700, Canberra, ACT 2601, Australia*
[2]*University of Wollongong, Wollongong, Australia*
[3]*The University of Melbourne, Melbourne, Australia*
e-mail: Ben.Gooden@csiro.au

It is well known that alien plant invasions significantly reduce the diversity and alters the composition of native forest communities. However, most extant studies examine impacts of invasion by comparing differences in native vegetation diversity between heavily invaded and native (non-invaded) reference sites, and often in a restricted number of landscape contexts. We have very little understanding of how native vegetation responds to invasion across gradients of invasion intensity or different landscape or habitat conditions. Furthermore, there is a need to determine how invader impacts vary amongst different functional groups within the native community, as this may inform which species to target for restoration post invader management.

We examined the effects of invasion by an alien, semi-succulent, stoloniferous, shade-tolerant herb *Tradescantia fluminensis* Vell. (commonly named wandering trad) on the diversity and composition of a cool temperate rainforest community in south-eastern Australia. Wandering trad was introduced to Australia from its native range of Brazil as an ornamental groundcover species and subsequently escaped suburban gardens into adjacent native forests. During 2018, we recorded the number and identity of native rainforest plant species from 90 plots ($4m^2$) across a gradient of increasing wandering trad biomass. We also randomly allocated plots across a gradient of anthropogenic development surrounding the invaded patches of rainforest (forest to cleared agricultural land to suburban areas) to test whether invader impacts are modulated by landscape context.

We found that native plant species diversity and richness declined significantly with increasing wandering trad cover, but only after 50% foliage cover, which indicates an impact threshold relationship. In plots with greater than 80% wandering trad foliage cover the number of native species was 90% lower than non-invaded areas. We also found that the landscape context significantly modulates native vegetation responses to invasion; i.e. the magnitude of native species decline in response to invasion was greater in suburban landscapes with low cover of native forest surrounding the plots. We speculate that a reduction in forest cover in the surrounding landscape reduces the resistance of remnant patches of rainforest to invader impacts, perhaps by preventing the replenishment of seed stocks to replace plants displaced by the invader.

In terms of native plant functional group responses, we found that the richness and cover of all plant growth forms declined significantly with increasing wandering trad biomass. However, the magnitude of decline in response to invasion was higher for species with a similar growth form (i.e. ground-cover, stoloniferous, herbaceous) to wandering trad. Species with divergent growth habits (i.e. tufted herbs, ferns, deep-rooted shrubs) were more resistant to invasion and only began to decline when wandering trad cover exceeded 80%.

Our results show that impacts of alien plant invader are non-linear and can be modulated by landscape context and the functional identity of resident native species. Management should focus upon limiting invader abundance to below the threshold abundance level in order to curtail significant native species losses. In terms of ecosystem restoration, revegetation may be required to replace native species in suburban areas that suffer the greatest decline in response to invasion after the target invader has been controlled.

Trait-based evaluation of a perennial alien species *(Asclepias syriaca*) in the invaded community

Anikó Csecserits, Melinda Halassy, Tamás Rédei, Katalin Szitár and Zoltán Botta-Dukát

MTA Centre for Ecological Research, Institute of Ecology and Botany, Vácrátót, 2163, Alkotmány Srt. 2-4, Hungary
e-mail: csecserits.aniko@okologia.mta.hu

The invasion of alien plant species can cause long-lasting impacts on plant communities, changing the diversity and functioning of native plant communities. This is especially true for intensively developing habitats, such as abandoned agricultural fields, in which alien species can have a detrimental effect as it impedes the regeneration of native plant communities. There are many hypotheses explaining the impact and success of alien species, most of which highlight the importance of functional characteristics of the non-native species. According to the trait divergence hypothesis, novel traits of alien species may promote these species to use their resources differently than the resident community, thus providing a competitive advantage for the alien species.

Milkweed is a widespread alien species in Hungarian Lowlands, especially in abandoned agricultural fields, causing nature conservation problems. Thus, it is important to understand the reason behind its success to enhance the effectiveness of management measures.

As a first step, we evaluated the position of milkweed in the local community. Our questions were: (i) does the non-native species, *Asclepias syriaca*, have different trait compositions than the native local species? (ii) is there a decline in native plant richness and abundance because of the non-native species during succession? (iii) do native species, which are most influenced by the spread of milkweed, have a similar or different trait composition compared to *Asclepias syriaca*?

We conducted our study in the Hungarian lowland, in the sandy area between the Danube and Tisza rivers. The vegetation of old-fields comprising four different age-groups (i.e. 35-26, 25-13. 12-7, 6-2) were studied from 2000 to 2017. We compared the trait spectrum of milkweed with the species from the local species pool on the basis of twelve traits. The effect of milkweed on native plant richness and abundance were evaluated using mixed effect models. The trait spectrum of milkweed was different from most of the local species, therefore, this species represents a novel trait combination for this region. During succession, the abundance of *Asclepias syriaca* increased in every age-group, while the abundance of native perennial species only increased in recently abandoned fields. We found a correlation between the changes of *Asclepias syriaca* abundance from 2000 to 2010 and the changes of perennial herb species from 2000 to 2010. Milkweed had a larger effect on the perennial herb species, showing similar trait composition. The better resource-use of *Asclepias syriaca* may be a possible reason for it, but this requires further study.

A global assessment of terrestrial alien ferns (Polypodiophyta): species' traits as drivers of naturalization and invasion

Emily J. Jones[1,2], Tineke Kraaij[1], Herve Fritz[3,1] and Desika Moodley[4]

[1]*Nelson Mandela University, Madiba Dr, George Central, George, 6530, South Africa*
[2]*Invasive Species Programme, South African National Biodiversity Institute, South Africa*
[3]*Université Lyon, CNRS, UCBL, UMR 5558, Villeurbanne, 69622, France*
[4]*Department of Invasion Ecology, Institute of Botany, Czech Academy of Sciences, CZ 252 43 Průhonice, Czech Republic*
e-mail: emilyjoy.jones@mandela.ac.za

The global threat posed by invasive alien plants has prompted inventory compilations and screening exercises that aim to understand invasiveness in various taxa. Various traits influence the invasiveness of a species but this does not apply to all plant taxa. Ferns are rare or absent from such inventories, but notable fern invasions do exist. We developed a global inventory of terrestrial alien true ferns (Polypodiophyta) comprising 157 species, using published literature and online inventories. We aimed to determine which traits influence the probability that a terrestrial alien fern will become naturalized or invasive. Generalized linear models with transition stages as response variables, were used to assess the effects of various anthropogenic, biological and distributional traits on invasiveness. Our model explained 30-40% of the variance associated with invasiveness and showed that a ground-dwelling life form, reproductive plasticity, tolerance for disturbance and varied light conditions, and a broad introduced range (interpreted as high environmental tolerance and popularity in horticulture) were important determinants of invasiveness in alien ferns. We highlighted which geographic regions and fern families had the highest incidences of alien ferns and identified particular species of concern. This study aids in the understanding of the mechanisms underlying invasiveness in alien ferns and the findings can inform future research on this understudied taxon as invasive species.

Mechanisms limiting seed recruitment in an invaded community

Maia Raymundo[1], John Dwyer[2] and Margie Mayfield[1]

[1]*The Ecology Centre, University of Queensland, St. Lucia, QLD 4072, Australia*
[2]*CSIRO Land and Water, EcoSciences Precinct, Dutton Park, QLD 4001, Australia*
e-mail: raymundo.mlh@gmail.com

Plant population growth is well known to be impacted by a range of factors, including seed production, dispersal, competition, herbivory, and predation, operating at various life-history stages. The recruitment phase (i.e. germination, survivorship and growth) has been identified as a bottleneck for population growth and is thus one of the key stages for understanding plant community structure and diversity. Numerous ecological models and empirical studies have focused on determining the mechanisms affecting survival during recruitment and successive life stages. However, the causes of recruitment limitation and the factors limiting subsequent population growth is particularly understudied in invaded communities. The annual understory of Southwest Australia's York gum woodland system is an ideal system for studying the complex processes involved in plant community assembly of invaded systems because of the relatively short growing seasons and heavily structured invasion patterns along biotic and abiotic gradients. Quantifying the extent to which abiotic and biotic filters influence the assembly of invaded communities and whether dispersal limitation is a factor in determining local heterogeneity is vital to understanding invasive species' persistence through time. We tested the extent to which dispersal and biotic and abiotic filtering impose constraints on germination and survival of native annual forb populations in invaded communities through a series of seed addition experiments along biotic and abiotic gradients associated with invasion. Our results showed that though focal species used in seed augmentation were common throughout the plots, diversity was almost five times higher in seed-augmented subplots than control subplots. This suggests that dispersal plays a vital role in influencing the diversity and heterogeneity of these invaded communities, particularly as natives are dispersal-limited and their introduction to a community increases overall diversity even in exotic dominated sites. We found that native annual forbs were generally seed limited, as indicated by the higher number of germinants in seed-augmented plots compared to control plots (Fig.1). However, the mean effect size for seed limitation were all below 35%, showing that only a small fraction of the viable seeds germinated, which suggests that microsite limitation may be more important for all focal species at the post-dispersal stage. Overall, post-dispersal processes were the strongest constraints to seedling emergence and overall population size. Canopy cover and soil phosphorus, both structuring factors in these communities, did not strongly influence population sizes of added focal species at the seedling and adult stages. Exotic densities also did not strongly limit population sizes across all species. The lack of strong trends indicates that native species may be more resilient to soil eutrophication and invasion in terms of population size after seedling emergence.

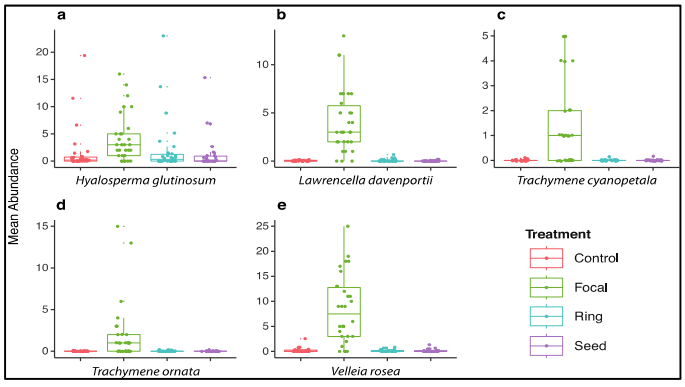


Fig. 1. Mean abundance of five focal germinants under four different treatments: Control, Focal, Ring, and Seed. Results show native seed limitation

Plant invasions are related to disturbance and native sapling diversity in tropical rainforest fragments

Emily H. Waddell[1,2,3], Lindsay F. Banin[1], Colin J. McClean[4], Susannah Fleiss[2], Jane K. Hill[2], Mark Hughes[3], Ahmad Jelling[5], Yeong Kok Loong[6], Bernadus Bala Ola[5], Azlin Bin Sailim[5], Joseph Tangah[7] and Daniel S. Chapman[1,8]

[1]*Centre for Ecology and Hydrology, Bush Estate, Penicuik, EH26 0QB, UK*
[2]*Department of Biology, University of York, Wentworth Way, York, YO10 5DD, UK*
[3]*Royal Botanic Garden Edinburgh, 20A Inverleith Row, Edinburgh, EH3 5LR, UK*
[4]*Department of Environment and Geography, University of York, York YO10 5DD, UK*
[5]*The South East Asia Rainforest Research Partnership, Danum Valley Field Centre, PO Box 60282, 91112, Lahad Datu, Sabah, Malaysia*
[6]*Leverhulme Centre for Climate Change Mitigation, University of Sheffield, Sheffield, S10 2TN, UK*
[7]*Forest Research Centre, Sabah Forestry Department, P.O. Box 1407, 90715 Sandakan, Sabah, Malaysia*
[8]*Faculty of Natural Sciences, University of Stirling, Stirling, FK9 4LA, UK*
e-mail: emilyhelen22@hotmail.com

Fragmentation and degradation of tropical forests reduce the native plant diversity in remnant forest patches, but consequences for invasion by non-native species are less clear. Occurrence of exotic plants may be greater in forests with increased edge habitat and disturbance, but biotic interactions with native plant communities may also be influential. Here, we examine the relative importance of fragmentation, forest disturbance, soil characteristics and native plant diversity for invasion of rainforest patches within agricultural landscapes.

We surveyed native and exotic plant communities in 49 plots at 18 sites, spanning gradients in landscape-scale fragmentation (i.e. measures of the amount of forest and edge in the landscape) and local forest disturbance (i.e. number of large trees and mean wood density) in oil-palm dominated landscapes of Sabah, Malaysian Borneo. We used partial least squares path modelling to examine the influence of fragmentation, disturbance, soil characteristics (i.e. pH, available phosphorus) and native community diversity (i.e. genus richness and phylogenetic diversity) on exotic occurrence. We first ran models using the total native community and then with different native community subsets (i.e. adult trees, saplings, seedlings and understorey plants excluding seedlings).

We surveyed 7268 stems from 332 genera. These included eight exotic species (0-51% of stems/plot, mean=5%) representing shrubs, herbs, graminoids and climbers. The best model explaining exotic occurrence (R^2=0.277) included a direct negative correlation with native tree sapling diversity and an indirect positive effect of local forest disturbance. We found no evidence for either landscape-scale fragmentation or soil characteristics significantly influencing exotic occurrence in any of the models.

We found that occurrence of exotic species is associated with forest disturbance, likely due to previous commercial selective logging and biotic interactions with native tree saplings. Evidence of a negative correlation between sapling diversity and exotics may indicate biotic resistance from saplings during regeneration after logging, or that dominant exotic species outcompete saplings and reduce their diversity. Our results show that the strength of interactions between native and exotic plants, and hence the potential impacts of plant invasions, varies according to the life stage of the native community. Thus, studies quantifying biotic interactions using the total native community may underestimate the role of biotic processes in mediating invasion.

Understanding hierarchical patterns of plant invasions impacting agriculture: the study case of *Parthenium* weed in Pakistan

Pablo González-Moreno[1,2], Muhammad Usman[3], Ahtisham Akbar[3], Hamza Khan[3], Saad Khan[3], Tim Beale[4], Julien Lamontagne-Godwin[2], Joseph Fennell[5], Abdul Rehman[3] and Rene P. Breton[5]

[1]*ERSAF, University of Cordoba, 14014, Spain*
[2]*CABI, Bakeham Lane, Egham, Surrey, TW20 9TY, UK*
[3]*CABI Data Gunj Baksh Road, Satellite Town, PO Box 8, Rawalpindi, Pakistan*
[4]*CABI, Nosworthy Way, Wallingford, Oxfordshire, OX10 8DE, UK*
[5]*Jodrell Bank Centre for Astrophysics, School of Physics and Astronomy, The University of Manchester, Manchester M13 9PL, UK*
e-mail: p.gonzalez-moreno@cabi.org

Understanding the factors shaping the distribution of invasive plants is a key aspect to efficiently manage them. For example, this information can be used as a tool to predict the likelihood of presence or potential abundance of an invasive plant impacting agriculture, informing policy and managers on where to act to avoid further spread or the locations where more intense management is required. Despite the relevance of this tool, little is known about the factors that influence the occurrence and abundance of agricultural and environmental invasive species at different temporal (seasons) and spatial scales (e.g. regional, landscape and local). We use *Parthenium* weed (*P. hysterophorus*) in Pakistan as study case to explore these questions. *Parthenium* weed is an herbaceous plant native to the American continent and is highly invasive in both disturbed and natural habitats around the world, particularly in south-east Asia, Australia and east Africa. *Parthenium* weed reduces local plant biodiversity; crop and pasture yields through aggressive competition and allelopathy; and poses health hazards to livestock and humans. *Parthenium* weed was introduced into Pakistan in the 1980s and is spreading rapidly from the Gujrat district in the Northern part of Punjab Province, where it was first reported. We carried out stratified road sampling across Punjab and KPK provinces of Pakistan collecting 1400 sampling points across two seasons (Autumn 2018 and Winter 2019) including information on the abundance of *Parthenium* weed at each habitat type. *Parthenium* showed higher probability of occurrence in the North of Punjab, reducing its likelihood of occurrence towards the north of KPK (lower temperature) and south of Punjab (drier areas). Besides climate suitability, this pattern also reflects the spread of *Parthenium* from its first introduction point in Pakistan. Regarding habitats, *Parthenium* had higher probability of occurrence in field crop margins and natural vegetation in wet areas, while planted field crops and forest areas showed the lowest probability. The abundance of *Parthenium* in field crops increased towards maturity and harvest of the crop indicating the high abundance of *Parthenium* seed in the soil bank likely suppressed by herbicides. *Parthenium* also showed higher probability of occurrence in national and district roads (i.e. higher vehicle frequency) in comparison to local and unpaved roads. This pattern reflects the association of *Parthenium* with higher disturbances, but also the likelihood of higher dispersal rates on roads with higher use. Considering the current distribution pattern, it is likely that *Parthenium* will continue spreading towards the south of Punjab and Sindh provinces taking advantage of the fertile and irrigated areas following the Indus river.

Which environmental factors affect the diversity of alien herbs in the ruderal flora in western Mexico?

Isabel Pérez Postigo[1], Jörg Bendix[2], Heike Vibrans Lindemann[3] and Ramón Cuevas Guzmán[1]

[1]*Universidad de Guadalajara, Centro Universitario de la Costa Sur, Av. Independencia Nacional #151, C.P. 48900, Autlán, Jalisco, Mexico*
[2]*Philipps-Universität Marburg, Germany*
[3]*Colegio de Postgraduados Texcoco, Mexico*
e-mail: perezpostigo@gmail.com

Disturbed areas are particularly prone to invasion by alien species (Espinosa-García & Villaseñor 2017). Though various hypotheses exist on the factors that influence invasive plant distribution, little is known about the relationship with environmental conditions, especially in the tropics (Pyšek & Richardson 2006, Rejmánek et al. 2005). In Mexico, a megadiverse country, studies on invasion ecology have been restricted mainly to central Mexico and to floristic comparisons between states (Espinosa-García et al. 2004, Espinosa-García & Villaseñor 2017, van Kleunen et al. 2015, Villaseñor & Espinosa-García 2004). In order to shed some light onto regional patterns we ask: (i) what is the floristic composition of alien and native herbaceous species in the ruderal vegetation in western Mexico?, and (ii) which environmental variables influence species distribution and abundance patterns of the alien and native herbaceous species?

We worked along an elevational gradient from the Jalisco state coast up to 2150 m in the Sierra de Manantlán, located in the northern part of the Southern Sierra Madre. Alien and native herb richness and abundance was documented in the field using 37 plots of 5 × 1 m² along with various environmental factors; other variables were obtained from databases. Floristic composition, species richness, abundance and their relation to 17 selected environmental variables were analysed using random forest modelling methods.

We registered 353 herbaceous species, of which 9% are introduced. The family Poaceae was richest in species for aliens and natives, with taxa present in all plots and among the most abundant. We found a positive correlation between native and introduced species richness but no correlation between abundances. Species composition formed clear clusters along the elevation gradient with variation in species composition, especially in plant families and a significant positive correlation between alien species abundance and elevation. For the behaviour of alien species richness along the elevation gradient no pattern was found.

This indicates the dominating influence of other environmental variables for species richness. The most important variables returned by the random forest modelling for alien species richness were distance to roads and highways, mean and maximum temperature and slope. Variable importance analysis for alien abundance patterns in general was not significant. Single species abundance patterns of *Melinis repens*, one of the most abundant taxa, showed good model performances. Pattern identification helps us to understand the factors shaping present and future distributions of exotic herb species.

Espinosa-García F. J., Vibrans H. & Villaseñor J. L. (2004) Geographical patterns in native and exotic weeds of Mexico. Weed Technol. 18: 1552–1558.

Espinosa-García F. J. & Villaseñor J. L. (2017) Biodiversity, distribution, ecology and management of non-native weeds in Mexico: a review. Rev. Mex. Biodivers. 88: 76–96.

Pyšek P. & Richardson D. M. (2006) The biogeography of naturalization in alien plants. J. Biogeogr. 33: 2040–2050.

Rejmánek M., Richardson D. M. & Pyšek P. (2005) Plant invasions and invasibility of plant communities. Veg. Ecol. 20: 332–355.

van Kleunen M., Dawson W., Essl F., Pergl J., Winter M., Weber E., … Pyšek P. (2015) Global exchange and accumulation of non-native plants. Nature 525: 100–103.

Villaseñor J. L. & Espinosa-García F. J. (2004) The alien flower plants of Mexico. Diversity Distrib. 10: 113–123.

The "Global Database of Alien Pathogenic Fungi"

Anna Schertler, Bernd Lenzner, Stefan Dullinger, Dietmar Moser, Collaborators and Franz Essl

University Vienna, Department of Botany and Biodiversity Research,
Rennweg 14, 1030 Vienna, Austria
e-mail: anna.schertler@univie.ac.at

As a consequence of globalization, the human-mediated introduction of species beyond their native ranges has undergone remarkable acceleration (Seebens et al. 2017). Hence, efforts to quantify biological invasions worldwide (e.g. Pyšek et al. 2017) and analyze patterns and identify underlying drivers (e.g. Seebens et al. 2017, Moser et al. 2018) have been undertaken. These studies have taken advantage of newly compiled global databases on alien species, e.g. vascular plants (van Kleunen et al. 2019), mammals, reptiles, amphibians, ants and birds (Dawson et al. 2017).

Unfortunately, invasion biology exhibits a strong bias towards vascular plants and vertebrates, often neglecting other major taxonomic groups, such as fungi (Desprez-Loustau et al. 2007, Gladieux et al. 2015), of which many are crucial for nutrient cycling and ecosystem functioning, while others engage in mutualistic relationships or act as pathogens (Willis 2018). The underrepresentation of fungi in invasion biology is partly attributable to the "Linnean", "Darwinian" and "Wallacean" shortfalls, i.e. a lack of knowledge on fungal taxonomy, distribution and ecology (Desprez-Loustau et al. 2007). However, advancing methods in molecular ecology have recently allowed for noteworthy progress on species delimitation and identification of native and alien ranges (Gladieux et al. 2015). Thus, the compilation of a global database on alien fungal pathogens has become feasible. Given the large impacts pathogenic fungi cause on the environment and human livelihoods (Desprez-Loustau et al. 2007, Willis 2018), this has become an important knowledge gap to address.

Here, we introduce the "Global Database of Alien Pathogenic Fungi", a comprehensive database on the worldwide distribution of introduced and emerging fungal pathogens, with particular emphasis on micromycetes. This database contains information on alien and native distribution (taken from a wide range of sources), complemented by data on phylogeny, traits and life-history characteristics relevant for invasion, such as host specificity and heteroecy (Philibert et al. 2011), years of first records, associated hosts and observed impacts. We will present applications of this database for answering macroecological and biogeographical questions, and highlight the role of plant-fungal relationships in invasion biology, which is of importance for understanding and managing plant invasions.

Dawson W. et al. (2017) Global hotspots and correlates of alien species richness across taxonomic groups. Nat. Ecol. Evol. 1: 0186.
Desprez-Loustau M. L. et al. (2007) The fungal dimension of biological invasions. Trends Ecol. Evol. 22: 472–480.
Gladieux P. et al. (2015) The population biology of fungal invasions. Mol. Ecol. 24: 1969–1986.
Moser D et al. (2018) Remoteness promotes biological invasions on islands worldwide. Proc. Natl Acad. Sci. 115: 9270–9275.
Philibert A. et al. (2011) Predicting invasion success of forest pathogenic fungi from species traits: predicting fungal invaders. J. Appl. Ecol. 48: 1381–1390.
Pyšek P. et al. (2017) Naturalized alien flora of the world: species diversity, taxonomic and phylogenetic patterns, geographic distribution and global hotspots of plant invasion. Preslia 89: 203–274.
Seebens H. et al. (2017) No saturation in the accumulation of alien species worldwide. Nat. Comm. 8: 14435.
van Kleunen M. et al. (2019) The Global Naturalized Alien Flora (GloNAF) database. Ecology 100: e02542.
Willis K. J. (2018) State of the World's Fungi 2018. Royal Botanic Gardens, Kew.

Neighbour tolerance, not suppression, provides competitive advantage to non-native plants

Marina Golivets[1,2] and Kimberly F. Wallin[1,3]

[1]*Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT, USA*
[2]*Helmholtz Centre for Environmental Research – UFZ, Halle, Germany*
[3]*USDA Forest Service, Northern Research Station, Burlington, VT, USA*
e-mail: marina.golivets@gmail.com

High competitive ability has often been invoked as a key determinant of invasion success and ecological impacts of non-native plants. Yet our understanding of the strategies that non-natives use to gain competitive dominance remains limited. Particularly, it is unknown whether the two non-mutually exclusive competitive strategies, neighbour suppression and neighbour tolerance, are equally important for the competitive advantage of non-native plants. We analyzed data from 192 peer-reviewed studies on pairwise plant competition within a Bayesian multilevel meta-analytic framework. We found that non-native plants outperform their native counterparts due to high tolerance of competition, as opposed to strong suppressive ability. Competitive tolerance ability of non-native plants was driven by neighbour's origin and was expressed in response to a heterospecific native but not heterospecific non-native neighbour. In contrast to natives, non-native species were not more suppressed by hetero- vs. conspecific neighbours, which was likely partially due to higher intensity intraspecific competition among the non-natives. Heterogeneity in the data was primarily associated with methodological differences among studies and not with phylogenetic relatedness among species. Altogether, this synthesis demonstrates that non-native plants are competitively distinct from native plants and challenges the common notion that neighbour suppression is the primary strategy for plant invasion success.

Community assembly rules of arbuscular mycorrhizal fungi in plant invasions: comparison between ranges

Kateřina Štajerová[1,2], Petr Kohout[1,3,4], Zuzana Kolaříková[1], Lukáš Sekerka[5], Petr Šmilauer[6], Dana Blumenthal[7], Ragan M. Callaway[8,9], Martin Hejda[1], Peter Kotanen[10], Diane L. Larson[11], Maarja Öpik[12], Urs Schaffner[13], Radka Sudová[1], Stanislav Vosolsobě[1,4] and Petr Pyšek[1,2]

[1]*Institute of Botany, The Czech Academy of Sciences, Průhonice, CZ-252 43, Czech Republic*
[2]*Department of Ecology, Faculty of Science, Charles University, Prague, Czech Republic*
[3]*Institute of Microbiology, The Czech Academy of Sciences, Prague, Czech Republic*
[4]*Dept of Experimental Plant Biology, Faculty of Science, Charles University, Prague, Czech Republic*
[5]*Department of Entomology, National Museum, Prague, Czech Republic*
[6]*Faculty of Science, University of South Bohemia, České Budějovice, Czech Republic*
[7]*Rangeland Resources and System Research Unit, USDA Agricultural Research Service, Ft Collins, USA*
[8]*Division of Biological Sciences, University of Montana, Missoula, MT 59812, USA*
[9]*Wildlife Biology and the Institute on Ecosystems, University of Montana, Missoula, MT 59812, USA*
[10]*Department of Ecology and Evolutionary Biology, University of Toronto Mississauga, Canada*
[11]*Northern Prairie Wildlife Research Center, U.S. Geological Survey, St. Paul, MN 55108, USA*
[12]*Department of Botany, Institute of Ecology and Earth Sciences, Tartu, Estonia*
[13]*CABI, Rue des Grillons 1, 2800 Delémont, Switzerland*
e-mail: katerina.stajerova@ibot.cas.cz

Despite intensive ecological research on mycorrhizal symbiosis, its importance in invasion biology has been rather underestimated. At least so far, when the rapid development of molecular techniques allowed us to incorporate the effects of mycorrhizal fungi on plant invasion success in ecological studies for a relatively reasonable amount of money. Here, we focused on one type of mycorrhizal symbiosis, arbuscular mycorrhizal fungi (AMF), which are ubiquitous, low host-specific, world-wide distributed and associated with the majority of terrestrial plants. Thus, it is highly probable that an invasive plant species will interact with AMF in its native as well as in the invaded range.

The present study aims to test this assumption by using a biogeographic comparison of three model (semi)grassland Asteraceae species – Canada thistle (*Cirsium arvense*), oxeye daisy (*Leucanthemum vulgare* agg.), and common tansy (*Tanacetum vulgare*) – native to Europe and invasive in North America. In both ranges, we established eighteen experimental sites in which the given species was either a native or an invasive dominant: 1) to identify AMF community assembly associated with the given species in both ranges, 2) to compare AMF community assembly of the given species with that of native species of resident communities in the native vs invaded range, and 3) to describe changes in AMF community assembly during the invasion process. The community structure of AMF were identified using MiSeq Illumina amplicon sequencing of SSU rDNA region (primer combination NS31/AML2). The AMF Virtual Taxa (VT) were determined using blast search of Illumina reads against MaarjAM database. All statistical analyses were performed on a subsampled dataset (1000 AMF seq. / sample) using R and Canoco.

In total, 163 AMF VT were identified (i.e. 119 Glomeraceae, 10 Diversisporaceae, 8 Acaulosporaceae, 8 Claroideoglomeraceae, 6 Gigasporaceae, 5 Paraglomeraceae, 4 Archaeosporaceae, 2 Pacisporaceae, 1 Ambisporaceae). Community assemblies of AMF associated with the given species significantly differed between ranges, whereas no important differences were found in the composition of AMF communities in the roots of the given species compared with that of native species of resident communities. In addition, we found higher variation in AMF community assemblies of *Cirsium arvense* and *Tanacetum vulgare* across the experimental sites in the invaded range compared to the native one. In general, the host plant effect and richness of AMF communities associated with the given species decreased during the invasion process.

The freshwater biodiversity crisis: what role do plant invasions play?

Zarah Pattison[1], Hannah Hamilton[1], Nigel Willby[1], Wayne Dawson[2] and Lynsey Bunnefeld[1]

[1]*University of Stirling, Biological and Environmental Sciences, Stirling, FK9 4LA, Scotland, UK*
[2]*Durham University, Department of Biosciences, Durham, DH1 3LE, England, UK*
e-mail: zarah.pattison@stir.ac.uk

Freshwater ecosystems, crucial to humanity, are in crisis and require immediate attention. Freshwater biodiversity has suffered a staggering 83% decline since 1970, a rate far exceeding that of marine or terrestrial systems. In addition, one in three of the 28,000 species dependent upon freshwater habitats are considered to be threatened with extinction. Although biological invasions are one of the greatest modern threats to biodiversity, a global assessment of freshwater invasions and how they vary geographically, is still lacking.

In order to quantify the current status of invasive alien plants in freshwater ecosystems globally, we integrated multiple global datasets such as the Global Naturalized Alien Flora (GloNAF) and the Global Inventory of Floras and Traits (GIFT). By categorizing invasive alien plant species as aquatic or terrestrial, we mapped the global distribution of aquatic invasive alien plants. These data show that aquatic alien plant species are more likely to become invasive, even though they represent <5% of alien flora. We used Structural Equation Modelling to identify which anthropogenic and background environmental variables drive the distribution of invasive alien species in freshwater habitats globally, and how this differs from terrestrial systems. Understanding these drivers will enable predictions of future invasion risk and promote the resilience of freshwaters.

Joined effect of anthropogenic factors, landscape structure, landrelief, soil and climate on alien plant invasion risk at regional scale

Tomasz H. Szymura[1], Magdalena Szymura[2], Maria Zając[3] and Adam Zając[3]

[1]*Department of Ecology, Biogeochemistry and Environmental Protection, University of Wrocław, Maksa Borna Sq. 9, 50-328 Wrocław, Poland*
[2]*Department of Agroecosystems and Green Areas Management, Wrocław University of Environmental and Life Sciences, Grunwaldzki Sq. 24A, 50-363 Wrocław, Poland*
[3]*Jagiellonian University in Kraków, Faculty of Biology and Earth Sciences, Institute of Botany, Kopernika 27, 31-501 Kraków, Poland*
e-mail: tomasz.szymura@uwr.edu.pl

The realistic modeling of invasion risk and/or invasion level requires data with appropriate quality regarding their spatial resolution. Due to data availability, models at large (e.g. continental, national) extents, which derive data from atlases of plant species distribution, usually prepared in rather coarse scales (e.g. 10 × 10 km) are quite numerous. This allows for studying relationships between environment and invasion level at large spatial scales, while such examinations at finer scales (e.g. regional) are scarce. This is problematic because the effect of a particular environmental factor on alien plant richness and its interactions with other environmental variables is context-dependent, and can vary from region to region. In our examination, we used an atlas of neophyte distribution prepared in 2 × 2 km grid covering 31.2 thousands square kilometers in Carpathian massif and its foreground, Central Europe. Using the boosted regression trees technique, we assessed the effect of anthropogenic factors, soil variables, land relief, climate and landscape structure on neophyte richness (NR). We found that each examined sphere of the environment explained the NR, but their explanatory ability varied more than two-fold. Climate explained the highest fraction of deviation, followed by anthropogenic factors, soil type, land relief, and landscape structure. A global model, which incorporated the crucial variables from all studied spheres of the environment, revealed that the deviation explained by variables representing particular environment spheres overlapped. When the variables representing landscape structure were not included in the global model as redundant, the climatic variables finally explained a smaller fraction of deviation compared to anthropogenic factors. We assessed the course of dependencies between NR and particular explanatory variables accounting for the average effect of the remaining variables. The relationships were usually curvilinear and revealed some threshold values of environmental variables (e.g. percentage of urbanized areas, human population density, and road network density) beyond which the NR changed rapidly.

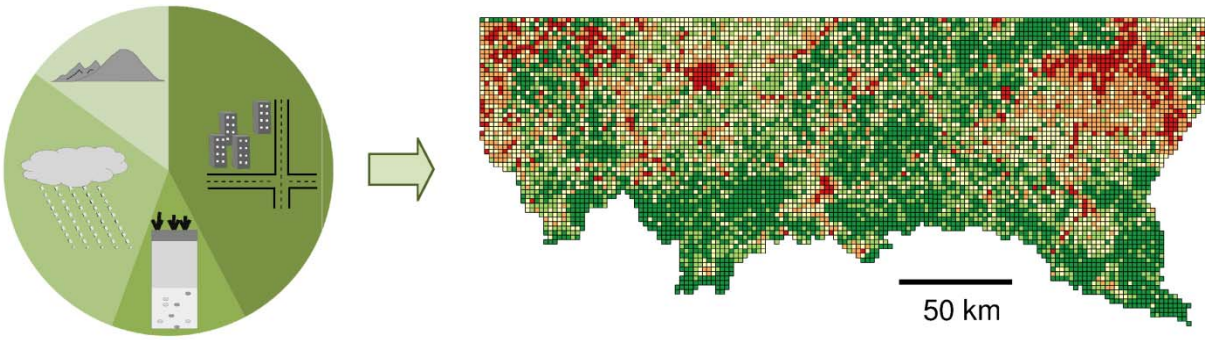


Fig. 1. Drivers (left) of neophyte richness (right) at regional scale. Green – low, red – high number of neophytes.

Szymura T. H., Szymura M., Zając M. & Zając A. (2018) Effect of anthropogenic factors, landscape structure, land relief, soil and climate on risk of alien plant invasion at regional scale. Sci. Total Environ. 626: 1373–1381.

Flood dynamics dictate distributions of invasive trees on floodplains

Natalie M. West[1], Ann Marie Reinhold[2], Geoffrey C. Poole[2] and Erin K. Espeland[1]

[1]*United States Department of Agriculture - Agricultural Research Service Pest Management Research Unit, 1500 North Central Avenue, Sidney, Montana 59270, USA*
[2]*Department of Land Resources and Environmental Sciences, Montana State University, Post Office Box 173120, Bozeman, Montana 59717, USA*
e-mail: Natalie.West@ars.usda.gov

Riparian plant communities are shaped by hydrology, and seed deposition is one process through which fluvial dynamics influence invasion pressure. Hydrochory may increase invader dispersal, but is difficult to measure and its importance can be obscured by demographic lags or establishment limitations. Linking fine-scale spatial patterns of inundation frequency to riparian invader distribution provides an initial evaluation of the relationship between likely areas of seed deposition from hydrochory and current invasions. We examined the importance of spatial patterns of flooding frequency (i.e. the distribution of flood return intervals through space) in predicting the distribution of Russian olive (*Elaeagnus angustifolia* L.) at the floodplain scale.

This nitrogen-fixing shrub or small tree is a prominent invader of riparian zones in western North America. Broad establishment tolerance and a persistent seedbank gives Russian olive an advantage over co-occurring woody species and facilitates its invasion along western rivers. Large vertebrate dispersed seeds are likely to be important to this competitive advantage, but often cited as a key factor limiting dispersal and slowing its invasion front. Hydrochory is assumed but not explicitly considered in spread dynamics. Specific data are mainly anecdotal or inferred from studies of other factors such as habitat limitation and large-scale range determinants. Current theory suggests an invasion lag of 30 years, but does not consider how increased propagule movement through water may relax dispersal limitations. This process should become even more important as Russian olive increases in the landscape, reducing the relative importance of demographic dynamics.

As a pilot study, we related inundation models generated using the United States Army Corps of Engineers Hydrological Engineering Center's River Analysis System (HEC-RAS) to a Russian olive geospatial dataset across a 10.6-km-portion of the Yellowstone River floodplain in Montana, USA. Our results demonstrate that the majority of Russian olive is found within a narrow range of flooding intervals. Russian olive cover was highly spatially associated with portions of the floodplain wetted under relatively frequent return intervals: 80.9% occurred within the 10-year inundation zone, three-quarters (i.e. 61.6% of total) of which occurred within the 5-year zone. Both density and occupancy was greatest in the 1.5-5 year zones; occupancy was moderate in the 10 year and lowest in the 20 year and greater inundation zones. As dispersal rather than establishment limitation is thought to be a priority filter for Russian olive invasions into riparian areas, these results highlight the importance of considering the potential contributions of hydrochory. Tying flooding frequency to likely spatial distributions would allow us to prioritize vulnerable sites and timelines for management and begin to tease apart how dispersal might interact with demography to drive the spatial and temporal spread of Russian olive along riparian corridors.

Developing an inventory of the alien flora for data deficient country like Bhutan

Dorjee[1], Tony Buckmaster[2], Stephen Johnson[3] and Paul Downey[2]

[1]*National Plant Protection Centre, Bhutan*
[2]*University of Canberra, Australia*
[3]*Department of Primary Industries, New South Wales, Australia*
e-mail: dorjeewang@gmail.com

Very few alien plants were recorded in the ancient historical texts and publications in Bhutan prior to the end of the country's self-imposed isolation until the early 1960s. Those species that were recorded were for sustenance (cereals and pulses) and nutrition (fruits and vegetables). The Bhutanese Government introduced many alien plants with the launch of modern economic development in 1961, however, a baseline inventory on which alien plant species were introduced and their status (i.e. cultivated, casual, naturalized or invasive) has not been created. A preliminary assessment, after reviewing the literature and consultation with government officials, revealed that the available data and information on alien plants introduced into the country were scattered across different sectors. It was also apparent that many old records would be lost if an effort was not made to collate the alien plant species data into one repository.

The baseline inventory of the alien flora of Bhutan was collated from many sources including herbarium records, published and unpublished documents, as well as global online botanical databases. I verified the data from non-scientific and unpublished reports (e.g. annual or project reports) using other published scientific papers and global online databases to minimise epistemic and linguistic ambiguities in the listing of alien plant species in Bhutan. My aim was to provide a reliable and comprehensive list of alien plant species for research, to support policy decisions and to prioritise management of potentially invasive alien plant species. I found that there was an unprecedented increase in alien plant species introduced into Bhutan, from 94 species before 1961 to 964 in 2016 (more than a ten-fold increase in alien flora). Importantly, it was noted that 88% of the alien plants in the database were intentionally introduced, indicating the potential for implementing pre-border screening and post-border management activities to minimise socio economic and environmental impact from invasive alien species in Bhutan.

Increases in local richness (α-diversity) following invasion are offset by biotic homogenization in a biodiversity hotspot

Alessandra R. Kortz[1,2] and Anne E. Magurran[2]

[1]*International Institute for Applied Systems Analysis (IIASA), Schlossplatz 1, Laxenburg, 2361, Austria*
[2]*Centre for Biological Diversity, School of Biology, University of St Andrews, Fife, KY16 9TH, United Kingdom*
e-mail: kortz@iiasa.ac.at

The world's ecosystems are experiencing unparalleled rates of biodiversity change with invasive species implicated as one of the drivers that restructure local assemblages (Dornelas et al. 2014). Here we focus on the processes leading to biodiversity change in the plant assemblage of a biodiversity hotspot, the Brazilian Cerrado. The null expectation that invasion leads to an increase in local species richness (Buckley & Catford 2016) is supported by our investigation of the grass layer in two key habitats (campo sujo and campo úmido). Overall, we recorded 80 plant taxa, belonging to 17 botanical families, of which 76 species are native. The four species invasive to Brazil – the pine *P. elliottii* (slash pine) and three grass species: *Urochloa decumbens* (signal grass, previously named as *Brachiaria decumbens*), *Melinis repens* (natal grass) and *Melinis minutiflora* (molasses grass) are established in the Cerrado (Zenni & Ziller 2011). We show, for two Cerrado habitats, that – as predicted by Buckley & Catford (2016) – local richness is correlated with invasive richness. In other words, sites that contain more invasive species also tend to have higher overall richness. However, at the same time, sites with more invasive species are less different from one another in terms of their composition than they would be if only native species were present. The reason for this is quite straightforward. Although there are few invasive species relative to native species, these taxa are widespread and occur in more localities than many native species. Thus, invasive species, even if relatively few in number (4/76), can reduce β-diversity and consequently homogenize biodiversity at regional (γ- diversity) scales. By focusing on changes in β-diversity in a known local system we detected a key mechanism of β-diversity change which would have been missed at the macroecological scale. This mechanism can help explain the paradox that species richness is not declining in many local assemblages, yet compositional change is exceeding the predictions of ecological theory (Gotelli et al. 2017). As we have shown, any increase (or stasis) in species richness cannot be viewed as benign unless the accompanying changes in composition (and potential shifts in ecosystem function; Hobbs et al. 2006) are considered. As such, our results emphasize the importance of quantifying both α-diversity and β-diversity in assessments of biodiversity change in the contemporary world.

Buckley Y. M. & Catford J. (2016) Does the biogeographic origin of species matter? Ecological effects of native and non-native species and the use of origin to guide management. J. Ecol. 104: 4–17.

Dornelas M., Gotelli N. J., McGill B., Shimadzu H., Moyes F., Sievers C. & Magurran A. E. (2014) Assemblage time series reveal biodiversity change but not systematic loss. Science 344: 296–299.

Gotelli N. J., Shimadzu H., Dornelas M., McGill B., Moyes F. & Magurran A. E. (2017) Community-level regulation of temporal trends in biodiversity. Sci. Adv. 3: e1700315.

Hobbs R. J. et al. (2006) Novel ecosystems: theoretical and management aspects of the new ecological world order. Glob. Ecol. Biogeogr. 15: 1–7.

Zenni R. D. & Ziller S. R. (2011) An overview of invasive plants in Brazil. Rev. Bras. Bot. 34: 431–446.

Relative performance of co-occurring alien plant invaders depends on traits related to competitive ability more than niche differences

Christine S. Sheppard and Viktoria Ferenc

Institute of Landscape and Plant Ecology, University of Hohenheim, 70593 Stuttgart, Germany
e-mail: christine.sheppard@uni-hohenheim.de

Although conservation managers usually have to deal with multiple invaders that co-occur in native ecosystems, research to date has concentrated onstudying single highly invasive species. Consequently, this study aims to better understand the interactions among co-occurring alien plants. Specifically, we aim to determine how relative performance in a mixture (compared to growing alone and growing in intraspecific competition) depends on phylogenetic relatedness and similarity in functional traits.

We investigated the interactions among 18–20 alien annual plant species in Germany belonging to six to nine families using two multi-species common garden experiments, where plant individuals were grown in all pairwise species combinations. We measured growth, reproductive output and functional traits of the species, and determined phylogenetic and multivariate trait distances between target and neighbour individuals as well as individual trait hierarchies between pairs (using specific leaf area, maximum height, seed mass, root:shoot ratio, and flowering onset).
Across the 153–170 interspecific species combinations, individuals equally often experienced higher intraspecific or interspecific competition, with competitive responses varying greatly depending on the species. Facilitation (i.e. growing better in a mixture than alone) was rare, but mostly occurred when growing with a leguminous alien neighbour. Overall, hierarchical trait differences related to competitive ability were more important than niche differences (described by phylogenetic or multivariate trait distance) in determining the performance of co-occurring alien plants. Specifically, growth and seed production always increased when an alien species was taller compared to its co-occurring alien neighbour, whereas the effects of specific leaf area, seed mass, root:shoot ratio, and flowering onset depended on the performance measure. A better understanding on the interaction type and strength among multiple plant invaders is crucial to determine appropriate management actions as well as contribute to the ecological theory of community assembly.

Sheppard C. S. (2019) Relative performance of co-occurring alien plant invaders depends on traits related to competitive ability more than niche differences. Biol. Invas. 21: 1101–1114.

Trait-environment relationships in native versus non-native plant species

Marija Milanović[1,2], Sonja Knapp[1,3], Petr Pyšek[4,5] and Ingolf Kühn[1,2,6,7]

[1]*Helmholtz Centre for Environmental Research – UFZ, Dept. Community Ecology, Theodor-Lieser-Str. 4, 06120 Halle, Germany*
[2] *Martin Luther University Halle-Wittenberg, Geobotany/Institute for Biology, Am Kirchtor 1, 06108 Halle, Germany*
[3]*Institute for Ecology, Technische Universität Berlin, Rothenburgstraße 12, 12165 Berlin, Germany*
[4]*Institute of Botany, The Czech Academy of Sciences, Průhonice, CZ-252 43, Czech Republic*
[5]*Department of Ecology, Faculty of Science, Charles University, Prague, Czech Republic*
[6]*Martin Luther University Halle-Wittenberg, Geobotany/Institute for Biology, Am Kirchtor 1, 06108 Halle, Germany*
[7]*German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, 04103 Leipzig, Germany*
e-mail: marija.milanovic@ufz.de

The success of non-native plant species partly depends on their functional traits and thus their adaptation to habitats in the introduced range. Studies have shown that non-native (especially invasive) plant species express traits differently to native (or non-invasive non-native) species, such as specific leaf area (SLA), height, seed size or flowering period. As a result, the success of non-natives should increase in habitats where they are functionally different to native species (i.e. limiting similarity hypothesis). However, introduced species can also thrive when sharing the traits of native species present in a habitat (i.e. habitat filtering hypothesis). To test these hypotheses we studied trait – environment relationships in native vs. non-native plant species (the latter comprising archaeophytes and neophytes), and in introduced neophytes vs. (potentially) invasive neophytes (The German-Austrian black list information system – GABLIS, 2013). We analyzed a total of 1300 plant species occurring across 1000 grid-cells in Germany and different climatic and land use variables. Our results show that temperature, precipitation, the proportion of natural habitats, as well as, the number of land use and geological patches affect archaeophytes and neophytes differently, regarding their level of urbanity and self-pollination. The same pattern was observed when comparing neophytes to invasive neophytes, where additionally, SLA, storage organs and start of flowering had a significant relationship with the environmental factors. However, the native species did not express any significant trait relationship with environmental conditions, possibly due to the high heterogeneity of species within that group. Non-native species at different stages of introduction showed both similarities and differences in terms of their trait-environment relationships. Therefore, our results support both hypotheses, showing that the success of introduced species is context dependent.

Functional and phylogenetic consequences of plant invasions

Enrique G. de la Riva[1 2], Oscar Godoy[3], Pilar Castro-Díez[4], Cayetano Gutiérrez-Cánovas[5] and Montserrat Vilà[1]

[1]*Estación Biológica de Doñana (EBD-CSIC), Avd. Américo Vespucio 26, Isla de la Cartuja, 41092 Sevilla, Spain*
[2]*Department of Ecology, Brandenburg University of Technology, Cottbus, Germany*
[3]*Departamento de Biología, Instituto Universitario de Investigación Marina (INMAR), Universidad de Cádiz, Puerto Real, 11510, Spain*
[4]*Departamento de Ciencias de la Vida. Universidad de Alcalá. Campus Universitario. Ctra. Madrid-Barcelona km 33.6. 28805 Alcalá de Henares, Madrid, Spain*
[5]*Freshwater Ecology, Hydrology and Management Group (FEHM Lab), Departament de Biologia Evolutiva, Ecologia i Ciències Ambientals, Facultat de Biologia - Institut de Recerca de la Biodiversitat (IRBio), Universitat de Barcelona, Diagonal, 643, 08028 Barcelona, Spain*
e-mail: montse.vila@ebd.csic.es

Do invasions by alien plant species with contrasting trait profiles (*Arctotheca calendula*, *Carpobrotus* spp., *Conyza bonariensis* and *Opuntia dillenii*) change the functional and phylogenetic structure of coastal plant communities? To answer this question, we identified species diversity and composition in 220 paired (invaded and non-invaded) plots along coastal habitats in Huelva (Spain). We measured nine functional traits for each native and invasive species, namely, specific leaf area (SLA), specific root length (SRL), leaf and root dry mass content (LDMC and RDMC) or carbon isotope fraction (δ13C). We calculated at the plot scale, community means (CMs) for each trait, functional richness, Faith's phylogenetic diversity and functional and phylogenetic mean pairwise dissimilarities.

Three out the four species showed rather extreme trait values compared to the native flora with greater impact on invaded communities. In plots invaded by *A. calendula* the values of the native communities of SLA and SRL increased, while LDMC, RDMC and δ13C decreased showing CMs more similar to its functional profile. Additionally, these plots showed lower functional and phylogenetic diversity in the native component of the community. In plots invaded by *Carpobrotus* spp. and *O. dillenii*, the CMs values for LDMC and $\delta^{13}C$ increased, but had little effect on the functional and phylogenetic structure of the native communities, while no differences were observed for the communities invaded by *C. bonariensis* (most functionally similar to the native species).

Our study highlights that inferring community assembly rules from the exploration of functional and phylogenetic differences between invaded and non-invaded plots is not straightforward. By considering invaders with different functional profiles, we have shown that species with different mechanisms of invasion have contrasting impacts on the community. Consequently, the effect of plant invaders differed depending on their functional distinction from the recipient community, rather than its phylogenetic origin.

Linking theory and practice: a site-specific risk assessment for introduced tree species in European forests based on inventory data

Anja Bindewald[1,2], Uwe Starfinger[3], Etienne Branquart[4], Giuseppe Brundu[5] and Jürgen Bauhus[2]

[1]*Department of Forest Conservation, Forest Research Institute of Baden-Württemberg (FVA), Freiburg 79100, Germany*
[2]*Chair of Silviculture, University of Freiburg, Freiburg 79085, Germany*
[3]*Research Department for natural and agricultural areas, Service Public de Wallonie, Gembloux, 5030, Belgium*
[4]*Julius Kühn Institute, Institute for Plant Health, Braunschweig, 38104, Germany*
[5]*Department of Agriculture, University of Sassari, 07100 Sassari, Italy*
e-mail: anja.bindewald@forst.bwl.de

Existing risk assessment tools are often used at the country level and rank introduced species based on their detrimental impact for the early detection of “invasive alien species” (IAS) of most concern. Yet, it is necessary to move beyond these IAS lists that are based on broad geographic areas and assess the risk in a way that addresses various management aspects. So far, the use of widely cultivated introduced trees was not supported by a Pan-European standardized risk assessment and it is likely that the management of the risk of invasion was not included in forestry planning and management practices by default. For the majority of introduced tree species used in forestry and considered as IAS, complete eradication is neither desired nor can it be achieved at reasonable costs. Instead, controlling further spread and the protection of ecosystems most sensitive to tree invasion should be considered more important. We propose a comprehensive risk analysis framework based on the quantification of site-specific environmental risks associated with these species. To underpin the assessment, we recommend using systematically sampled data from national forest inventories and regional selected habitat maps covering areas of high conservation value. To support this approach, regular (forest) monitoring should be improved, for example, by recording all tree species separately. Our proposed framework can be simply applied by the responsible forest authorities and is considered cost-effective. With respect to risk management, it provides on-site assistance regarding introduced tree species control, eradication or prevention measures. Furthermore, a solid standardized evaluation provides reliable invasiveness assessments and thus facilitates meaningful comparisons among ecosystem types in various regions or jurisdictions.

A plea for multiple responses to invasive plant species exemplified by the case of *Ailanthus altissima*

Ingo Kowarik

Department of Ecology, Ecosystem Science/Plant Ecology, Technische Universität Berlin, D-12165 Berlin, Germany
e-mail: kowarik@tu-berlin.de

Widespread invasive plant species can negatively affect biodiversity and are thus often subject to legal regulations, prevention and control. Yet, these actions require substantial resources, do not guarantee success, and carry the risk of losing the benefits that may be associated with invasive species. Therefore, I advocate for the increased use of multiple responses to invasive species. These responses should be evidence-based and consider the context dependence of invasion processes, associated risks and benefits, as well as, the underlying societal values, including the aim of biodiversity conservation. The case of *Ailanthus altissima* (tree of heaven), a widespread invasive tree species in Europe and beyond, exemplifies limitations of a general ban of invasive species since invasion risks and invasion impacts cannot be generalized for natural, rural or urban ecosystems. The case of *A. altissima* further shows significant advantages to be obtained with multiple responses to widespread invasive species. These findings can be useful in adapting regulations or management plans for *A. altissima* and other widespread invasive plant species.

Does awareness of invasive freshwater plants mitigate the dispersal risk posed by lake users?

Philip E. Hulme[1], Sam Beaumont[2], Paul Champion[3] and Daniel Clements[3]

[1]*Bio-Protection Research Centre, Lincoln University, Canterbury, New Zealand*
[2]*Ministry of Primary Industries, Wellington, New Zealand*
[3]*National Institute of Water and Atmospheric Research (NIWA), Hamilton, New Zealand*
e-mail: philip.hulme@lincoln.ac.nz

Recreational users of freshwaters (e.g. fishers, boat users etc.) are recognized as leading vectors by which alien plants are spread among lakes. Many countries expend considerable financial resources making lake users aware of the role they play in spreading and the actions they can take to reduce these risks. To date no study has integrated information on the associations between awareness, mitigation and residual risk of different lake users, that might provide insights into more effective management of this introduction pathway. Using data from 1351 interviews of lake users across New Zealand to capture details of more than 1700 lake visits, we present the first comprehensive analysis of this pathway. Interviews were undertaken face-to-face using a standardized questionnaire delivered on a mobile app platform. The questionnaire captured data on the main activity, location of residence, visit frequency, other lakes visited in the last fortnight, awareness of alien freshwater species, and any actions they might take to prevent their spread.

The dominant lake users were water-skiers (27%), swimmers (21%) boat fishers (18%), jetskiers (10%) kayakers (7%) and lakeside fishers (5%) with other users including jetboater, sailors and hikers, less frequent. Awareness of alien plant species was high overall (78%) but with marked variation among user groups. While almost all jetboaters knew the name of at least one alien plant species, this was true for only half of all swimmers. The freshwater diatom, didymo (*Didymosphenia geminata*), which was subject to a major awareness raising campaign over the last decade, was the most widely known alien species. But this knowledge did not transfer to most alien freshwater plants species. In general, awareness was higher in users who had been directly affected by alien plants, particularly those whose equipment (fishers) or boat engines (jetboaters) were fouled causing negative associations. As a result, it was these users who were most likely to take mitigating actions such as cleaning and/or drying their equipment to prevent further spread. Nevertheless, those most impacted travelled the furthest from home to visit lakes (up to 150km) and visited more lakes within a season. Users who had been negatively impacted by alien freshwater plants generally visited lakes with lower levels of weed invasion than unaffected users. To derive an overall assessment of the risk posed by different users, data on distances travelled, likelihood of visiting invaded lakes, willingness to take action to prevent spread and the relative abundance of users were integrated. As a result, this study highlights that the highest risk to lakes is posed by powerboat users (water-skiers and boat fishers), while sailboats represent a lower risk. Water-skiers have not been a major target for awareness raising and their risk may have been underestimated historically. This study recommends that awareness raising should better target boat users, particularly water-skiers, focusing on the impacts upon their leisure activity rather than biodiversity.

The role of species charisma in biological invasions: ornamental plants and beyond

Ivan Jarić[1], Franck Courchamp[2], Ricardo A. Correia[3], Sarah L. Crowley[4], Franz Essl[5], Anke Fischer[6], Pablo González-Moreno[7], Gregor Kalinkat[8], Xavier Lambin[9], Bernd Lenzner[5], Yves Meinard[10], Aileen Mill[11], Camille Musseau[8,12], Ana Novoa[13], Jan Pergl[13], Petr Pyšek[13,14], Klára Pyšková[13,14], Peter Robertson[11], Menja von Schmalensee[15], Ross T. Shackleton[16], Robert A. Stefansson[15], Kateřina Štajerová[13,14], Diogo Veríssimo[17] and Jonathan M. Jeschke[8,12]

[1]*Biology Centre of the Czech Academy of Sciences, Institute of Hydrobiology, Na Sádkách 702/7, 370 05, České Budějovice, Czech Republic*
[2]*Ecologie, Systématique and Evolution, Univ. Paris-Sud, CNRS, AgroParisTech, Université Paris-Saclay, Orsay, France*
[3]*DBIO & CESAM-Centre for Environmental and Marine Studies, University of Aveiro, Aveiro, Portugal*
[4]*Environment and Sustainability Institute, University of Exeter, Penryn, Cornwall, United Kingdom*
[5]*Department of Botany and Biodiversity Research, University of Vienna, Vienna, Austria*
[6]*Social, Economic and Geographical Sciences, James Hutton Institute, Aberdeen, United Kingdom*
[7]*CABI, Egham TW20 9TY, United Kingdom*
[8]*Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin, Germany*
[9]*School of Biological Sciences, University of Aberdeen, Aberdeen, United Kingdom*
[10]*Université Paris Dauphine, PSL Research University, CNRS, Paris, France*
[11]*Modelling, Evidence and Policy Group, Newcastle University, Newcastle, United Kingdom*
[12]*Institute of Biology, Freie Universität Berlin, Berlin, Germany*
[13]*The Czech Academy of Sciences, Institute of Botany, Department of Invasion Ecology, Průhonice, CZ-252 43, Czech Republic*
[14]*Department of Ecology, Faculty of Science, Charles University, Prague, Czech Republic*
[15]*West Iceland Nature Research Centre, Stykkishólmur, Iceland*
[16]*Institute of Geography and Sustainability, University of Lausanne, Lausanne, Switzerland*
[17]*Department of Zoology, University of Oxford, Oxford, United Kingdom*
e-mail: ivan.jaric@hbu.cas.cz

Species charisma, understood as a set of characteristics that affect people's perceptions, attitudes and behaviour, is a highly relevant concept for invasion science, with implications across all stages of the invasion process. We propose a definition of charisma for invasive alien species (IAS), with particular reference to plants, provide a set of recommendations for further research, and highlight management implications. The charisma of IAS can have far-reaching ecological and socioeconomic effects, but this issue has not yet been systematically investigated. We will review how charisma affects processes associated with plant invasions, including the effects on species introductions and spread, media portrayals, public perceptions of species management, research attention, and active public involvement in research and management. Explicit consideration of IAS charisma is critical to improve understanding of the drivers of people's attitudes towards particular IAS and planned management measures and strategies, and to implement a combination of education programs, awareness raising and public involvement campaigns.

Who's next? How species distribution models can and should support the identification of new invasive plant species

Sandra Skowronek

German Federal Agency for Nature Conservation, Bundesamt für Naturschutz, Konstantinstraße 110, Bonn, Germany
e-mail: Sandra.Skowronek@BfN.de

Most countries carry out risk assessments following a certain methodology to decide whether or not a species should be listed as invasive or potentially invasive on their territory. To identify candidate species which could become invasive in the future and should thus be prioritized for early detection, different approaches exist, from expert gatherings to systematic evaluation of species inventories. And while species distribution models have been proven to be helpful in predicting whether a species will potentially occur, they are not regularly included in the process of identifying candidate species. Most scientific studies, applying species distribution models for invasive species, focus on one or a few single species and/or specific methodological aspects.

This study therefore proposes an easy workflow to generate and evaluate species distribution models for a large number of candidate species. The resulting species distribution models are based on climate and land use data available globally. The models in this study were run for terrestrial plant species that might become invasive in Germany in the near future. However, the workflow can be applied to any terrestrial plant species. This study aimed at incorporating the latest knowledge and recent datasets to build a comprehensive workflow applicable to a large set of species and provide practical guidance. Here, I will present the workflow and the first modelling results for a set of about 30 candidate species that are included in lists of potentially invasive species in Germany.

Driving up standards of invasive weed management through training and assessment: a United Kingdom success story

Laura Jones[1], Peter Fitzsimons[2] and Max Wade[3]

[1]*AECOM, 1 Callaghan Square, Cardiff, CF10 5BT, Wales, UK*
[2]*Property Care Association, Hinchingbrooke Business Park, 11 Ramsay Court, Kingfisher Way, Huntingdon, PE29 6FY, England, UK*
[3]*AECOM, Wellbrook Court, Girton, Cambridge, CB3 0DA, England, UK*
e-mail: laura.v.jones@aecom.com

2019 marks the fifth year of a United Kingdom (UK) training and assessment programme for contractors dealing with invasive weeds in the UK. This has been developed and implemented by the Invasive Weed Control Group (IWCG) of the Property Care Association (PCA), a trade body representing professional contractors and consultants in this sector.

The PCA's training programme has been taken by 526 attendees, of whom 497 have gone on to take an assessment. The programmes and assessments are described and the data collected by the PCA are used to explore aspects such as pass rates, gender balance, and the nature of the attendees and examinees, and the companies and organizations from which they come. An analysis is undertaken of the programme, including feedback from its participants, to determine its real value 'on-the-ground' on the control and management of Japanese Knotweed and other invasive weeds. This includes identifying its strengths and areas for development. A comparison is made with invasive weed training programmes and assessments in other countries, identifying similarities and differences. Combined with feedback from attendees of the PCA programme and the External Examiners for the assessments, the programme is reviewed to identify lessons learned that are applicable widely across the invasive weed control sector internationally. The launch of a new PCA course, the first of its kind in the UK to provide a certified structured learning and assessment process for invasive weed ecology and identification, will also be considered.

Impacts of four common non-native tree species on regulating ecosystem services

Pilar Castro-Díez, Álvaro Alonso, Asunción Saldaña and Elena Granda

Department of Life Sciences, University of Alcalá, 28805 Alcalá de Henares, Madrid, Spain
e-mail: mpilar.castro@uah.es

Non-native tree (NNT) species have been widely introduced to enhance different types of ecosystem services (e.g. timber production, ornamental values, soil erosion control, etc.; MacDicken 2015). However, NNTs can also produce undesired effects on ecosystems (e.g. loss of biodiversity) andsome of them may affect human well-being (e.g. fire proneness or water depletion; Brundu & Richardson 2016, Vaz et al. 2018). Based on a previous worldwide literature review on the effects of NNTs on "regulating ecosystem services" (RES; Castro-Díez et al. 2019), here we present a first analysis of how four worldwide spread NNT taxa (*Acacia* spp., *Ailanthus altissima*, *Eucalyptus* spp. and *Pinus* spp.) alter the following RES: climate regulation, fire risk prevention, soil erosion control, soil fertility, soil formation and water regulation. Data availability differed across the studied taxa, the best represented being *Pinus* spp., with 80 case studies, followed by *Acacia* spp. with 61, *Eucalyptus* with 45 and *A. altissima* with 22. Ecosystem services were also unevenly represented, soil fertility and soil formation being the best represented with 55 and 54 case studies, respectively, while water regulation and fire risk prevention were the least represented with 27 and 14 case studies, respectively. *Acacia* species increased climate regulation, soil erosion control, soil fertility and water regulation, and seem to decrease fire risk prevention (although the low number of case studies resulted in a non-significant effect). By contrast, *Eucalyptus* species decreased soil fertility and soil formation, and increased climate regulation, with non-significant effects (or not enough case studies) for other RES. *Pinus* species tended to decrease fire regulation (marginally significant) but did not affect the rest of the studied RES. Finally, *A. altissima* increased soil fertility and soil formation, but we did not find enough information for the remaining RES. We conclude that NNT taxa may widely differ in their impacts on different RES, but the available information is too biased to allow comparisons across species and across RES.

Brundu G. & Richardson D. M. (2016) Planted forests and invasive alien trees in Europe: a Code for managing existing and future plantings to mitigate the risk of negative impacts from invasions. NeoBiota 30: 5–47.

Castro-Díez P., Vaz S. A., Silva J. S., van Loo M., Alonso A., Aponte C., Bayón A., Bellingham P. J., Chiuffo M. C., Di Manno N., ... & Godoy O. (2019) Global effects of non-native tree species on multiple ecosystem services. Biol. Rev. 94: 1477–1501.

MacDicken K. G. (2015) Global Forest Resources Assessment 2015: what, why and how? For. Ecol. Manage. 352: 3–8.

Vaz A. S., Castro-Díez P., Godoy O., Alonso A., Vilà M., Saldaña A., Marchante H., Bayón A., Silva J. S., Vicente J. R. & Honrado J. P. (2018) An indicator-based approach to analyse the effects of non-native tree species on multiple cultural ecosystem services. Ecol. Indic. 85: 48–56.

Impacts of alien plants at regional levels

Katharina Dehnen-Schmutz[1] and Kevin Walker[2]

[1]*Centre for Agroecology, Water and Resilience, Coventry University, UK*
[2]*Botanical Society of Britain and Ireland (BSBI), UK*
e-mail: ab6340@coventry.ac.uk

There is an increasing need for the systematic assessment of the impacts of alien species, and criteria for consistent assessments have been developed (Bartz & Kowarik 2019). One widely used scheme is the IUCN EICAT framework (Environmental Impact Classification of Alien Taxa, https://www.iucn.org/theme/species/our-work/invasive-species/eicat) which has recently been used in an assessment for alien taxa in Great Britain (in preparation). This assessment was conducted at the national level by groups of experts from their knowledge of published evidence, anecdotal knowledge and own field experience. However, at the regional level and from the knowledge of local field recorders, the results could be different.

The division of the British Isles into vice counties, based on a recording scheme devised in 1852 and maintained to this day by the Botanical Society of Britain and Ireland (BSBI) for botanical recording offers a scale suitable for comparative impact assessments at regional scales. Vice counties have an average size of about 2000 sqkm, and volunteer vice county recorders are appointed by the BSBI to keep records for their respective vice county. They are therefore likely to have good knowledge and field experience of alien plant occurrences in their vice county.

In this study, we contacted all vice county recorders and asked them, using the EICAT framework, to name the ten highest scoring alien plants at the level of the vice county they are responsible for. The online survey provided definitions about the different impact categories, confidence scoring as well as a habitat classification scheme. We also asked them to score the ten highest scored species from a GB national impact scoring exercise conducted in 2016 using the same methodology.

An analysis of the responses for 45 vice counties shows that 410 scores for 130 species in total were reported with the most frequent species *Fallopia japonica* listed by 32 vice county recorders, and other frequent species being *Impatiens glandulifera* (27), and *Rhododendron ponticum* (26). In terms of impacts, most records were scored as either having “major” or “moderate” impacts, however, 51 were scored in the highest category of “massive”. Among these, *R. ponticum* was the most frequent, which is also the only species scored in this category for current impacts in the assessment for Great Britain. Among the species reported were also several species that were not considered in the GB assessment, with some of them scored to have massive impacts at vice county level. This shows that national assessments broken down into several separate regional assessments can also be useful to identify species that are not currently considered as high impacts nationally.

Bartz R. & Kowarik I. (2019) Assessing the environmental impacts of invasive alien plants: a review of assessment approaches. NeoBiota 43: 69–99.

Fire hazard and plant invasions: the cases of *Hakea sericea* and *Acacia dealbata* in Portugal

Joaquim S. Silva[1,2], Mauro Nereu[1,2] Luis Queirós[1,2], Ernesto Deus[3] and Paulo Fernandes[4]

[1]*College of Agriculture, Polytechnic of Coimbra, 3040-316 Coimbra, Portugal*
[2]*Centre for Functional Ecology, University of Coimbra, 3000-456 Coimbra, Portugal*
[3]*Centre for Applied Ecology, University of Lisbon, 1349-017 Lisbon, Portugal*
[4]*Centre for Research and Technology of Agro-environmental and Biological Sciences (CITAB), University of Trás-os-Montes e Alto Douro, Apartado 1013, 5001-801 Vila Real, Portugal*
e-mail: jss@esac.pt

Alien plant invasions may change fire regimes by increasing the fire hazard. This work presents results on fuel characteristics and fire behavior of plant communities dominated by two aggressive, fire-adapted Australian species that are rapidly expanding in Portugal and elsewhere: *Hakea sericea* and *Acacia dealbata.* This work, based on the ongoing Aliens & Flames project, aims at: (i) assessing the fuel characteristics of plant communities dominated by these two species, (ii) simulating the potential fire behavior of these fuel complexes, and (iii) comparing these results with potential fire behavior in native plant communities. Fuel samples were collected at nine different sampling sites (n=9) for each species, reasonably representative of intermediate-mature developmental stages. *Hakea sericea* stands were in general thick shrublands ranging between 1.5 and 4.5 m height, whereas *A. dealbata* stands generally had a clear separation between the canopy and the surface fuel layers, with trees up to 10 m in height. Fuel characterization followed standard methodology aimed at obtaining the fuel parameters necessary to run the Rothermel fire behavior model, using the BehavePlus 5.0.5 software. Some fuel parameters were obtained from the literature and from allometric relationships developed within the project. Fire simulations were performed using a very dry moisture scenario, with 5km/h wind speed and zero slope. Fuel characteristics and simulated fire behavior were averaged and compared with native plant communities (shrublands, broadleaves) characterized by Fernandes et al. (2009), using one-sample t-tests.

The two species presented remarkably distinct fuel characteristics. The *H. sericea* stands had a higher load of fine fuels than the native shrubland. The fuel complexes associated to *A. dealbata* stands showed complete absence of shrubs and herbaceous layer. The litter (L+F) layer was particularly compacted, with nearly 8 t ha^{-1}, concentrated in only 2 cm of fuel depth, because of the very fine leaves that accumulate on the forest floor. The results obtained with the fire simulations were consistent with the fuel characteristics. The fuel complex dominated by *H. sericea* presented the highest flammability followed by the shrubland model, whereas the native broadleaf model showed the lowest flammability and there was no fire propagation in the *A. dealbata* stand.

These preliminary results suggest that generalizations about the higher fire hazard of plant communities in areas invaded by alien woody species may not always hold true. While areas invaded by *H. sericea* seem to present a high fire hazard, because of the high loads of 1h fuels and the vertical continuity of these plant formations, on the contrary, mature *A. dealbata* stands showed a low fire hazard, mostly because of the absence of shrubs in the understorey and the very compact fuel bed. Preliminary burn experiments in the same study plots, were consistent with the fuel data. While flame lengths in *H. sericea* plots reached 3 m, there was strong difficulty in burning the litter floor of *A. dealbata* stands, for similar environmental conditions. Our results for *H. sericea* are apparently contradictory to those of Van Wilgen and Richardson (1985) who obtained a higher fire hazard in native shrublands of South Africa. However, as these authors point out, the limitations of the Rothermel model must also be taken into account when interpreting these fire behavior results.

Van Wilgen B. W. & Richardson D. M. (1985) The effects of alien shrub invasions on vegetation structure and fire behaviour in South African fynbos shrublands: a simulation study. J. Appl. Ecol. 22: 955–966.

Ornamental plants: a threat to the environment due to climate change?

Tomos Jones[1], Alastair Culham[1], Brian Pickles[1] and John David[2]

[1]*School of Biological Sciences, University of Reading, Whiteknights Campus, Reading, UK*
[2]*Royal Horticultural Society, UK*
e-mail: mk818656@reading.ac.uk

The Royal Horticultural Society's (RHS) Plant Finder (Cubey 2019) contains over 78,000 entries including 17,000 different species. This compares to a native flora of only 1,500 in Britain and Ireland. Most of these ornamental plants have not 'escaped the garden fence' and naturalized, and even fewer have become invasive (Fig.1). However, some currently well behaved ornamental plants have the potential to naturalise and/or become invasive in the future as a result of a changing climate (Webster et al. 2017). This project adopts an interdisciplinary approach to investigate the impact of climate change on this invasive potential.

Ornamental plants can show characteristics typical of invasive species and gardeners can be the first to observe plants showing invasive characteristics within gardens. For this reason, an online survey asked gardeners in Britain and Ireland to report ornamental plants taking over or invading their gardens. Over 500 gardeners completed the survey, reporting over 150 different ornamental plants at different stages of the naturalization-invasion process. Plants from this survey have been chosen for an exhibit called *Ornamental plants: our future invaders?* in the Discovery Zone at the RHS Chelsea Flower Show (May 21– 25). At Chelsea, a survey will also ask gardeners to report problematic species growing in their gardens and collect information on how they try to manage or eradicate these plants. Chelsea attracts over 166,800 visitors every year and this will be an important opportunity to promote this citizen science project. The Chelsea survey will also be available online for gardeners who have not visited the Show, which will widen the demographic and geographic scope represented by survey respondents.

The ornamental plants reported by gardeners in such a way will not necessarily become invasive in the wider environment. Therefore, these plants are being investigated further using species distribution modelling (SDM) to indicate which ones might find future climates suitable. Results from the survey at Chelsea, along with the SDM, will be presented. It is important to identify which ornamental plants have naturalization or invasive potential before they become problematic. This interdisciplinary approach has the potential to identify problematic plants early in the naturalization-invasion process.

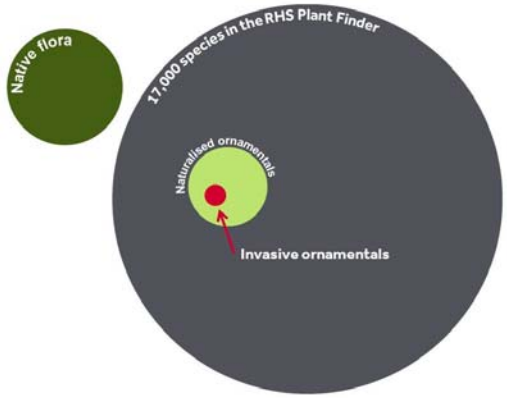


Fig. 2. The number of ornamental plants relative to the native flora of the British Isles (data from Stace & Crawley, 2015).

Cubey J. (2019) RHS Plant Finder 2019. RHS, London.
Stace C. A. & Crawley M. J. (2015) Alien plants. HarperCollins Publishers, London.
Webster E., Cameron R. & Culham A. (2017) Gardening in a changing climate. RHS, Wisley.

The absence of keystone indigenous trees inhibits bird recovery up to a decade after invasive tree removal from riparian habitats

S. Geerts and J. R. Mangachena

Department of Conservation and Marine Sciences, Cape Peninsula University of Technology, Cape Town, South Africa
e-mail: sjirkgeerts@gmail.com

When invasive alien trees are removed, ecosystems are usually left to "self-repair". Little is known about the extent of recovery or whether plant and animal taxa respond similarly over time. In most cases, the absence of a historical condition makes it more difficult to measure restoration success and a flexible approach is usually followed using practical target communities. We explored these questions by sampling bird and plant assemblages after the removal of invasive trees, using a chronosequence (time-for-space substitution) approach. We used the Berg River as a case study, one of the most invaded riparian systems in the Cape Floristic Region of South Africa. Study sites – cleared of *Eucalyptus camaldulensis* in 2005, 2007, 2008 and 2014 – were sampled in 2014 and compared to invaded and near-pristine areas. In total 27 native plant species (four trees, six shrubs, seven forbs, four geophytes, and two vines) and 28 alien plant species (four trees, three shrubs, eleven herbs, and seven graminoids) from 50 genera and 31 families were recorded across all sites and years. Cleared sites had higher total plant species richness compared to invaded and near-pristine sites, but significantly lower canopy cover. 2049 birds from 52 species were recorded across all sites and years. A decade after clearing, bird species richness, abundance and composition partially recover as some species are still lacking and assemblages are not yet comparable to near-pristine sites. This is probably due to the lower abundance and diversity of native trees in cleared sites, which could be important as a habitat or food source for specialist birds in an agricultural landscape. We conclude that monitoring of cleared sites is vital to evaluate recovery and to determine the need for further management interventions.

Evaluation of invasive plant species in Poland: methods adopted and results of their application as a basis for practical action

Barbara Tokarska-Guzik et al.[1]

Department of Botany and Nature Protection, Faculty of Biology and Environmental Protection, University of Silesia in Katowice, Bankowa 12, 40-007, Katowice, Poland
e-mail: barbara.tokarska-guzik@us.edu.pl

The new regulations that have come into force in the EU brought about, for the first time in Poland, a risk assessment for 118 species of alien origin, including 60 plant species, which was carried out by the initiative of the General Directorate for Environmental Protection in the department of the Ministry of the Environment. In this evaluation the *Harmonia*$^{+PL}$ procedure was used, based on protocol *Harmonia*$^{+}$, developed in Belgium, adopted to the situation in Poland. The procedure comprises 41 questions that refer to the present status of the invasive species and its impact in specific domains. We distinguished the environmental domain (wild plants and animals, habitats and ecosystems), the plant domain (cultivated plants), the animal domain (domesticated animals), the human domain (humans), other domains (targets not included elsewhere), ecosystem services, and the effect of expected climate change on species invasiveness. Each species was assessed independently by two experts, and the joint version was agreed in consultation with a third expert (the reviewer). Risk scores referring to the current (or potential) situation of the assessed species in Poland were calculated based on the answers obtained. The final grade of the species was calculated based on the number of domains affected by the species, scope of this impact and the degree of certainty of the assessment.

Among the 60 plant species analysed, seven are not yet found in Poland, and 12 occur only in cultivation. All the analysed species have a negative impact on the natural environment, 50 species (83.3%) have a negative impact on cultivated plants, 31 species (51.7%) on the animal domain, 46 species (76.7%) on other domains, and 25 species (41.7%) showed negative effects on humans. One of the aspects of the analysis of the 60 alien plant species in Poland is the reference of the obtained results to the degree of risk caused by individual species, and then their allocation to one of four lists of species - white, warning, alarm and black lists (Fig. 1). These lists are designed in order to facilitate management and make appropriate decisions on how to deal with particular species. The analysis identified 10 priority species for which remedial actions will be taken first. Among them there are two species at the initial stage of spread (e.g. *Cabomba carliniana*), those rapidly increasing the number of localities (e.g. *Impatiens capensis*), as well as those that are already very numerous (e.g. *Echinocystis lobata* or *Heracleum sosnowskyi*). Regardless of the activities aimed at developing the most effective logistics solutions, a large part of the action plan was devoted to the development of legal solutions, control of dispersal corridors, training of administration and public service employees, as well as educational campaigns.

[1]Zygmunt Dajdok, Alina Urbisz, Karolina Mazurska, Wojciech Solarz, Katarzyna Bzdęga, Władysław Danielewicz, Bogdan Jackowiak, Barbara Sudnik-Wójcikowska, Teresa Nowak, Damian Chmura, Maciej Gąbka, Dan Wołkowycki, Czesław Hołdyński, Zbigniew Celka, Magdalena Szymura, Anna Gazda, Wojciech Adamowski, Emilia Brzosko, Julian Chmiel, Izabela Sachajdakiewicz, Agnieszka Kompała-Bąba, Agnieszka Popiela, Dorota Michalska-Hejduk, Zofia Sotek, Adam Zając, Maria Zając, Agnieszka Kolada, Tadeusz Korniak, Anna Krzysztofiak, Elżbieta Melon, Monika Myśliwy, Stanisław Rosadziński, Edyta Sierka, Ewa Szczęśniak, Michał Śliwiński, Aleksandra Halerewicz, Anna Halladin-Dąbrowska, Dominik Kopeć, Anna Otręba, Andrzej Purcel, Blanka Wiatrowska, Beata Woziwoda, Justyna Wylazłowska, Przemysław Bąbelewski, Anna Bomanowska, Ryszard Kamiński, Łukasz Krajewski, Paweł Mirski, Magdalena Podlaska, Zbigniew Sobisz, Marian Szewczyk, Gabriela Woźniak, Ludwik Żołnierz, Wiesław Król, Lech Krzysztofiak, Kamil Najberek, Andrzej Pasierbiński, Agnieszka Smieja, Adrian Zarychta and Ian C. Trueman

Global homogenization of flowering plants by naturalized species

Qiang Yang[1], Anke Stein[1], Patrick Weigelt[2], Hanno Seebens[3], Marten Winter[4], Christian König[2], Wayne Dawson[5], Stefan Dullinger[6], Franz Essl[6], Trevor Fristoe[1], Holger Kreft[2], Bernd Lenzner[6], Noëlie Maurel[1], Dietmar Moser[6], Jan Pergl[7], Petr Pyšek[7] and Mark van Kleunen[1,8]

[1]*Department of Biology, University of Konstanz, Martin-Schleyer-Straße 36, 78465 Konstanz, Germany*
[2]*Biodiversity, Macroecology & Biogeography, University of Göttingen, Germany*
[3]*Senckenberg Biodiversity and Climate Research Centre, Germany*
[4]*German Centre for Integrative Biodiversity Research, Germany*
[5]*Department of Biosciences, Durham University, UK*
[6]*Division of Conservation Biology, Vegetation and Landscape Ecology, University of Vienna, Austria*
[7]*Institute of Botany, Department of Invasive Ecology, The Czech Academy of Sciences, Czech Republic*
[8]*Zhejiang Provincial Key Laboratory of Plant Evolutionary Ecology and Conservation, Taizhou University, China*
e-mail: qiang.yang@uni-konstanz.de

Human activities and the consequent extirpations of native species and introductions of non-native species have largely modified the composition of species assemblages throughout the world (Winter et al. 2009, Villéger et al. 2014). These anthropogenic impacts have not only changed the richness of regional assemblages but also reduced the taxonomic dissimilarity among them, leading to the homogenization of many taxonomic groups across regions (Lockwood & McKinney 2001, Villéger et al. 2014). Moreover, Darwin's naturalization hypothesis predicts that invaders less related to native flora are more likely to be successful than those closely related to natives (Darwin 1859), implying that the addition of naturalized species to a regional flora from more distantly related clades would also increase the evolutionary similarity between regional floras. While some work has been conducted assessing biotic homogenization at the national level, the extent of homogenization of the global flora, especially its phylogenetic component, has rarely been explored (Winter et al. 2009).

Using inventories of native species from the database GIFT (Global Inventory of Floras and Traits; Weigelt et al. 2019) and records of naturalized species from the GloNAF database (Global Naturalized Alien Flora; van Kleunen et al. 2018), we estimate to what extent naturalized species contribute to the taxonomic and phylogenetic homogenization of flowering plants between global regions. To have a comprehensive understanding of the main drivers of homogenization, we further assess how the relative changes in the taxonomic and phylogenetic dissimilarity between global regions relate to biogeographical and macroeconomic factors. We pay special attention to drivers that are most likely to determine the species introduction and establishment rate, including geographic connectivity, climatic and landscape similarity, bilateral trade, human migration, and the colonial relation between global regions.

Darwin C. (1859) The origin of species. John Murray, London.
Lockwood J. L. & McKinney M. L. (2001) Biotic homogenization. Springer.
van Kleunen M. et al. (2018) The Global Naturalized Alien Flora (GloNAF) database. Ecology 100: e02542.
Villéger S. et al. (2014) Functional homogenization exceeds taxonomic homogenization among European fish assemblages. Glob. Ecol. Biogeogr. 23: 1450–1460.
Weigelt P. et al. (2019) GIFT: a Global Inventory of Floras and Traits for macroecology and biogeography. Journal of Biogeography, doi: 10.1111/jbi.13623.
Winter M. et al. (2009) Plant extinctions and introductions lead to phylogenetic and taxonomic homogenization of the European flora. Proc. Natl Acad. Sci. USA 106: 21721–21725.

Comparative effects of non-native tree species on forest ecosystems in Europe

Thomas Wohlgemuth[1], Thomas Campagnaro[2], Pilar Castro-Díez[3], Martin M. Gossner[1], Elisabeth Pötzelsberger[4], Joaquim Sande Silva [5] and the NNT-invasiveness working group

[1]*Swiss Federal Research Institute WSL, CH-8903 Birmensdorf, Switzerland*
[2]*Università degli Studi di Padova, I-35020 Legnaro, Italy*
[3]*Universidad de Alcalá de Henares, Faculty of Sciences, E-28805 Alcalá de Henares, Spain*
[4]*University of Natural Resources and Life Sciences, Vienna, A-1190 Vienna*
[5]*Polytechnic of Coimbra, P-3045-601 Coimbra, Portugal*
e-mail: thomas.wohlgemuth@wsl.ch

Most non-native tree (NNT) species in Europe were introduced more than 100–150 years ago, mostly to increase timber production, to plant them in parks and yards as ornamental trees, or to stabilize slopes or restore land, e.g. in post-mining landscapes. Today, proportions of alien tree species in European countries range between 0.2 and over 30% of the total national forest area (Fig. 1). Here we question whether higher proportions of these trees cause negative effects on native ecosystems and their functions and services, beyond considerations on the invasiveness status depending on life history traits (e.g. Richardson & Rejmánek 2004) and unequal regulation in different countries (Hasenauer et al. 2016). We therefore evaluated the effects of the 15 most abundant NNT species – nine broadleaved and six conifers – on forests in European countries in the frame of the EU-COST-Action "NNEXT" (Hasenauer et al. 2016). We found 550 published papers with information on multiple pairwise comparisons of ecosystem responses in stands with native (control) and NNT species (test). To quantitatively assess ecosystem responses, we used (i) soil parameters such as nutrient availability and pH, and (ii) measures of biodiversity such as richness of vascular plants, arthropods and fungi. Soil conditions were affected in both positive and negative ways, probably depending on leaf traits, in particular to litter decomposition. For biodiversity, a majority of the analysed papers showed negative effects of NNT species on species richness, partly due to altered micro-environmental conditions near ground (e.g. reduced light transmission) and a lack of time for adaptations to the new host. Here, broadleaved NNT species affected native ecosystems more often than coniferous NNT species. The results of our comprehensive review provide a unique basis for evidence-based comparisons of the ecological significance of NNT species in native forest ecosystems in Europe.

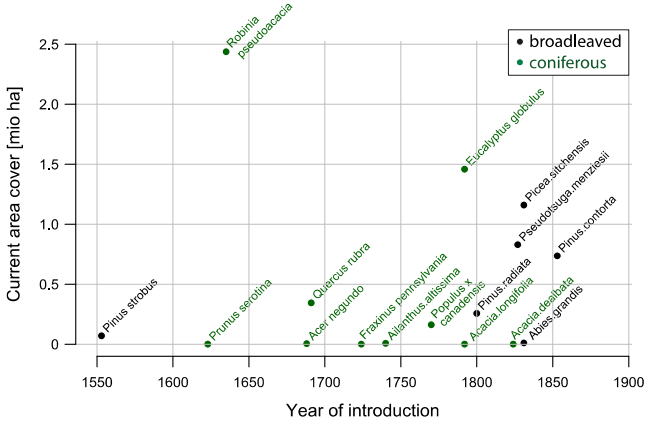


Fig. 1. Year of introduction and current cumulative cover of 15 non-native tree species in European countries.

Hasenauer H., Gazda A., Konnert M., Lapin M., Mohren G. M. J., Spiecker H., Van Loo M. & Pötzelsberger E. (2016) Non-native tree species for European forests: experiences, risks and opportunities. COST Action FP1403 NNEXT Country Reports, Joint Volume. Ed. 2. University of natural Resources and Life Sciences Vienna, Vienna.

Richardson D. M. & Rejmánek M. (2004) Conifers as invasive aliens: a global survey and predictive framework. Diversity Distrib. 10: 321–331.

Integrating ecological and socioeconomic impacts of *Prosopis*, a woody invasive alien species, to inform management

Urs Schaffner[1], Eric Allan[2,3], Tena Alamirew[4], Ketema Bekele[5], Sandra Eckert[3], René Eschen[1], Jema Haji[5], Theo E. W. Linders[1,2], Lisanework Nigatu[5] and Hailu Shiferaw[4,6]

[1]*CABI Switzerland, Rue des Grillons 12800, Delémont, Switzerland*
[2]*Institute of Plant Sciences, University of Bern, Switzerland*
[3]*Centre for Development and the Environment, University of Bern, Switzerland*
[4]*Water and Land Resource Centre, Addis Ababa, Ethiopia*
[5]*Department of Agricultural Economics, Haramaya University, Dire Dawa, Ethiopia*
[6]*Addis Ababa University, College of Natural Sciences, Addis Ababa, Ethiopia*
e-mail: u.schaffner@cabi.org

Invasive alien species (IAS) not only affect ecosystems, but also human well-being. Hence, developing management strategies requires a multidisciplinary approach that is based on a clear understanding of both the ecological and the socioeconomic implications of biological invasions. We assessed the ecological and socioeconomic effects of *Prosopis juliflora*, a species which was deliberately introduced in Eastern Africa for the provisioning of fuelwood and for soil stabilization, but has escaped from plantations and has invaded large areas of grassland and shrubland. We found that in a lowland region in Ethiopia, *Prosopis* invasion significantly affects the provisioning of ecosystem services and land cover /land use dynamics. At the local scale, *Prosopis* invasion threatens traditional livelihood forms such as pastoralism since most of the dry-season grazing areas have already been invaded or are likely to be invaded by this tree over the next decades. At the regional scale, *Prosopis* was found to be a key driver of losses in ecosystem service values, a parameter increasingly recommended in decision-making. We propose that future assessments of the impacts of IAS should not only measure the effects on single indicators of ecosystem patterns or processes, but also try to further our understanding of their consequences for the social-ecological systems in the invaded range.

Invasive and native grasses exert negative plant-soil feedback effects on *Artemisia tridentata* whereas conspecific effects are neutral

Jacob A. Cowan[1], Catherine A. Gehring[2] and Kevin C. Grady[1]

[1]*School of Forestry, Northern Arizona University, Flagstaff, AZ, 86011-5018 USA*
[2]*Department of Biological Sciences, Northern Arizona University, Flagstaff, AZ, 86011 USA*
e-mail: cowanjacob@gmail.com

The displacement of high diversity big sagebrush (*Artemisia tridentata*) dominated communities by cheatgrass (*Bromus tectorum*) invasion, an annual grass which supports much less diverse communities, is widely recognized to represent a major threat to regional biodiversity in the shrub-steppe communities of the western US. Once established, cheatgrass maintains dominance by altering fire regimes and because of its early germination, which makes it a very effective competitor for soil water and nutrients. Additionally, there is increasing recognition that cheatgrass may be altering soils in a way that suppresses sagebrush germination and regrowth. To assess the role that cheatgrass-induced plant-soil feedbacks may be playing in the maintenance of dominance by this invasive, we grew sagebrush seedlings without direct competition in soils conditioned with either cheatgrass, *Elymus elymoides* (a common native perennial bunchgrass) or conspecifics. Seedling growth was compared with controls to determine the direction and magnitude of feedbacks being exerted by the different conditioning plants. We found that cheatgrass and *Elymus* exerted negative feedback on sagebrush, and the effect of the invasive was not significantly different than that of the native. Surprisingly, negative feedbacks did not increase with increasing biomass of the conditioning plant (i.e. there was no density-dependent effect). Despite averaging six times larger than *Elymus* during our conditioning phase, cheatgrass had no greater suppressive effect on sagebrush growth. Conspecific feedbacks were neutral to slightly negative, which is not unusual for a climax species. To explore some potential mechanisms driving these feedback patterns, we looked at nutrient depletion and reduction in colonization by arbuscular mycorrhizal fungi (AMF), important symbionts of sagebrush. Neither of these seems to be playing a role in sagebrush suppression. Additionally, we are in the process of using next-generation amplicon sequencing to characterize root microbial communities (fungal and bacterial), to allow for the comaprison between the conditioning treatments. These data will likely be included in the presentation. Alteration of root microbial communities away from compositions beneficial to natives has been implicated in other invasions and could be driving the observed feedback patterns. We discuss aspects of cheatgrass biology that allow it to extensively alter soils that contain native bunchgrasses. Finally, we consider implications for restoration.

Removal of alien plants: any effect on native macrophyte recovery and pollinator services?

Iris Stiers and Ludwig Triest

Ecology and Biodiversity, Department of Biology, Vrije Universiteit Brussel, Belgium
e-mail: istiers@vub.be

Mechanical control methods are the most widely used measures to control alien aquatic plants in Europe and their success varies considerably between growth forms and the different habitats. Further, it remains unclear whether management practices targeting alien removal actually improve habitat quality for resident biota and will have the desired impacts or if management practices are only implemented with the hope that native species are returning. The objectives of this study were two-fold, namely: to assess the effect of (i) invasive amphibious macrophyte removal on native macrophyte recovery, and (ii) *Ludwigia grandiflora* removal on plant-pollinator interactions of co-flowering native plants. Cover and composition of native macrophytes were investigated in 2007 in 15 invaded sites in Belgium (by *L. grandiflora*, *Hydrocotyle ranunculoides* or *Myriophylum aquaticum*) and again in 2015 after manual/mechanical control in 2009. To study the plant-pollinator interactions, we set up an experiment to compare visitation rate and pollen transfer of native *Lythrum salicaria* and *Alisma plantago-aquatica* in the presence of *L. grandiflora* and after removal. Firstly, the native vegetation showed no general increase in cover after removal of the invasive macrophytes. Species richness did not increase indicating that additional restoration management might be needed. Secondly, *L. salicaria* showed a significant increase in visitation rate after removal of *L. grandiflora*, but no difference in pollen deposition. For *A. plantago-aquatica* there was an increase in conspecific pollen deposition after removal of the alien species. Removal of an invasive species seems to have a strong species-specific effect and depends on the overlap in the pollinator community.

Plural realities of plant invasions: *Prosopis juliflora* in the Banni grassland, India

Ramya Ravi, Siddhartha Krishnan and Ankila J. Hiremath

Ashoka Trust Research for Ecology and Environment (ATREE), Royal Enclave, Srirampura, Jakkur Post, Bengaluru, Karnataka, India
e-mail: ramya.ravi@atree.org

Banni is a ~2500 km^2 arid grassland in Western India. It is one of the largest natural grassland systems in the Indian sub-continent. Banni is historically home to *Maldharis* (Mal~livestock, dhari~owners), a traditional pastoralist community, wellknown for their animal husbandry practices and milk economy. Banni adjoins a large salt-marsh desert system, the Rann of Kutch. Concerns over rising salt-water ingress and desertification in Banni led to the introduction of *Prosopis juliflora* (hereafter, *Prosopis*), an invasive tree native to the Americas. Since its introduction in the 1960s, *Prosopis* has spread to about 60% of the grassland. This has prompted local stakeholders—the *Maldharis* and NGOs—to call for its removal. However, using a combination of quantitative and qualitative methods we find that Banni is in a state of 'novel' dependence on *Prosopis* for economic and cultural uses. Almost 70% of Banni's residents are dependent on income from *Prosopis* charcoal for their sustenance. Charcoal income is a source of primary and secondary income among Banni's people as a result of prevailing social stratification. For individuals with small-to-no livestock holdings, charcoal is a primary source of income that helps reduce income-related vulnerabilities, while for individuals with large livestock holdings, charcoal is a source of secondary income that helps in business expansions and in furthering political interests. In fact, for both these groups, income from charcoal has led to herd expansion, resulting in an upsurge in the local milk economy. This intricate network among Banni's people, of primary and secondary charcoal-dependents, has formalized the charcoal economy in the region. In addition, 60% of all homes are made of *Prosopis*. *Prosopis* is also used in shelters for livestock, in groundwater harvesting systems, and for local rituals. Almost 95% of fuelwood used comes from *Prosopis*. In addition to their steady use among the locals, honey, pods, resin, and wood collected from *Prosopis* also have a sizeable market demand. With such multi-layered dependencies, the removal of *Prosopis* is now contentious among the various social classes of Banni.

Our work demonstrates the importance of interdisciplinary research even in the context of ecological problems like invasions. The dominant narrative that shapes invasive species management policies focuses on the origins of these species, their negative impacts on native species, and the value that we place on historical states prior to invasion. Just as importantly, narratives about invasive species must also focus on 'novel' cases where these species have become a part of the landscape due to people's economic and cultural dependence on them.

Plant invasions and greenhouse gas emissions

Mauricio C. Mantoani and Bruce A. Osborne

UCD School of Biology and Environmental Science and UCD Earth Institute, University College Dublin, Dublin, Belfield, Ireland
e-mail: Bruce.Osborne@ucd.ie

Plant invasions represent a major global change in land/vegetation cover and, because of documented alterations in C and N cycling and enhanced litter production, they may potentially result in significant increases in soil greenhouse gas (GHG) emissions. To assess the effects of invasive terrestrial plant species on GHG emissions, we performed a search of the literature and found 50 cases reporting 22 species. The results were, however, equivocal and only in 38% of the cases soil respiration increased, contradicting the common assumption that invasive plants increase CO_2 emissions. CH_4 emissions only increased in studies conducted in wetlands or areas prone to flooding and, of a total of four cases analysing N-fixing species, only two detected enhanced N_2O emissions. To get a better understanding of the impacts of invasive plants on GHG emissions, we conducted an experiment on invasive populations of the N-fixing species *Gunnera tinctoria* on Achill Island, Ireland. *G. tinctoria* showed > 50% lower soil CO_2 emissions, mainly due to a reduction in autotrophic respiration, with a strong seasonal dependency (Fig. 1), but with little change in N_2O or CH_4 emissions. Comparisons of these results with literature values is difficult because of the often low and limited sampling effort of previous investigations, a failure to assess all three major GHGs and because of marked seasonal variations. Consequently, there is considerable uncertainty about the likely impact of plant invasions on the land-atmosphere exchange of GHGs and their global significance. Based on the results for *G. tinctoria* there is, however, no reason to expect an enhancement of GHG emissions or that N-fixing species will increase N_2O emissions, as is often assumed. In part, the results may reflect species and site-specific results, but the limited regional coverage and the experimental deficiencies inherent in many previous investigations argue for more detailed and comprehensive assessments.

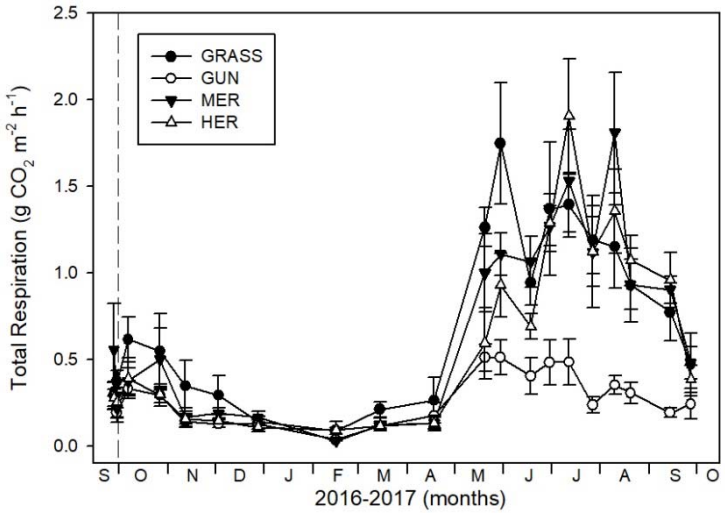


Fig. 1. Seasonal variation in total soil respiration (g CO_2 m^{-2} h^{-1}, n = 5, mean ± SE) on Achill Island, Co. Mayo, Ireland. Legend: GRASS, uninvaded semi-natural grasslands; GUN, areas invaded by *G. tinctoria*; MER, mechanical removal; and HER, herbicide application. The dashed line represents the initial removal performed in the invaded sites on 29th of September 2016.

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

Florencia A. Yannelli[1], Jan-Hendrik Keet[2] and Johannes J. Le Roux[1,3]

[1]*Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, Matieland 7602, South Africa*
[2]*Department of Botany and Zoology, Stellenbosch University, Matieland 7602, South Africa*
[3]*Department of Biological Sciences, Macquarie University, Sydney, 2109, Australia*
e-mail: florenciayannelli@gmail.com

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 the composition of plant communities as well as their 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 soil physico-chemical properties and soil microbial communities in the CFR. We seek to disentangle the legacy effects of *Acacia* invasions on the recovery of native vegetation following clearing by comparing neighbouring areas where pristine fynbos, *Acacia saligna*-invaded, and previously-cleared sites were present. We conducted vegetation surveys, sampled soil chemical composition and overall soil bacterial communities. In all areas, we also collected leaves from the widespread native species *Phylica cephalantha* and the invasive *A. saligna* to analyze the impact of nitrogen fixation by the latter on native and invasive species. We found that invasive Australian acacias change the diversity and the structure of above-ground plant communities, soil bacteria, and some soil chemical conditions, but these alterations were site specific. Our results showed that the impact of acacia-driven nitrogen fixation can often persist in native and invasive species even after sites have been cleared. Furthermore, even when acacias are removed from the system, our field study shows that legacy effects driven by soil conditions hinder the full recovery of the native vegetation.

Predicting benefits and risks of biological control of the invasive common ragweed in Europe: from ecological to evolutionary studies

Heinz Müller-Schärer[1], Yan Sun[1], Maria Litto[1], Sarah Bouchemousse[1], Suzanne Lommen[1] Benno Augustinus[1,2] and Urs Schaffner[2]

[1]*Department of Biology, University of Fribourg, CH-1700 Fribourg, Switzerland*
[2]*CABI, CH-2700 Delémont, Switzerland*
e-mail: heinz.mueller@unifr.ch

Balancing benefits with risks is key in developing a successful biological control program. In 2013, we were confronted with the accidental introduction of the North American native ragweed leaf beetle (*Ophraella communa*) into Europe, which needed an urgent decision on how to respond to this unforeseen arrival of an oligophagous insect. We immediately reacted to this event by our newly formed COST-SMARTER consortium composed of specialists in weed and invasive species management, ecology, aerobiology, allergology and economics.

Firstly, we will summarize our findings on the beetle's potential benefits, ranging from its impact on ragweed performance, demography, spread, aerial pollen concentrations up to reducing health cost. We will further present our results on the risks of the beetle for non-host plants in Europe. So far, we detected no impact on sunflower, probably because the window of vulnerability of this crop does not coincide with high beetle densities at the end of the growing season. The same holds true for taxonomically closely related ornamental and endangered native plant species.

Secondly and in view of improving predictions for future long-term benefits and risks of this potential biological control program, we initiated a novel experimental evolutionary approach to assess the beetle's potential to select for resistant/tolerant ragweed populations (study 1), as well as the beetle's potential for evolutionary adaptation to novel biotic (host plants) and abiotic (colder temperature for the yet unsuitable habitats in Central Europe, and considering climate change) conditions (study 2), using next generation sequencing and bioassay approaches. We will present the 2017 and 2018 results of both studies from our demographic, phenotyping, as well as genomic analyses, of both the experimental ragweed (over two generations) and beetle (over six generations) populations.

This is the first attempt to rigorously and simultaneously assess the evolvability of a biological control agent with its target weed.

Lommen S. T. E., Jongejans E., Melinda Leitsch-Vitalos M., Tokarska-Guzik B., Zalai M., Müller-Schärer H. & Gerhard Karrer G. (2018) Time to cut: population models reveal how to mow invasive common ragweed cost-effectively. NeoBiota 39: 53–78.

Mouttet R., Augustinus B., Bonini M., Chauvel B., Gachet E., Le Bourgeois T., Müller-Schärer H., Thibaudon M. & Schaffner U. (2018) Estimating economic benefits of expected biological control of an allergenic weed: a case study for *Ophraella communa* against *Ambrosia artemisiifolia* in southeastern France. Bas. Appl. Ecol. 33: 14–24.

Modelling the biocontrol of an invasive tree by a bud-galling wasp, *Trichilogaster acaciaelongifoliae*

Jael Palhas[1], João Cabral[3], Francisco Alejandro López Núñez[1], Elizabete Marchante[1] and Hélia Marchante[2]

[1]*Centre for Functional Ecology - Science for People & the Planet, Department of Life Sciences, University of Coimbra. Calçada Martim de Freitas, 3000-456 Coimbra, Portugal*
[2]*Instituto Politécnico de Coimbra, Escola Superior Agrária, Centre for Functional Ecology – Science for people and the planet, Bencanta, 3045-601 Coimbra, Portugal*
[3]*Laboratory of Applied Ecology, CITAB – Centre for the Research and Technology of Agro-Environment and Biological Sciences, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal*
e-mail: ecopalhas@gmail.com

Acacia longifolia is one of the most widespread invasive plants in the coastal areas of Portugal, mainly because of its ability to produce a large number of long-lasting seeds that accumulate in soil seed banks. Seeds frequently germinate after disturbance (e.g. fire, control interventions) resulting in rapid reinvasion of the areas. After host-specificity testing, several years of national and European risk assessments and bureaucratic procedures, the Australian bud-galling wasp, *Trichilogaster acaciaelongifoliae*, was introduced as a biocontrol agent (BCA) for *Acacia longifolia* in late 2015. The wasp is highly host-specific, exclusively attacking *A. longifolia*. It is univoltine and most of the annual life cycle is spent as eggs, larvae and pupae within the developing galls. The adults are small (3 mm), short lived (2–3 days) and parthenogenic. After emergence, the females lay their eggs in the flower (and vegetative) buds of *A. longifolia* which develop into galls instead of pods. This wasp has been used as a biocontrol agent in South Africa for more than 30 years with great success. In the short term, it reduces the annual seed production, which in turn results in fewer seeds for dispersal and in the long-term, it results in a reduction of reinvasion after control operations, fire or other disturbances. We created a dynamic model to simulate the establishment and population growth of this BCA and its impacts on the *A. longifolia* seed production over time. The model was developed using STELLA 10.0.5 and was divided in three interconnected sub-models: the climatic scenario, the Acacia model and the *Trichilogaster* model. The model was featured with an intuitive interface to promote its use by non-experts in the management of invaded areas, e.g., when deciding how many wasps to release in their areas. Parameters were obtained from a literature review, field records and expert knowledge. Results show that it's expected an initial exponential growth of the BCA population followed by stabilization with natural fluctuations between years, in response to meteorological variations. *Acacia longifolia* seedbank in the soil stops growing 5 years after the BCA release and starts decreasing slowly, due to the reduction or even suppression of seed production and stable seedbank loss rate. Advantages of this approach for biocontrol research and for management of invaded areas are discussed.

The future of biological control in South Africa: effects of elevated CO_2

N. C. Baso[1,2], J. Coetzee[2] and B. Ripley[1]

[1]*Dept. of Botany, Rhodes University, Lucas Ave, Grahamstown, 6139, South Africa*
[2]*Dept. of Zoology and Entomology, Rhodes University, African Street, Grahamstown, South Africa*
e-mail: g14b4197@campus.ru.ac.za

The past two centuries have seen a rapid increase in atmospheric CO_2 concentration and this trend is predicted to continue into the future. Studies have shown that plants grown above 600 ppm tend to have increased fitness. This has important implications for the management of invasive alien plants, especially for the field of biological control which is mostly dependent on herbivorous insects. Nevertheless, most of the studies on potential changes in plant-insect interactions under elevated CO_2 are based on agricultural systems. However, climate change and invasive species are two of the most prevalent features of global environmental change. Therefore, this warrants active research to help prepare for the future predicted by the IPCC. Thus, the aim of this study was to investigate how elevated CO_2 affects the biological control of four invasive aquatic weeds (*Pistia statiotes, Salvinia molesta, aquaticum* and *Azolla filiculoides*) that are a threat to natural resources but are currently being successfully controlled by their biological control agents in South Africa. To achieve this, the focal plants were grown at ambient (400 ppm) and elevated (800 ppm) CO_2 concentrations with and without their respective biological control agents. The general trend from this study shows that we will continue to enjoy the current levels of control in future climates as the insects were able to reduce plant biomass under elevated CO_2 to match those of plants that were grown without herbivory at ambient CO_2.

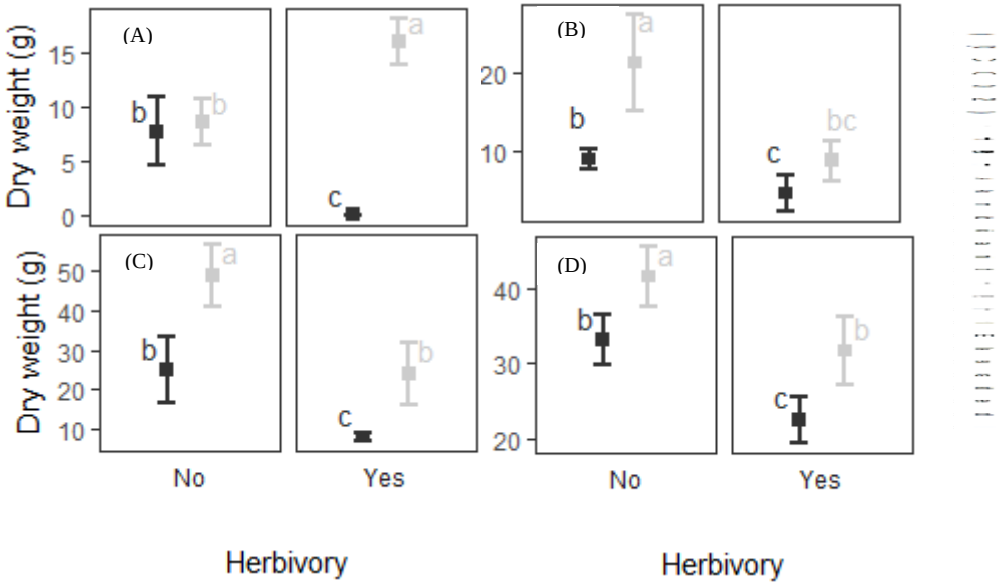


Fig. 1. Effects of CO_2 manipulation and herbivory on biomass production of (A) *A. filliculodes*, (B) *S. molesta*, (C) *M. aquaticum* and (D) *P. stratios*. Dot=Mean, Error bars= ±SE

Cornelissen T. (2011) Climate change and its effects on terrestrial insects and herbivory patterns. Neotrop. Entomol. 40: 155–163.

Moss B., Kosten S., Meerhoff M., Battarbee R. W., Jeppesen E., Mazzeo N., Havens K., Lacerot G., Liu Z., De Meester L., Paerl H. & Scheffer M. (2011) Allied attack: climate change and eutrophication. Inland Waters 1: 101–105.

Rahel F. J. & Olden J. D. (2008) Assessing the effects of climate change on aquatic invasive species. Cons. Biol. 22: 521–533.

Control of *Acacia saligna* with aminopyralid direct application: new perspectives in the control management of one of the most widespread invasive wattle species

Jean-Marc Dufour-Dror[1] and Tuvia Yaacoby[2]

[1]*Ecologist, invasive plant specialist, consultant, Israel*
[2]*The Hebrew University of Jerusalem, Israel*
e-mail: jmdd@netvision.net.il

Acacia saligna (Labill.) H.L. Wendl. (Port Jackson willow) is one of the worst invasive tree species in several countries of the Mediterranean basin (e.g. Israel, Cyprus, Italy, Portugal and Spain). It is also one of the main invasive plants in South Africa. This wattle species forms dense stands where all native plants are displaced while the thick litter produced increases the concentration of soil organic matter and soil nitrogen. *Acacia saligna* invades various natural ecosystems ranging from coastal sand dunes, dry rocky slopes to riparian habitats, where it completely modifies the basic characteristics of the ecosystems. Due to the nature and extent of its impacts, this wattle species is regarded as a major woody invasive transformer.

Several control techniques, either chemical or biological, have been tested and developed in order to stop and reduce the proliferation of *Acacia saligna*. While biocontrol attempts in South Africa have, to some degree, proven less successful than initially anticipated (Strydom et al. 2017; Impson & Hoffmann 2019), chemical control of *Acacia saligna* requires relatively large quantities of herbicides and the direct application procedures are time consuming and therefore expensive (Krupek et al 2016). In order to improve the control of *Acacia saligna* significantly, several experiments based on the direct application of aminopyralid (Milestone©) were conducted at four different sites in Israel between 2016 and 2018. The trees were controlled with the hack and squirt technique using 1 ml of aminopyralid per 5 cm of trunk diameter. Undiluted volumes of aminopyralid were applied with a pipettor directly into the cambium immediately after the cuts. The experiment was carried out in five groups of 30 mature individuals (n=150) forming dense stands in natural sites within the Mediterranean region (Csa) of Israel. The trees were only treated once between March and October and each tree was tagged. The experimental sites included natural habitats among the most infested by this wattle in Israel: coastal sand dunes, riparian habitat along river banks in the alluvial plain, as well as dry habitats. The impact of the control was evaluated through systematic monitoring of each tree over a period of 13 months from the date of application. The results showed that 94.7% of the trees completely lacked signs of vitality and died as a result of the control; 3.3% of the trees had less than 5% green phyllodes at the end of the follow-up period, while 2% of the trees still had between 5% and 20% green phyllodes after the application. Among the trees that did not die, none produced flowers and therefore the seed production was stopped.

The outstanding results obtained during these experiments constitute a major breakthrough in the control management of *Acacia saligna* for the following reasons: (i) The control procedure is basic and extremely easy to apply as it requires only an axe and a pipettor or a small plastic squeeze bottle; (ii) the control operations take less than 30 seconds per tree; (iii) the volume of herbicide needed is at least 5 times less than when controlling *A. saligna* with common herbicides such as glyphosate or imazapyr; (iv) the ecotoxicological profile of aminopyralid is much better than that of commonly used herbicides (Cal-IPC 2015); (v) this control method can be applied in all types of habitats and terrains infested with *A. saligna*; and (vi) at last, the fact that large quantities of trees can be controlled within short time periods, while more than 94% of the trees do not require repeated action, make this control technique far cheaper compared to other chemical control methods currently in use. Considering the recent ban of imazapyr by the EU, the public controversy over glyphosate, and the multiple advantages mentioned above, this control method opens new perspectives for the control of *Acacia saligna,* and by extension for the control of all invasive wattle species.

How to establish grassland on sites invaded by *Solidago*: results of a five-year experiment

Magdalena Szymura[1], Sebastian Świerszcz[2], Tomasz H. Szymura[3] and Dawid Jarczak[1]

[1]*Institute of Agroecology and Plant Production, Wrocław University of Environmental and Life Sciences, Wrocław, Poland*
[2]*Botanical Garden-Centre for Biological Diversity Conservation, Polish Academy of Sciences, Warsaw, Poland*
[3]*Department of Ecology, Biogeochemistry and Environmental Protection, University of Wrocław, Wrocław, Poland*
e-mail: magdalena.szymura@upwr.edu.pl

The semi-natural grasslands are species-rich and form habitats for numerous rare and endangered species. The grasslands also provide a wide range of ecosystem services: provisioning, regulating (e.g. climate regulation, erosion prevention and regulation of water flows), habitat, cultural and amenity. In Europe, in the last hundred years, more than 90% of semi-natural grasslands were destroyed due to production intensification or abandonment. To prevent this deterioration, semi-natural grasslands are recently protected in the pan-European Nature 2000 network. Despite the current protection, the effect of agriculture abandoning is still visible in Europe.

The spread of exotic species is a crucial element of environmental global changes. Invasion by alien plant species alters biodiversity, landscape structure, ecosystem functions and services, local economy, as well as human health and well-being. One of the most common invasive plants in abandoned lands and grasslands in Europe are species from *Solidago* genus of the North American origin, especially *S. gigantea* Aiton and *S. canadensis* L. s.l. Consequently, it is necessary to restore areas occupied by the goldenrods. The long-term successful elimination of the invasive species needs two stages: removing of invasive plant species and the subsequent habitat restoration (Reid et al. 2009).

We show the result of a long-term field experiment where species-rich grasslands were restored on post-agricultural lands overgrown by dense stands of *Solidago* spp. We examined different methods of *Solidago* spp. eradication and grassland species seed supply. We would like to answer the question: which method of eradication is the best, in the long run? As the treatments were applied: sod-cutting (depth ~1 cm); rototilling; and herbicide application (glyphosate, 5 L ha-1). Afterwards, two methods of seed application were used: (i) spreading fresh hay, obtained from a high-biodiversity meadow, and (ii) sowing the commercial seed mixture. These treatments and seed application were used once, in the first year of the experiment. All plots were mowed twice per year during the course of the experiment. Our targets in the experiment were: the highest possible reduction of *Solidago* biomass/cover and simultaneously increase of graminoids and grassland herbs cover/biomass. After five years we substantially reduced the cover of *Solidago* (average form 95% to 25%). We found significant differences between the effects of seed addition and lack of differences between applied methods of eradication. The lowest biomass of goldenrods, as well as the highest biodiversity, was observed in plots where fresh hay, as a method of seed application was used. At the end of the experiment we observed that the cover of alien species was at the level which had no visible impact on bees and butterflies abundance and species richness (Moroń et al. 2019). The results reveal that five years after eradication the establishment of semi-natural grassland, with a reasonable low cover of *Solidago*, on formerly strongly invaded sites is possible.

Moroń D., Skórka P., Lenda M., Kajzer-Bonk J., Mielczarek Ł., Rożej-Pabijan E. & Wantuch M. (2019) Linear and non-linear effects of goldenrod invasions on native pollinator and plant populations. Biol. Invas. 21: 947–960.

Reid A. M., Morin L., Downey P. O., French K. & Virtue J. G. (2009) Does invasive plant management aid the restoration of natural ecosystems? Biol. Conserv. 142: 2342–2349.

Patterns and implications of alien plant invasions at multiple scales

Llewellyn C. Foxcroft[1,2], Sandra MacFadyen[3,4], Petr Pyšek[5,6], David M. Richardson[2] and Cang Hui[7]

[1]*South African National Parks, Conservation Services, Private Bag X402, Skukuza 1350, South Africa*
[2]*Centre for Invasion Biology, Dept. of Botany and Zoology, Private Bag X1 Matieland, Stellenbosch University, Stellenbosch 7602, South Africa*
[3]*Vrije Universiteit Amsterdam, Institute for Environmental Studies, De Boelelaan 1085, 1081 HV, the Netherlands*
[4]*Dept. of Botany and Zoology, Private Bag X1 Matieland, Stellenbosch University, Stellenbosch 7602, South Africa*
[5]*Institute of Botany, Department of Invasion Ecology, Academy of Sciences of the Czech Republic, Průhonice, CZ 252 43, Czech Republic*
[6]*Department of Ecology, Faculty of Science, Charles University in Prague, Viničná 7, CZ 128 44 Prague 2, Czech Republic*
[7]*Department of Mathematical Sciences, African Institute for Mathematical Sciences, Stellenbosch University, South Africa*
e-mail: Llewellyn.foxcroft@sanparks.org

Determining the invasiveness of an introduced plant species and the inherent vulnerability of an area to invasion, is one of the most challenging questions in invasion ecology. However, answers to these questions are frequently species and site specific and operate across spatial scales. Elucidating the factors underlying the patterns of alien plant invasions not only provides insight into basic ecological principles that may be tested in other similar systems, but also potentially the ability to identify hotspots of invasion, and potentially for different groups of alien species. However, species distributions are collected at different scales, and potentially used at scales inappropriate for the intended purpose. Using a large database of > 30,000 alien plant records covering Kruger National Park (~20 million ha), we aim to determine whether it is possible to disentangle and quantify (i) the effect of local site environmental variables (abiotic factors, climate, habitat, and natural disturbance), (ii) the effect of propagule pressure, and (iii) anthropogenic drivers. This unique setting also allows these questions to be tested at multiple spatial scales; that is, the sensitivity of each driver to particular scales. This can have implications for data collection for management prioritization and monitoring. For example, guiding where in the landscape distribution data, and therefore early detection, could be focused, or how the data are interpreted when developing management plans or future ecological research.

Assessing biological invasions in protected areas

Ross T. Shackleton[1,2], Llewellyn C. Foxcroft [3,2], Petr Pyšek[4,5], Louisa E. Wood[6], Bastian Bertzky[7,8], Nancy Bunbury[9], Heinke Jäger[10], Kevin Smith[11], Remco van Merm[7], Arne Witt[12], John R. U. Wilson[2] and David M. Richardson[2]

[1]*Institute of Geography and Sustainability, University of Lausanne, 1015 Lausanne, Switzerland*
[2]*Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, Matieland 7602, South Africa*
[3]*Scientific Services, South African National Parks, Kruger National Park, Private Bag X402, Skukuza 1350, South Africa*
[4]*Institute of Botany, Department of Invasion Ecology, Czech Academy of Sciences, Průhonice, Czech Republic*
[5]*Department of Ecology, Faculty of Science, Charles University, Prague, Czech Republic*
[6]*Centre for Environment Fisheries and Aquaculture Science, Barrack Road, Weymouth DT4 8UB, UK*
[7]*International Union for Conservation of Nature (IUCN), Rue Mauverney 28, 1196 Gland, Switzerland*
[8]*European Commission, Joint Research Centre (JRC), Via Enrico Fermi 2749, 21027 Ispra (VA), Italy*
[9]*Seychelles Islands Foundation, La Ciotat Building, Mont Fleuri, Victoria, PO Box 853, Seychelles*
[10]*Charles Darwin Research Station, Charles Darwin Foundation, Santa Cruz, Galápagos, Ecuador*
[11]*International Union for Conservation of Nature (IUCN), Pembroke Street, Cambridge CB2 3QZ, UK*
[12]*Centre for Agriculture and Biosciences International (CABI), Nairobi, Kenya*
e-mail: rtshackleton@gmail.com

Invasive alien species pose a major threat to conservation areas globally. This presentation will discuss the findings from two projects relating to 1) monitoring biological invasions in World Heritage Sites, and, 2) assessing changes in invasion threat and management over the last 30 years in protected areas that were studied in the 1980s as part of the SCOPE programme on biological invasions. The presentation will present some recent statistics on the status of plant invasions in protected areas and highlight key differences between plant invasions and other invasive taxa. We also discuss some successes and challenges regarding monitoring and managing biological invasions in protected areas. We will conclude by discussing the need for a framework to standardize monitoring to allow for comparison between sites.

Sustainable management of *Acacia* spp: an applied perspective of natural control and other methodologies to improve habitat recovery in protected areas

Liliana Duarte[1], Hélia Marchante[1], Francisco A. López-Núñez[2], Jael Palhas[2], Olímpia Sobral[1], Marília Claro[1] and Elizabete Marchante[2]

[1]*Instituto Politécnico de Coimbra, Escola Superior Agrária, Centre for Functional Ecology – Science for people and the planet, Bencanta, 3045-601, Coimbra, Portugal*
[2]*Centre for Functional Ecology, Department of Life Sciences, University of Coimbra. Calçada Martim de Freitas, 3000-456 Coimbra, Portugal*
e-mail: lduarte@esac.pt

Successful management of plant invasions is frequently difficult to attain and entail prohibitive costs. A combination of methodologies, persistence and adaptive management, may improve chances against invasive alien plants (IAP). *Acacia longifolia, Acacia dealbata* and *Acacia melanoxylon* are worldwide invaders and are amongst the most widespread IAP in Portugal, causing diverse negative impacts that turn them into transformer species. Managers usually cut them, even though this is not the most effective technique, resulting in low levels of success. GANHA (Sustainable management of *Acacia* spp: an applied perspective of natural control and other methodologies to improve habitat recovery in protected areas; POSEUR-03-2215-FC-000052) is an applied project focused on the integration of different techniques to control *A. longifolia, A. dealbata* and *A. melanoxylon* in Natura 2000 sites and protected areas. The added value of the project is based on (i) the use of the Australian bud-galling wasp (*Trichilogaster acaciaelongifoliae*), the first biocontrol agent (BCA) released in Portugal (November 2015) to control *A. longifolia*, to reduce seed formation; (ii) the selection of the most effective techniques according to each species characteristics; (iii) the persistence of follow up treatments; and (iv) the close collaboration amongst operational staff, managers and academics in an adaptive management approach.

The main goals are to (i) reduce the seed bank of *A. longifolia*, by the release of *Trichilogaster acaciaelongifoliae*; (ii) reduce the areas currently invaded by *A. longifolia, A. dealbata* and *A. melanoxylon* through physical techniques (i.e. hand pull, cut and/ or debarking), and/ or combined with chemical methods; (iii) start testing the specificity of two new biocontrol agents, in quarantine, targeting the reduction of *A. dealbata* and *A. melanoxylon* seed production; and (iv) increase awareness of IAP amongst the population of the project intervention areas.

In June – July 2018 the BCA release was made, for the first time, exclusively with wasps of Portuguese origin. Preliminary results indicate new sites with galls in early 2019, with apparent higher abundances than the first generation of South African wasps detected in 2016. Initial controls and a first follow up treatment with physical and/or chemical techniques have been completed in most of the areas, debarked *A. dealbata* and *A. melanoxylon* trees are dying and other follow ups are planned. The persistence of follow up treatments is expected to contribute in achieving higher success in IAP control but operational difficulties and dealing with limitations imposed by managers can be challenging and will be discussed.

Plant risk assessment tools to reduce invasive plant use in ornamental plant industries

Hillary Cherry

National Parks and Wildlife Service, PO Box 1967, Hurstville, NSW 1481, Australia
e-mail: hillary.cherry@environment.nsw.gov.au

Invasive plants (weeds) are a significant threat to the environment. Historically, the ornamental plant trade has been a significant pathway for weed spread. For example, over 65% of introduced plants that have naturalized in Australia are considered garden escapes (Groves et al. 2005). In Australia, there is a strong desire in industry, government and the community to reduce the use of 'weedy' ornamental plants and prevent future invasive plants. Major ornamental plant suppliers in Australia also want to achieve broader sustainability and environmental goals. The Plant Sure project contributes to achieving these goals by developing mechanisms for industry to prevent the use of plants that have a high risk of becoming invasive, with a focus on reducing impacts to the environment (Cherry et al. 2018).

The aim of the Plant Sure initiative is to develop a voluntary accreditation scheme for ornamental plant industries, such as forestry stewardship schemes or Plant Right California (www.plantright.org). The scheme will be underpinned by a plant risk assessment and categorization process that classifies plants according to invasive risk. Plants that pose a high risk of becoming invasive can be excluded from use, while low risk plants can be encouraged. The scheme will allow industry to take a proactive approach and assess new plant introductions to ensure they are environmentally sustainable (i.e. low invasive risk). It will also support ornamental plant industries in promoting environmentally-safe (low risk) plants, and provide training for industry and consumers to avoid the use of plants that pose an environmental weed risk. The scheme will initially be trialled in one Australian state (New South Wales) but is being designed for national uptake. It will be open to all industries along the ornamental plant 'supply chain', including plant breeders, growers, sellers, installers and those entities that recommend plants, such as local governments and landscape architects. The scheme will provide confidence to industry and consumers that their plant choices are environmentally sound. It will allow industry to showcase their environmental stewardship, and to develop strong brand awareness that supports a 'self-sustaining' voluntary scheme. By including education and training components, the Plant Sure scheme will seek to elicit long-term attitudinal and behavioural change in ornamental plant suppliers and consumers.

Invasive species experts have a role to work with the ornamental plant industry to provide weed and plant risk assessment expertise, as well as help co-design tools with industry to allow them to reduce the use of invasive plants. Robust plant risk assessments and categorization protocols, including cultivars and subspecies, that are useful and trusted by industry, government and consumers are a foundational part of the process of preventing future invasive plants. This talk outlines the first phase of the scheme development; a) collaboration and partnership building across industry, government and community, b) co-developing plant risk assessment and decision support tools, c) scoping what is needed for a successful accreditation scheme, and d) future work to establish a scheme.

Cherry H., Johnson S. & Boorman D. (2018) An ounce of prevention: an accreditation scheme for ornamental plant industries. In: Johnson S., Weston L., Wu H. & Auld B. (eds) Proceedings of the 21st Australasian Weeds Conference, Weed Biosecurity – Protecting our Future, Novotel Sydney Manly Pacific, NSW, 9–13 September 2018, p. 96–99, The Weed Society of NSW. http://caws.nzpps.org/awc_contents.php?yr=2018 (Accessed 14 April 2019).

Groves R. H., Boden R. & Lonsdale W. M. (2005) Jumping the garden fence: invasive garden plants in Australia and their environmental and agricultural impacts. CSIRO report prepared for WWF-Australia. WWF-Australia, Sydney.

Stronger regional biosecurity is essential to prevent hundreds of harmful biological invasions

Katelyn T. Faulkner[1,2], Mark P. Robertson[2] and John R. Wilson[1,3]

[1]*South African National Biodiversity Institute, Kirstenbosch Research Centre, Claremont 7735, South Africa*
[2]*Centre for Invasion Biology, Department of Zoology and Entomology, University of Pretoria, Hatfield 0028, South Africa*
[3]*Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, Matieland, 7602, South Africa*
e-mail: katelynfaulkner@gmail.com

Biological invasions often transcend political boundaries, but the capacity of countries to prevent introductions varies. How this variation in biosecurity affects the invasion risks posed to the countries involved is unclear. We aimed to improve the understanding of how the biosecurity of a country influences that of its neighbours. We developed six scenarios that describe biological invasions in regions with contiguous countries. Using data from alien species databases, socioeconomic and biodiversity data, and species distribution models, we determined where 86 of the 100 of the world's worst invasive species are likely to invade and have an impact in the future. The predicted invasions were classified according to the scenarios and information on the capacity of countries to prevent invasions was used to determine whether the invasions are likely to be avoided. Introductions of the 86 species could result in 2523 future invasions, most of which could have impacts and are unlikely to be prevented as the invaded countries have a low capacity to prevent invasions. Of the invasions, 38.6% could spread from the country in which the species first establishes into neighbouring countries. For almost a third of the invasions (31.4%), countries where impacts could occur will rely on a neighbouring country's biosecurity. Most of these invasions are unlikely to be prevented as the country of first establishment has a low capacity to prevent invasions or has little incentive to do so as there will be no impact in that country. Invasions that conform to the latter scenario are particularly concerning, as their management could cause conflicts of interest and as many of these invasions were predicted to occur in developing regions where their impacts are likely to be most severe. Therefore, regional co-operation and communication are required to prevent the vast number of biological invasions that could occur in the future.

European Union policy on invasive alien species: latest developments and next steps

Spyridon Flevaris

European Commission, Directorate-General for Environment, Avenue de Beaulieu 51160, Brussels, Belgium
e-mail: spyridon.flevaris@ec.europa.eu

Within the framework of the EU commitments as a party to the Convention on Biological Diversity and in implementation of the EU Biodiversity Strategy to 2020[1], Regulation 1143/2014 on invasive alien species (IAS)[2] came into force on 1 January 2015. As a result, for the first time concerted action across the EU is undertaken to address IAS. At the core of the Regulation is a list of IAS of Union concern (i.e. the Union list). Three types of interventions are applied across the EU in relation to the species on the Union list: (i) prevention, (ii) early detection and rapid eradication of new invasions, and (iii) management of IAS that are already widely spread. Collaboration between the European Commission services and the competent authorities of the Member States has resulted in the publication of a "baseline distribution"[3] of the species on the Union list. Beyond the listed species, Member States can act on other IAS at national or regional levels. Member States will report on progress made by 1 June 2019. Next steps include the revision of the EU biodiversity policy in the context of the post-2020 global biodiversity framework and review the application of the Regulation in 2021.

[1] http://ec.europa.eu/environment/nature/biodiversity/strategy/index_en.htm
[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1417443504720&uri=CELEX:32014R1143
[3] https://easin.jrc.ec.europa.eu/easin/Documentation/Baseline

How Japanese knotweed stopped me from selling my house: the history of Japanese knotweed in the United Kingdom, 1981 to 2019

Mark Fennell[1], Lois Child[2] and Max Wade[1]

[1]*AECOM, Wellbrook Court, Girton, Cambridge, CB3 0DA, United Kingdom*
[2]*Loughborough University, Loughborough, LE11 3TU, United Kingdom*
e-mail: mark.fennell@aecom.com

In the United Kingdom, *Reynoutria japonica* (Japanese knotweed) is regarded as such a threat to property that there have been a number of cases where vendors are unable to obtain a mortgage to purchase a property on which the plant is growing, properties have experienced diminution in value if they have *R. japonica* growing on them, and land owners have taken legal action against a neighbouring land owner who has *R. japonica* on his/her land. This situation is unique in Europe although there are indications that the Republic of Ireland may follow the same way. The phases in the history of *R. japonica* in the United Kingdom since 1981, which account for the mythology that has grown up around the plant and its apparent impact on built structures, are described. These are the enactment of legislation, the development of an industry around *R. japonica* management, the impact of the press and media, the formation of a trade association to bring order to the management of the plant, landmark legal cases, and recent research into the impact of *R. japonica* on buildings and a Parliamentary inquiry. An analysis is presented of the factors that interacted to allow this state of affairs to happen and the key role of evidence based decision making in invasive species management. A comparison is made with other countries in Europe and the United States of America and consideration is given to whether a similar situation might occur elsewhere for *R. japonica* or other invasive non-native plants.

Different strategies in national and subnational legal frameworks on non-native forest tree species in Europe

Elisabeth Pötzelsberger[1], Katharina Lapin[2] and Giuseppe Brundu[3]

[1]*Department of Forest and Soil Sciences, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria*
[2]*Austrian Research Center for Forests (BFW), Vienna, Austria*
[3]*Department of Agriculture, University of Sassari, Sassari, Italy*
e-mail: elisabeth.poetzelsberger@boku.ac.at

Non-native tree species (NNTs) are of considerable importance in European forestry, but can also pose various ecological risks to ecosystems. National and subnational legislations deal with non-native tree species in many different ways. In this study we (i) identified the most relevant legal instruments dealing with NNTs, and (ii) analysed and mapped the range of national and subnational legal strategies pertaining to the regulation of NNTs in EU and non-EU European countries. We focused on legislation with a high relevance for the management of NNTs in forests and non-forest plantations, including legislation prohibiting the use of NNTs, as well as laws governing introduction and species selection for plantations.

The method for data collection included questionnaires sent to over 60 experts from almost all European countries; in addition, the FAOLEX and ECOLEX databases were searched. We reviewed around 400 legislative acts to identify relevant information on NNTs.

Our study revealed that forest laws and/or nature conservation laws of almost all European countries deal with non-native tree species. We detected a remarkably broad range of regulatory intensity within the European legislative landscape, ranging from not dealing with non-natives at all to total prohibition against the introduction and use of NNTs. Two thirds of the European countries deal with the question of invasiveness and either ban specific tree species or prohibit the use of invasive tree species in general, without listing them. About one third of European countries apply the logic of a legally binding black list, which prohibits the use of listed NNTs in forestry. Not allowing for the unauthorized import of new NNTs into the country and introduction into nature is another general approach that a third of European countries follow, mainly Eastern European countries. Authorization, in these cases, often involves a risk assessment. In addition, most countries define special sites or conditions where NNTs are not allowed to be used. Some countries may include a recommendation in their legislation to preferably plant native forest tree species. This circumstance becomes more relevant in those countries where forest management plans authorized or developed by an authority are mandatory. Besides legislative acts and degrees (orders), certifications or guidelines have a significant influence on the management of NNT in European forests. The concern about potential harm from non-native organisms is thus clearly discernible in European national and subnational legislations.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) thematic assessment of invasive alien species and their control

Aníbal Pauchard[1,2], Helen Roy[3] and Peter Stoett[4]

[1]*Laboratorio de Invasiones Biológicas (LIB), Facultad de Ciencias Forestales, Universidad de Concepción, Chile*
[2]*Instituto de Ecología y Biodiversidad (IEB), Chile*
[3]*Biological Records Centre, NERC Centre for Ecology and Hydrology – Wallingford, Crowmarsh Gifford, Oxfordshire OX10 8BB, United Kingdom*
[4]*Faculty of Social Science and Humanities, University of Ontario, Oshawa, ON, Canada*

Invasive alien species were highlighted as one of five main direct drivers of global diversity declines within the recently published Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Global Assessment report on biodiversity and ecosystem services. Recently IPBES announced the scope for a thematic assessment of invasive alien species and their control; this will be the first comprehensive assessment. The assessment will comprise six chapters: 1. Introduction; 2. Analysis and synthesis of past and future trends in the spread, pathways, evolutionary change and distribution of invasive alien species and gaps in existing knowledge; 3. Analysis and synthesis of direct and indirect drivers responsible for the introduction, spread, abundance and dynamics of invasive alien species; 4. Global and overall analysis and synthesis of the environmental, economic and social impact of invasive alien species; 5. Effectiveness of past and current programmes and tools for the global, national and local prevention and management of invasive alien species and their impacts; 6. Future options for the prevention and management of invasive alien species and analysis of possible support tools for decision makers. A number of overarching themes are being developed to guide the assessment including interactions of invasive alien species climate change.

The IPBES assessment of invasive alien species and their control will bring together more than 70 experts spanning diverse disciplines. The completed assessment will be presented to the tenth session of the IPBES Plenary composed of representatives from over 130 member States.

***Poster presentations*[1]**

Invasive alien trees species as phorophytes affecting the composition of lichens. *Acer negundo* on Vistula River Valley case (N Poland)

Edyta Adamska and Dariusz Kamiński

Faculty of Biology and Environmental Protection, Chair of Geobotany and Landscape Planning, Nicolaus Copernicus University, Lwowska 1, PL-87-100 Torun, Poland
e-mail: adamska@umk.pl

Invasive alien species affect the ecosystem at various levels of its organization. The effect of the invasion can be, among others, change in the species composition of different groups of organisms caused by the transformation of biotic and abiotic properties of the habitat. Bark of trees is a substrate for lichens and there is a strong correlation between epiphytic lichens and phorophytes, which result from the physico-chemical properties of the bark. Trees in natural riparian forests are phorophytes for the group of stenotopic lichens defined as indicators of naturalness of forests and common eurytopic. A good example of negative impacts may be the invasion of *Acer negundo* in Poland, which is particularly well spread in river valleys in riparian forest habitats. It occurs as an admixture in natural willow and poplar forests, it can also form almost single-species communities. In this study, we explored the relationship between kind of native and invasive phorophytes and biota of epiphytic lichens. Our research on the lichens species composition were conducted in the Vistula River Valley in the city of Toruń and in its vicinity in riparian forests with the participation of *Acer negundo*. On the bark of *Salix* spp. and *Populus* spp., we found a total of 50 stenotopic lichen species (e.g. *Bacidia incompta, Chaenotheca brachypoda*, *Ch. trichialis*, and *Ch. chrysocephala*). On the *Acer negundo* bark, 13 species of lichens occurred, mainly toxitolerant – nitrophilous, photophilous and coniophilous (e.g. *Phaeophyscia orbicularis*, *Physcia tenella*, *Ph. adscendens*, *Physconia grisea*; and *Xanthoria parietina*). On the bark of *A. negundo*, the lichens were abundant, while on native phorophytes they covered a small percentage of the bark's surface. The *Acer negundo* invasion causes qualitative and quantitative changes in the lichen species list. The availability of substrates for stenotopic species is reduced while the abundance of toxitolerant species is increasing. It can be assumed that replacing natural forests by xenospontaneous *A. negundo* communities will result in the disappearance of stenotopic lichen species.

[1] For abstracts of posters accompanying flash talks see Oral presentations

Current status of alien ornamental flora in Turkey

Necmi Aksoy[1], Zübeyde Filiz Arslan[2], Ayşe Yazlik[2], İlhan Üremiş[3] and Ahmet Uludağ[4]

[1]*Düzce University, Faculty of Forestry, Department of Forest Engineering, Düzce, Turkey*
[2]*Düzce University, Faculty of Agriculture and Nature Science, Department of Plant Protection, Düzce, Turkey*
[3]*Mustafa Kemal University, Faculty of Agriculture, Department of Plant Protection, Hatay, Turkey*
[4]*Onsekiz Mart University, Faculty of Agriculture, Department of Plant Protection Çanakale, Turkey*
e-mail: ahuludag@yahoo.com

Importing ornamental plants is the most common pathway of invasive alien plant introductions. Alien ornamental plants has been studied for several countries and regions including Europe. However, it has not been researched enough in Turkey. The recent alien flora of Turkey, which was published in 2017, reported that among a total of 340 taxa, 55.2% of the intentionally introduced taxa are ornamental plants. The inventory did not account for the planted species that are not recorded in nature although they were listed. The alien (exotic) plant imports have increased in Turkey due to changing lifestyles as a result of fast urbanization. It is expected that more ornamental species might escape into the wild. The aim of this study is to list ornamental alien plants which have been imported recently and discuss the threats that can be born, as well as prepare basic data to be used for risk analysis. We found 190 ornamental alien taxa that have been recently introduced, some of which have already been recorded in the wild after the first inventory which includes 256 ornamental alien taxa. The most common families of alien species in Turkey include Asteraceae (30 taxa), Fabaceae (27 taxa), Cupressaceae (23 taxa), and Pinaceae (20 taxa).

A new suggested model of a semi-regional plant protection organization for the Gulf Cooperation Council (GCC countries) in order to enhance The Pest monitoring and Control Strategy including transboundary pests

Saad Alotaibi

Biotechnology Department, Faculty of Science, Taif University, Taif 888, Saudi Arabia
e-mail: dralotaibisaad@gmail.com

The Transboundary Pest monitoring and Control Strategy is a tool that requires regional and international cooperations to reduce the spread of pests and pathogens. The GCC (Gulf Cooperation Council) countries are transforming from cooperation to Union, therefore there was a need for semi-Regional Plant Protection Organization for GCC, in which the objectives of the International Plant Protection Convention (IPPC) will be realized and act within GCC in order to improve the exchange of information and the harmonization of Phytosanitary measures, and to apply IPPC Standards.The rapidly expanding globalization of trade and tourism is an increasing challenge for plant health systems worldwide in protecting plant resources from alien plant pests. The spread of the red palm weevil *Rhynchophor ferruginous*, which has spread to the GCC countries through the import of large quantities of coconut plant as ornamental plants, is an example of an invasive pest. The results from this study recommends to work towards the establishment of a semi-regional organization that includes the GCC countries similar to the South American Southern Phytosanitary Organization (COSAVE) as one of the internationally successful models. This is supported by similarities in the number of member countries and the volume of trade exchange in the field of agricultural products and according to cost benefit analysis.

Modelling potential dispersal of *Prosopis juliflora* in East Africa: scaling and assembling correlations

Miguel Alvarez[1], Samuel Kiboi[2], Mathias Becker[1] and Itambo Malombe[3]

[1]*INRES-Plant Nutrition, University of Bonn, Germany*
[2]*School of Biological Sciences, University of Nairobi, Kenya*
[3]*East African Herbarium, National Museums of Kenya*
e-mail: malvarez@uni-bonn.de

The spread of *Prosopis juliflora* in the Marigat Plains at the Kenyan Rift Valley has led to severe environmental changes with negative socioeconomic impacts. While many publications have dealt with *Prosopis* invasion, none of them have proposed an objective way for the quantification of invasion degrees, which is essential for assessment and modelling purposes.

We developed a methodology for characterizing and classifying degrees of *Prosopis* infestation on the basis of relative vegetation cover. This methodology is correlated with a classification of stands on the basis of different metrics, such as height, density and absolute cover. For the estimation of potential invasion by *Prosopis* in the Marigat Plains, we calculated univariate correlation models using either a logistic function for monotonic responses or a Gaussian function for unimodal responses. In all those cases, we applied a quantile regression for a better description of the potential response. The outcomes of the models were than reclassified according to the proposed invasion scale.

The described procedure was suitable for the estimation of potential invasivity of *Prosopis* in univariate ecological dimensions. From the assessed factors, the distance of invaded stands from original plantations and environmental attributes related to water availability (i.e. ground water table, rainfall and soil water-holding capacity) are the most suitable for the prediction of potential and future invasion risks. In this contribution, we will also discuss upscaling models and using assembly procedures for considering multiple factors.

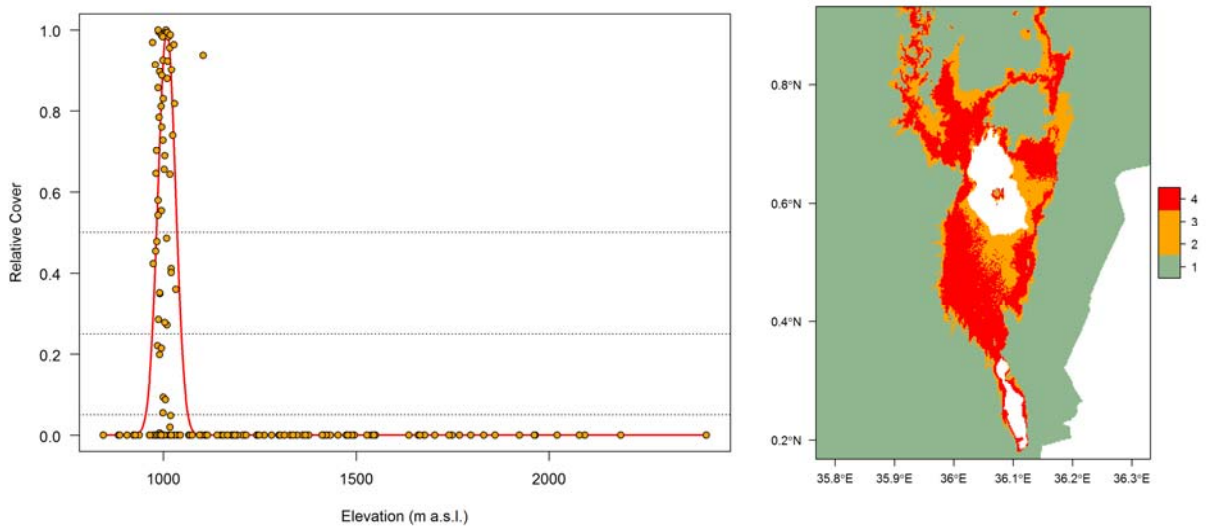


Fig. 1. Model estimating the potential invasion by elevation. Left: regression curve and observed abundance of *Prosopis*. Right: Spatial distribution of potential invasion classes.

The influence of hydromorphological characteristics of riparian areas on the presence of invasive alien plants

Ana Anđelković[1], Milica Živković[2], Dušanka Cvijanović[2], Maja Novković[2], Slađana Popović[3], Dragana Marisavljević[1], Danijela Pavlović[1] and Snežana Radulović[2]

[1]*Institute for Plant Protection and Environment, Teodora Drajzera 9, 11040 Belgrade, Serbia*
[2]*University of Novi Sad, Faculty of Sciences, Department of Biology and Ecology, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia*
[3]*University of Belgrade, Scientific Institution, Institute of Chemistry, Technology and Metallurgy, National Institute, Center for Ecology and Technoeconomics, Njegoševa 12, 11000 Belgrade, Serbia*
e-mail: ana.andjelkovic21@gmail.com

River hydromorphology and the dynamics of anthropogenic activities are two crucial factors affecting the vegetation of riparian zones and increasing the potential for alien plant invasions. Given the vulnerability of riparian areas to the colonization of invasive alien species (IAS), our aim was to determine which parameters of hydromorphology are linked with the presence and abundance of IAS in river and canal riparian areas of Serbia. Field research was conducted over four years at 250 riparian field sites, along the course of 39 rivers and six canals in Serbia. The location of the field sites and relevant hydromorphological parameters were determined and scored following the standard River Habitat Survey methodology and field protocol, while the cover and abundance of the vegetation was scored on site, in accordance with the *van der Maarel* scale. The influence of these hydromorphological parameters on the analysed subset of IAS, grouped by their life form and status of invasiveness, was illustrated using principal component analysis (PCA) in Canoco 5.0. Of the analysed hydromorphological parameters, the presence of a natural berm in the field site and over-deepening of the river channel were shown to be positively correlated with the cover and abundance of potentially invasive species, while the group of highly invasive species was positively correlated with the presence of dams. The PCA analysis of the cover/abundance of IAS grouped by their life form and selected hydromorphological parameters revealed a positive correlation between weirs and the cover/abundance of phanerophytes. Similarly, the cover and abundance of phanerophyte, chemicryptophyte and geophyte IAS were positively correlated with the presence of bridges in the vicinity of the field site and the natural profile of the riverbank. Furthermore, bank profile modifications were shown to be negatively correlated with all the recorded IAS groups, except for nanophanerophytes and lianas.

Long term impacts of *Lantana camara* invasion in a heterogeneous landscape of a biodiversity hotspot

P. S. Aravind[1,2], Subhrajit Goswami[1,3], Ankila J. Hiremath[1] and Bharath Sundaram[1]

[1]*Ashoka Trust for Research in Ecology and the Environment (ATREE), Bengaluru, India*
[2]*Pondicherry University, India*
[3]*Doon University, Dehradun, India*
e-mail: palasseryaravind@gmail.com

The invasion of *Lantana camara* L. (hereafter, lantana) is considered as one of the primary threats to plant communities in the Western Ghats biodiversity hotspot in India. The bulk of the research on the impacts of invasive plants lacks a temporal context, with more than half of all studies lasting less than 1 year and less than 8% of studies extending over 4 years or more (Stricker et al. 2015). We examined the pattern of spread and impacts of lantana invasion on native vegetation across different forest types in a heterogeneous landscape from 1997 to 2018. This is probably the only long term study tracking invasive species and its impacts in India. We extend the study on lantana inventory done by Murali & Shetty (2001) in 1997 across a study area of 540 km^2, which was re-censused by Sundaram & Hiremath (2012) in 2008. In 2018, we revisited the plots and evaluated the impact caused by lantana at the landscape level and at the level of individual forest types. Over two decades, there was a tremendous increase in the presence and abundance of lantana, accompanied by a decline of native species. The mean density of lantana increased tenfold over two decades, while native species density declined by nearly half. Lantana invasions were accompanied by reductions in species richness and diversity, and an increase in evenness both at the landscape level and at the level of forest types. The highly heterogeneous landscape has become more homogeneous over the 20 year period. Lantana became the dominant species by 2008 (Sundaram & Hiremath 2012), and seems to have accelerated its dominance by 2018. Species composition and demographic structure in different forest types also showed a significant shift. Overall, our long-term monitoring of lantana invasion enables prediction of possible future trajectories of invasives and impacts on native species, and therefore can aid in remedial management.

Murali K. S. & Setty R. S. (2001) Effect of weeds *Lantana camara* and *Chromelina odorata* growth on the species diversity, regeneration and stem density of tree and shrub layer in BRT sanctuary. Curr. Sci. 80: 675–678.

Stricker K. B., Hagan D. & Flory S. L. (2015) Improving methods to evaluate the impacts of plant invasions: lessons from 40 years of research. AoB Plants 7: plv028

Sundaram B. & Hiremath A. J. (2012) *Lantana camara* invasion in a heterogeneous landscape: patterns of spread and correlation with changes in native vegetation. Biol. Invas. 14: 1127–1141.

Levels of alien plant invasions in European grasslands

I. Axmanová[1], V. Kalusová[1]., M. Chytrý[1], J. Danihelka[1], J. Dengler[2], J. Pergl[3], P. Pyšek[3,4], F. Attorre[5], I. Biurrun[6], S. Boch[7], T. Conradi[8], R. Gavilán García[9], S. M. Hennekens[10], B. Jiménez-Alfaro[11], I. Knollová[1], A. Kuzemko[1,12], J. Lenoir[13], J. Medvecká[14], J. E. Moeslund[15], J.-C. Svenning[15], I. Tsiripidis[16] and K. Vassilev[17]

[1]*Department of Botany and Zoology, Masaryk University, Brno, Czech Republic*, [2]*Institute of Natural Resource Management (IUNR), Zurich University of Applied Sciences (ZHAW), Wädenswil, Switzerland*, [3]*Department of Invasion Ecology, Institute of Botany, Czech Academy of Sciences, Průhonice, Czech Republic*, [4]*Department of Ecology, Faculty of Science, Charles University, Prague, Czech Republic,* [5]*Department of Environmental Biology, Sapienza University of Rome, Rome, Italy*, [6]*Department of Plant Biology and Ecology, University of the Basque Country, Bilbao, Spain*, [7] *WSL Swiss Federal Research Institute, Birmensdorf, Switzerland*, [8]*Plant Ecology, Bayreuth Center for Ecology and Environmental Research (BayCEER), University of Bayreuth, Bayreuth, Germany*, [9]*Unit of Botany, Faculty of Pharmacy, Complutense University, Madrid, Spain*, [10]*Wagenigen Environmental Research (Alterra), Wagenigen University and Research, Wagenigen, The Netherlands*, [11]*Research Unit of Biodiversity (CSIC/UO/PA), Mieres, Spain*, [12]*M.G. Kholodny Institute of Botany of the National Academy of Sciences of Ukraine, Ukraine*, [13]*Ecologie et Dynamiques des Systèmes Anthropisés, Université de Picardie Jules Verne, Amiens, France*, [14]*Institute of Botany, Plant Science and Biodiversity Centre, Slovak Academy of Sciences, Bratislava, Slovakia*, [15]*Department of Bioscience, Aarhus University, Aarhus, Denmark*, [16]*Department of Botany, School of Biology, Aristotle University of Thessaloniki, Greece*, [17]*Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, Sofia, Bulgaria*
e-mail: kalveron@tiscali.cz (V. Kalusová)

The human-related spread of alien plants has serious environmental and socioeconomic impacts. One of the most important goals of invasion biology is to identify habitats that are most threatened by invasive plants and mechanisms responsible for their high vulnerability. We studied a wide range of European grasslands as recipients of alien plant species to describe general patterns of invasion at the continental scale. We used comprehensive vegetation data available in the European Vegetation Archive to assess (i) which grassland types in Europe have high levels of invasions, (ii) which alien species are the most successful invaders in these habitats, and (iii) how habitat levels of invasion and invaders change across different European countries and along major environmental gradients.

Our initial dataset contained more than 300,000 vegetation plots assigned to EUNIS grassland habitats sampled in geographically delimited European regions (excl. Macaronesia, Anatolia and Cyprus). For the final dataset (consisting of 91,293 plots), we only selected plots that were sampled from 1970 onwards, 1–100 m^2 in size, and subject to geographically stratified random resampling based on countries' sizes to avoid oversampling of particular regions and enable comparisons among them. We updated the DAISIE database of alien taxa in Europe using available national and regional alien species checklists, local expert assignments and the Euro+Med database to assign alien or native status to plant taxa in vegetation plots in different countries. We only considered neophytes (i.e. alien species introduced to a country after 1500 AD) and divided them, based on their native range, in those that originated outside versus within Europe.

We present an overview of EUNIS grassland habitats with their levels of invasion (i.e. the mean proportion of neophytes in all plots assigned to a habitat) and a list of successful invaders at the European scale. We also compare the levels of invasion in particular European countries along the major geographical and environmental gradients across the continent.

Mechanisms of adaptation of photosynthetic apparatus in invasive plant *Euthamia graminifolia* to drought stresses

Wojciech Bąba[1], Agnieszka Kompała-Bąba[2], Jolanta Luźniak[1] and Robert Hanczaruk[2]

[1]*Department of Plant Ecology, Institute of Botany, Jagiellonian University, Gronostajowa 3, 30-387 Kraków, Poland*
[2]*Department of Botany and Nature Protection, University of Silesia in Katowice, Jagiellońska 28, 40–032, Katowice, Poland*
e-mail: wojciech.baba12@gmail.com

Grass-leaved goldenrod, *Euthamia graminifolia* (L.) Nutt., is an invasive neophyte in Poland which mainly colonizes seminatural wet habitats (e.g. moist meadows of the order *Molinetalia*, marshes of the *Caricion davallianae* allianceand banks of watercourses). Moreover, it expands to more dry habitats such as segetal and ruderal habitats (e.g. sand-pits, quarries, railway embankments, abandoned lands and pine plantations).

After the colonization of novel habitats, photosynthesis is a process central to the plants resistance to different stresses, ability of spreading and competition. As such, studies on acclimatization of photosynthetic machinery are of prime importance. In this work, we study the acclimatization potential of photosynthetic apparatus to drought conditions with use of chlorophyll fluorescence, emitted by a chlorophyll *a* molecule. Using pot experiments, we grew 400 *Euthamia* specimens in mixture potting compost and sand under a light intensity of ca. 450-500 PAR photons $m^{-2}\,s^{-1}$, day/night period 12/12 hours. Half of the individulals were fully watered (FW) to 80-90 RWC (%), while the rest underwent simulated drought stress (DRY, 30-40 RWC).

Changes occurring in the photosynthetic apparatus related to drought stress are realized, among others, as a significant decrease of maximum quantum yield of PSII photochemistry (F_v/F_M) and in the performance potential for conserving the energy absorbed by PSII photons until the reduction of PSI end acceptors (PI_{TOT}). Moreover, we found the changes in antenna organization in DRY plant: an ungrouping of the PS2 antenna complexes and a suppression of the Oxygen Evolving System while in the FW the effects are opposite. We can speculate, that the *Euthamia* photosynthetic apparatus strongly (and negatively) responds to high intensity drought stress. Our results are also confirmed by a decrease in leaf dry mass by a factor 0.5.

Long-term impacts of two herbaceous invasive species on the standing and below-ground vegetation

Vasiliki Balogianni[1,2], Margherita Gioria[1,2,3], Amanuel Gebremichael[1,2,4], Mauricio Mantoani[1,2] and Bruce Osborne[1,2]

[1]*UCD School of Biology and Environmental Science, University College Dublin, Belfield, Dublin, Ireland*
[2]*UCD Earth Institute, University College Dublin, Belfield, Dublin 4, Ireland*
[3]*Institute of Botany, Czech Academy of Sciences, CZ-252 43 Průhonice, Czech Republic*
[4]*Teagasc, Environmental Research Centre, Johnstown Castle, Wexford, Ireland*
e-mail: vasiliki.balogianni@ucd.ie

Invasive alien plants can promote long-term changes in invaded plant communities, as well as, their revegetation potential by altering not only the diversity and composition of the standing vegetation but also the soil seed bank. Here, we assessed changes in the vegetation (above- and below-ground) associated with two major invasive herbaceous species in Ireland, *Gunnera tinctoria* and *Impatiens glandulifera*. Changes in the vegetation were monitored throughout the growing season at three coastal grassland communities for *G. tinctoria* and three riparian communities for *I. glandulifera*, as these represent the typical habitats invaded by these species in Ireland and where both species are dominant in the standing vegetation. Soil seed banks were collected in March 2018 and November 2018, to capture both the more persistent and transient components of the seed bank, respectively.

Preliminary analyses indicate that *G. tinctoria* dominated the more persistent component of the soil seed bank and caused the displacement of several native species from species-rich coastal grassland communities. *Impatiens glandulifera* had instead become invasive in already species-poor and degraded communities, where giant hogweed (*Heracleum mantegazzianum*) was also present. Both invaders promoted the homogenization of the seed flora towards an over-representation of seeds of native problematic species and/or those of other alien species. However, seed banks invaded by *G. tinctoria* were highly distinct from uninvaded seed banks, while those invaded by *I. glandulifera* were often similar to uninvaded ones. This indicates differences in the reversibility of the impacts of these invaders on the above- and below-ground flora and in the efforts required to restore pre-invasion conditions. Moreover, *I. glandulifera* suppressed the growth of giant hogweed, which can be regarded as a positive effect. The large, persistent seed bank formed by *G. tinctoria* in the invaded communities confirmed the need to develop control measures targeting the seed bank and not only the standing vegetation for the long-term management of this species.

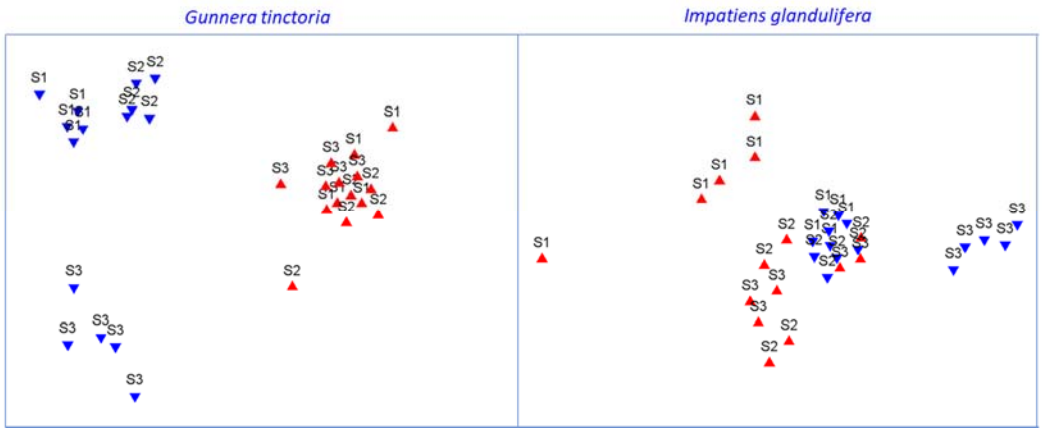


Fig. 1. Non MDS plots of the invaded (red triangles) and univaded (blue inverted triangles) of the seed banks of *Gunnera tinctoria* and *Impatiens parviflora*. S1-S3 refers to different sites.

GEO-BI – new GEOportal for Biological Invasions

Kateřina Berchová-Bímová[1], Martina Kadlecová[1], Miroslav Kopecký[2], Jiří Patoka[3], David Petrus[1], Ondřej Simon[1], Johana Vardarman[1] and Martin Vojík[1,4]

[1]*Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Kamýcká 129, Praha 6 Suchdol, 165 00, Czech Republic*
[2]*GISAT s.r.o., Milady Horákové 57, Praha 7, 170 00, Czech Republic*
[3]*Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Kamýcká 129, Praha 6 Suchdol, 165 00, Czech Republic*
[4]*Institute of Botany, Department of Invasion Ecology, The Czech Academy of Sciences, Průhonice, 252 43, Czech Republic*
e-mail: berchova@fzp.czu.cz

Invasive alien species (IAS) monitoring and their appropriate management planning are key problems for nature conservation. Once non-native species exist in an area, predictions of future spread are important for management approach selection and evaluation of the practical feasibility of possible further actions. GEO-BI provides a science-based tool to illustrate IAS spatial distribution in the Czech Republic, presenting results of two types of projected future spread. The main purpose of the geoportal is to help land managers stop or reduce the spread of IAS across the country, to create a useful tool for planning regional IAS management strategies and thus protect the environment and economy from IAS impacts.

GEO-BI includes (i) Maps of species' current distribution – using both published and unpublished data to illustrate the selected IAS current distribution based on net-mapping. (ii) Prediction models of maximal potential distribution – using species distribution modelling tools built on presence or presence/absence data which shows the particular species area of suitability and environmental limits of further spread under contemporary conditions. (iii) Mechanistic models of local spreading – using a combination of spread probability based on spreading vectors, species ecology and habitat characteristics, and species distribution shows the possible local species spread modelled in a GIS environment. The input data for all three above-mentioned sections of the geoportal are gained from the Digital Register of the Nature Conservation Agency of the Czech Republic, which is regularly updated.

What are the GEO-BI goals? IAS distribution and predictive maps show where species are currently present and where they are most likely to spread. For particular species and regions, GEO-BI suggests management possibilities and sets the spatial priorities of IAS management. It is possible to choose a strategy in terms of three categories as determined by the species' spatial distribution: surveillance, eradication, or containment. These informed decisions can provide a starting point for establishing priorities and goals at the regional level of IAS management. The predictive GEO-BI maps may affect decision-making of management at a landscape level and coordinate regional strategic mapping, planning, and implementation of IAS control projects. The GEO-BI maps can also serve as support to secure funding for strategic IAS control projects and policies.

Polyphenolic profiles of invasive *Sorghum halepense* within the Belgrade urban and suburban area

Ivana Bjedov[1], Dragica Obratov-Petković[1], Marija Nešić[1], Dragana Skočajić[1], Uroš Gašić[2] and Danijela Mišić[3]

[1]*University of Belgrade, Faculty of Forestry, Kneza Višeslava 1, 10030 Belgrade, Serbia*
[2]*University of Belgrade, Faculty of Chemistry, P.O. Box 51, 11158 Belgrade, Serbia*
[3]*University of Belgrade, Institute for Biological Research "Siniša Stanković", Bulevar despota Stefana 142, 11060 Belgrade, Serbia*
e-mail: ivana.bjedov@sfb.bg.ac.rs

Johnson grass, *Sorghum halepense* (L.) Pers., is recognized as a globally successful invader and one of the most aggressive weeds in Europe. According to data from 2012 this species had the status of a sporadically invasive species in Serbia. Since then, *S. halepense* has been increasing in frequency and range. Its populations are widespread and numerous, which represents a strong pressure on autochthonous flora and vegetation. Considering all the aforementioned, the revision of *S. halepense* status of invasiveness for Serbia is necessary, in order to improve management strategies for this invasive species.

It is known that the allelopathic effects of plant secondary metabolites present a potential mechanism of invasive plant success. High concentrations of phenolic compounds, with their diverse functionality, may confer an advantage to plants in response to environmental conditions.

With the aim to examine the chemodiversity of *S. halepense* in Belgrade (Serbia) urban areas, we performed UHPLC/DAD/MS^2 targeted metabolomic analysis of leaves, rhizomes and inflorescences of plants originating from 5 localities. These populations are located in the wider area of Belgrade, from urban and suburban zones. One population from Montenegro was used as outgroup. The analysis was targeted towards 19 polyphenolic compounds: 9 phenolic acids, 6 flavonoid aglycones and 4 flavonoid glucosides. Phenolic acids were recognized as the dominant group of polyphenolics in samples, with chlorogenic acid being the major compound in inflorescences and leaves, while in rhizomes *p*-hydroxybenzoic acid predominated. The third and fourth most abundant compounds in samples were *p*-coumaric acid and protocatechuic acid, respectively. Flavonoids were less abundant in the analysed *S. halepense* samples. Interestingly, the amount of flavonoid aglycones (quercetin and luteolin) and flavonoid glycosides (quercetin 3-*O*-rutinoside, quercetin 3-*O*-glucoside, isorhamnetin 3-*O*-rutinoside, and isorhamnetin 3-*O*-rutinoside) were the highest in inflorescences. The results pointed to the considerable differences in polyphenolics composition among plant organs. In addition, inter-population variability was also recognized. As revealed by the PCA, the population originating from Montenegro was well distinguished from the Belgrade populations based on the metabolite profiles. In addition, population 1 (i.e. population from Jakovo) was distinguished from the rest of Belgrade populations.

Considering the high diversity and amount of polyphenolic compounds identified in *S. halepense*, and their known phytotoxic and allelopathic effects, it might be presumed that these compounds, at least partially contribute to fast-spreading of Johnson grass in the urban and suburban areas of Belgrade. To take advantage of this species invasiveness, we propose the usage of *S. halepense* methanol extracts as bioherbicides for the effective and environmentally sustainable weed control. Further studies should be conducted in order to test these possibilities.

Ecology and management of alien annual grasses in the deserts of southwest North America

John H. Brock

College of Integrative Sciences and Arts, Arizona State University Polytechnic, Mesa, Arizona, USA
e-mail: john.brock@asu.edu

Seven alien invasive annual grasses are found in the southwest region of the United States and northern Mexico. All of these annual grasses germinate with autumn and winter rainfall. They begin rapid growth as temperatures increase in February and March and reach peak standing crop late in the spring, either May or June depending on their distribution by elevation. When in the vegetative mode, they are consumed by grazing animals, but when they produce seed heads, grazing essentially ceases. Their seeds are easily dispersed and in general have about a three-year life in the seed bank. All of these species were introduced from Europe/Asia. The dominant genus is *Bromus* and includes: *Bromus rubens* syn. *B. madritensis* (red bromegrass), *B. tectorum* (downy bromegrass), *B. carthicus* (rescue grass), *B. japonicus* (Japanese bromegrass), and *B. diandrus* (ripgut brome). *Schimus barbatus* (Mediterranean grass) a short lived small grass is found primarily in the warm deserts. *Avena fatua* (wild oats) provides good forage in the spring and is currently found at elevations of less than 1,500 m. All of these grasses compete with native vegetation and can promote wild fires. Management of these species includes targeted grazing by domestic livestock, prescribed burning, mowing and the use of both pre and post emergence herbicides.

The application of the spatio-temporal geostatistical modelling in predicting distribution of invasive plant species

Katarzyna Bzdęga[1], Adrian Zarychta[1], Barbara Fojcik[1], Roksana Zarychta[2], Alina Urbisz[1], Sylwia Szporak-Wasilewska[3] and Barbara Tokarska-Guzik[1]

[1]*University of Silesia, Faculty of Biology and Environmental Protection, Department of Botany and Nature Protection, Jagiellonska 28, 40-032 Katowice, Poland*
[2]*Pedagogical University of Cracow, Institute of Geography, Department of Geoinformation and Environmental Research, Podhorążych 2, 30-084 Cracow, Poland*
[3]*Warsaw University of Life Sciences, Faculty of Civil and Environmental Engineering, Water Centre Laboratory, Nowoursynowska 166, 02-787 Warsaw, Poland*
e-mail: katarzyna.bzdega@us.edu.pl

Distribution modelling focused on forecasting the spread of plant species is an important and desired method that supports resource management, conservation decision making, as well as monitoring and control of invasive species. The goal of this study was to model the current spatial distribution of invasive plant species and to predict their coverage using geostatistical tools. The main species of interests were: *Heracleum sosnowskyi* and *Fallopia* spp. (*Fallopia japonica* and *F.* × *bohemica*). The field data were acquired during days of species optimum development in selected areas during 2017 and 2018 to generate spatio-temporal cover patterns of the invasive plant species. We then predicted their spatial distribution in 2019 with the use of Sequential Gaussian Simulation (SGS). To visualise the spatial variability of the analysed species, spherical variograms in both areas and years were created. In order to verify the correctness of the conducted modelling, the cross-validation was tested. The values of each calculated error (e.g. mean error, root mean square, average standard error, mean square error) oscillated from -0.007 to 0.883, whereas root mean square standardized error took values more than one (i.e. between 1.067 and 1.454). These error values indicate correctness of SGS. For the purpose of this study, the collected field data were tested for the presence of spatial autocorrelation by computation of the Moran's I and z-score for the analysed species on these areas in both years. The results showed that the Moran's I Index values (i.e. 0.521–1.076) and z-score (i.e. 7.683–13.412) indicate significant clustering of spatial phenomena, which confirmed the existence of spatio-temporal patterns (Fig.1). Although further research is needed using other species, the study results indicate that these determined spatio-temporal patterns with calculated autocorrelation may be used to better predict the spread of invasive species in subsequent yearsand will therefore enhance the effectiveness of management strategies.

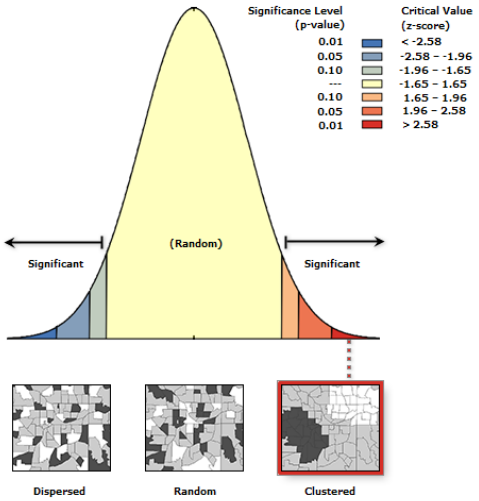


Fig.1. Spatial autocorrelation (Moran's I). The z-score from 7.683 to 13.412 shows a less than 1% likelihood that this clustered pattern could be the result of random chance.

Assessing the invasion risk of industrial hemp

Susan Canavan, Deah Lieurance and S. Luke Flory

Agronomy Department, University of Florida, Gainesville, Florida, USA
e-mail: scanavan@ufl.edu

The cultivation of industrial hemp, *Cannabis sativa* L., has received increasing attention in the United States, and interest is expected to rise following the 2018 Farm Bill legalizing cultivation. Since the early 21st century, hemp production has been controlled under drug enforcement laws because other varieties of *C. sativa* (i.e. "marijuana") have high levels of Δ9-tetrahydrocannabinol (THC), which causes inebriation. By definition, "hemp" has THC levels of < 0.3%, while marijuana has THC levels of > 0.3%. Hemp has been cultivated for fibre, grain, and pharmaceuticals, such as cannabidiol (CBD). Some states already have licenced programs for hemp cultivation, and it's anticipated that the change in federal status will result in widespread plantings. Although hemp has highly anticipated value as an agricultural commodity, it is known to escape cultivation and may present an invasion risk. In 2018, the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) initiated a pilot project to evaluate hemp cropping systems and to assess invasion risk. Using the Predictive Tool (PT) from the UF/IFAS Assessment of Non-native Plants in Florida's Natural Areas, we conducted a risk assessment to evaluate the invasion risk of hemp in the U.S and to identify traits requiring further evaluation.

Our results from the risk assessment indicate that *C. sativa* as a parent species (i.e. generally across hemp and marijuana varieties) scored "high risk" for invasion. In total, the species received 19 points for the 49-question assessment (score of ≥7 is high risk). The questions related to the history of invasiveness elsewhere contributed most to the high invasion risk conclusion. Sufficient evidence supported positive responses to questions 3.01 "Naturalized beyond native range" (+1 point), 3.02 "Garden, amenity, disturbance weed" (+2), and 3.04 "Environmental weed" (+4). Additionally, questions that assess life history traits identified reproductive attributes such as the ability to produce viable seed, hybridize naturally, and self-pollinate as other factors contributing to the high risk conclusion. Finally, the risk assessment identified gaps in knowledge where additional information or data is needed, such as seed dispersal methods (e.g. animal, accidental and produce contaminant) and whether hemp can be easily managed with herbicides. Additional research is needed to determine if invasion risk varies among hemp cultivars that will be grown for different purposes (e.g. fiber, grain, CBD) and to develop best management practices for commercial cultivation.

An updated status of introduced and invasive plants in Canada

Karen Castro[1], Alec McClay[2], Claire Wilson[1] and Andrea Sissons[1]

[1]*Plant Health Risk Assessment Unit, Canadian Food Inspection Agency, Ottawa, Ontario, Canada*
[2]*McClay Ecoscience, Ottawa, Ontario, Canada*
e-mail: karen.castro@canada.ca

The numbers of introduced and invasive plant species reported in Canada have both increased by approximately 15% over the past decade. This is one of several key findings in a recent update to a baseline "Invasive Alien Plants in Canada" report produced by the Canadian Food Inspection Agency (CFIA) in 2008. Since then, Canada's known vascular plant flora increased from 5052 to 5161 species; the number of introduced species increased from 1229 to 1406 species; and the number of invasive species within the pool of introduced species increased from 486 to 555 species. These increases represent current rates of accumulation of introduced and invasive plant species well above the long-term historical averages. While the overall trend is clear, it should be noted that some of the additions or removals of species resulted from changes in taxonomic status or botanical knowledge. The largest numbers of introduced and invasive species are still found in the provinces of Ontario and British Columbia, which also import the largest proportions of products potentially associated with invasive plant introductions. However, the largest percentage increases in introduced and invasive species were recorded in Nunavut and Newfoundland and Labrador. The majority of new introductions into Canada still come from the West Palaearctic region (Europe, North Africa and the Middle East), though the percentage of introductions from that region dropped from 77% to 53%, possibly reflecting some exhaustion of the pool of species not already introduced. Introductions from the East Palaearctic (primarily China and Japan) and Oriental (primarily India and southeast Asia) regions combined, increased from just over 15% to 33%, possibly reflecting increased trade with those regions and some overlap in climate suitability. As Canada's national plant protection organization, the CFIA is responding to the ever-increasing threat of invasive plants through its invasive plant program, which has undergone significant developments over the past decade. Examples include the creation of an *Invasive Plants Policy* (2012), an update of Canada's noxious weed list in the *Weed Seeds Order* of the *Seeds Act* (2016), and the addition of 21 regulated pest plants under the *Plant Protection Act* (2009–2018).

Invasion of freshwater ecosystems is promoted by network connectivity to hotspots of human activity

Daniel S. Chapman[1], Iain D. M. Gunn[2], Henrietta E. K. Pringle[3], Gavin M. Siriwardena[3], Philip Taylor[2], Stephen J. Thackeray[4], Nigel J. Willby[1] and Laurence Carvalho[2]

[1]*Biological and Environmental Sciences, University of Stirling, Stirling, FK9 4LA, UK*
[2]*Centre for Ecology & Hydrology, Penicuik, EH26 0QB, UK*
[3]*British Trust for Ornithology, The Nunnery, Thetford, IP24 2PU, UK*
[4]*Centre for Ecology & Hydrology, Lancaster Environment Centre, Library Avenue, Lancaster, LA1 4AP, UK*
e-mail: daniel.chapman@stir.ac.uk

Hotspots of human activity act as hubs for ecosystem disturbance and non-native species introduction, from which invading populations disperse and spread. As such, connectivity to locations used by humans may have an important influence on large-scale patterns of biological invasion. Moreover, in freshwater ecosystems, this connectivity may reflect preferential dispersal of invading species within the hydrological network. Here, we tested how well the connectivity to human activities explains invasion of freshwater ecosystems using 125 species of non-native plants, birds, crustaceans, fish and molluscs across England, UK. We first predicted spatial gradients in human recreation, fishing and water sports using machine learning, demonstrating the importance of vehicle parking, fishing and boating infrastructure for human activity. We then developed a range of connectivity indices, in which human influence percolated away from activity hotspots in all directions (spatial connectivity) or within the hydrological network (downstream, upstream and along-channel connectivity). Connectivity to human activities was positively related to invasion by all taxonomic groups. Furthermore, the human connectivity index that best explained the invasion of each group was generally consistent with its predominant human spread pathway and dispersal mode. For example, fishing and water sports both disturb ecosystems and spread aquatic non-native species and had stronger associations with invasion than general recreation or urban land cover. In addition, downstream human connectivity was most important for mainly aquatic and passively dispersed groups, such as plants, while by contrast spatial connectivity was most important for groups with overland dispersal capacity, such as birds. These findings support the hypothesis that the distributions of invasive non-native species are structured by an interaction between human activity, species dispersal and spread behaviour. By modelling human activity, network connectivity and invasion, we offer a general framework for inferring invasion processes from spatial data and improving predictions of risk that should assist in prioritizing surveillance and management for invasive non-native species.

Feasible or foolish: restoration of *Parthenium hysterophorus* invaded landscapes with native grass seed

Blair Cowie[1,2], Nic Venter[1], Ed Witkowski[1] and Marcus Byrne[1,2]

[1]*School of Animal, Plant & Environmental Sciences, University of the Witwatersrand, Johannesburg, South Africa*
[2]*DST-NRF Centre of Excellence for Invasion Biology, School of Animal, Plant & Environmental Sciences, University of the Witwatersrand, Johannesburg, South Africa*
e-mail: blair.cowie.bc@gmail.com

The invasive shrub *Parthenium hysterophorus* L. (Asteraceae) is one of South Africa's most significant invasive plants as it poses a severe threat to national food security, native biodiversity and human health. The rapid reinvasion of *P. hysterophorus* in grazing, pastural and crop lands after clearing efforts remains a constant problem in managing the weed. However, native grasses may be useful as competitive and restorative species. To investigate the restoration potential of native grasses, trial patches were established in a nature reserve during the spring of 2016. 30 trial patches, each 10 m^2 in size, were used and consisted of 10 sown patches with native grass seed (1g/m^2), 10 non-sown patches with all *P. hysterophorus* cleared, and 10 non-sown and uncleared patches. Patches sown with grass seed showed significant increases in basal grass cover and grass species richness thus reducing the overall density of *P. hysterophorus* by more than 50%. Additionally, plots sown with native grass seeds presented significantly higher biomass as well as smaller *P. hysterophorus* plants when compared to those without seeds. Unsown patches which were not cleared also showcased lower *P. hysterophorus* densities than those which were unsown but cleared, highlighting the detriment of disturbance. This research suggests that the active restoration of *P. hysterophorus* invaded landscapes is feasible provided that good land management practices are employed subsequent to clearing efforts, with particular attention paid to the avoidance of overgrazing and similar disturbances.

Regeneration of *Phragmites australis* from rhizome and stem fragments: testing the effects of environment, population origin and status

Jan Čuda[1], Hana Skálová[1], Laura A. Meyerson[2] and Petr Pyšek[1,3]

[1]*The Czech Academy of Sciences, Institute of Botany, CZ-252 43 Průhonice, Czech Republic*
[2]*Department of Natural Resources Science, The University of Rhode Island, Kingston, Rhode Island, 02881 USA*
[3]*Department of Ecology, Faculty of Science, Charles University, Viničná 7, CZ-128 44 Prague, Czech Republic*
e-mail:jan.cuda@ibot.cas.cz

Phragmites australis is a tall helophytic perennial grass that often dominates both aboveground, where stems grow up to ~4 m, as well as belowground, where rhizomes form extensive and dense mats. It reproduces and spreads both generatively by seed and vegetatively by stem and rhizome fragments. *Phragmites australis* is a cosmopolitan species which naturally occurs on all continents except Antarctica. The populations of European origin cryptically invaded wetlands in North America, leading to extensive displacement of native American populations. Although the species is among the most studied invasive plants, little is known about its vegetative regeneration ability that is crucial for its spread, colonization of new habitats, as well as recovery of disturbed populations. There is no information on how regeneration differs between clones of different origin and what is the effect of environment.

We tested the regeneration of *P. australis* stem and rhizome fragments over six weeks (mid-June to end of July 2017) in a common-garden pot experiment at the Institute of Botany of CAS, Czech Republic. We used cuttings of standardized length (20 cm) and thickness taken from well-developed rhizomes and from the basal part of the stem. To simulate different scenarios that may happen to a fragment of plant (propagule) in nature, we placed cuttings in 6 l pots (i) in water, (ii) on sand surface, and (iii) buried 5 cm deep in sand. We included 20 distinct populations representing three phylogenetic groups (North American invasive, North American native and European clones). We tested the effect of phylogeographic group, organ (stem, rhizome), environment (water, surface, buried) on clone regeneration using generalized mixed-effect models, where clone identity was set as a random effect.

Our results show that the biggest differences were between organs: stems regenerated surprisingly much better (on average 74% of them created new stems and/or roots) than rhizomes (34%). Regeneration was significantly better in water (60%) and under sand (58%) than on the sand surface (44%), where fragments were not protected from drying out. There were considerable differences in regeneration between particular *Phragmites* populations (from 37% in North American native tetraploid up to 81% in North American invasive octoploid), however with no significant differences among phylogeographic groups. There was a significant interaction between environment and organ, rhizomes performed better when buried, while stems in water and both organs regenerated worst on the sand surface.

Veronica peregrina as a potentially invasive species in European temporarily flooded habitats: a case study from Lower Silesia (SW Poland)

Zygmunt Dajdok[1], Ludmiła Polechońska[2], Agnieszka Klink[2], Małgorzata Dambiec[2], Edyta Gola[3] and Michał Gleńsk[4]

[1]*Department of Botany, Institute of Environmental Biology, University of Wrocław, Kanonia 6/8, 50-328 Wrocław, Poland*
[2]*Department of Ecology, Biogeochemistry and Environmental Protection, University of Wrocław, Kanonia 6/8, 50-328 Wrocław, Poland*
[3]*Department of Plant Developmental Biology, Institute of Experimental Biology, University of Wrocław, Kanonia 6/8, 50-328 Wrocław, Poland*
[4]*Department of Pharmacognosy, Wrocław Medical University, Borowska 211a, 50-556, Wrocław, Poland*
e-mail: zygmunt.dajdok@uwr.edu.pl

Communities of ephemeral plant species growing on the borders or bottoms of water reservoirs are classified in Europe as indicators of a protected habitat "oligotrophic to mesotrophic standing waters with vegetation of *Littorelletea uniflorae* and/or *Isoëto-Nanojuncetea* 3130", with many regionally threatened species (e.g. *Lindernia procumbens*, *Elatine* spp., *Eleocharis ovata* or *Coleanthus subtilis*). Importantly, plant species alien to Europe, which reveal invasive properties, such as *Veronica peregrina*, can be a threat for these communities. In SW Poland, this species appears massively, with hundreds of thousands of individuals in some places, and colonizing mainly the exposed bottoms of fishponds. We aimed to evaluate *Veronica peregrina* in terms of the traits that may enable effective competition with other plants, such as (i) habitat preferences, (ii) the number of seeds produced outside of the native range and germination capacity, and (iii) the phytotoxic potential of the species.

The study covered 11 dried ponds in three fishpond complexes located in Lower Silesia, SW Poland. In each studied fishpond, the sample plots (1 × 1 m^2) were designated along linear transects. All vascular plants growing within these plots were listed and their cover was determined. Within each plot, a top layer of bottom sediment was randomly sampled (10 × 10 cm^2, depth of 0–5 cm). Sediment samples were used to determine the pH and concentrations of macroelements (N, P, K, Ca, Mg, Na). Additionally, all specimens of *V. peregrina* were counted and collected in each sampling plot in order to determine the biomass and to identify allelopathic substances present in the plants tissues. Furthermore, in three of the studied fishponds, samples of *V. peregrina* were collected for biometric studies: the plant height, number of branches and fruit (capsules) per plant, and the number of seeds in each capsule were determined.

Our results showed that populations of *Veronica peregrina* were more numerous on sites characterized by sandy substrates with a low content of N, K, Mg, Ca and Na and a high content of P. In such habitat conditions, *V. peregrina* covered up to 90% of the stand, while on muddy sediments, rich in macroelements, other species prevailed, limiting the *V. peregrina* cover to 10-40%. Biometric analyses showed that unbranched individuals with an average shoot length of 88.9 ± 45.3 mm predominated in the studied populations. The average fruit number was 6.25 ± 5.3 per plant, while the average number of seeds in the capsule was 71.4 ± 24.9. The presence of allelopathic compounds in *V. peregrina* tissues was confirmed by biochemical analysis, while the biotest showed that the aqueous extract of dried plant material inhibited the germination of *Sinapis alba* seeds.

The obtained results prove that the chemical composition of the bottom sediments affects the population density and biomass production of *V. peregrina*. Importantly, this species can play a key role as a component of ephemeral plant communities inhabiting periodically exposed water banks, e.g. due to its phytotoxic activity. However, the effectiveness of its impact on the particular species in these communities requires further research.

Plant Alert: a new tool for the submission of records of potentially invasive ornamental garden plants

Katharina Dehnen-Schmutz[1], Tom Humphrey[2] and Kevin Walker[2]

[1]*Centre for Agroecology, Water and Resilience, Coventry University, UK*
[2]*Botanical Society of Britain and Ireland (BSBI), UK*
e-mail: ab6340@coventry.ac.uk

Ornamental horticulture is the main pathway for alien plants in the British Flora. However, insufficient resources are available to conduct risk assessments and preventive management for all non-native ornamentals planted in gardens (the Royal Horticultural Society's Plant Finder lists about 70,000 plants for sale in Britain). It is therefore vital to identify those species that may have a higher potential to become invasive aliens outside gardens with negative impacts on biodiversity. A recent pilot study demonstrated that asking gardeners to report on spreading ornamentals from their gardens seems to be a valuable contribution for the identification of potential future invasive ornamental plants and would be useful for horizon scanning and risk assessments (Dehnen-Schmutz & Conroy 2018). As a result of this pilot study, a permanent web-based reporting tool "Plant Alert" has been created to enable gardeners to report plants whenever they become aware of the problems. The project aims to promote the web page whenever reports of invasive garden plants appear, for example in the popular press or in social media. Annual reports of submitted records will be published and communicated to policy makers and the horticultural industry.

Dehnen-Schmutz K. & Conroy J. (2018) Working with gardeners to identify potential invasive ornamental garden plants: testing a citizen science approach. Biol. Invas. 20: 3069–3077.

Biotic and abiotic changes in subtropical Seasonal Deciduous Forest associated with invasion by a non-native tree

Alexandre Deschamps Schmidt, Tânia Tarabini Castellani and Michele de Sá Dechoum

Programa de pós-graduação em Ecologia, Universidade Federal de Santa Catarina, Campus Universitário s/n – Córrego Grande, Florianópolis, SC 88040-900, Brazil
e-mail: mdechoum@gmail.com

There are several tree species among the best known and most impacting invasive plants. Invasive non-native trees can result in changes in native plant species richness, abundance and composition, as well as in environmental characteristics and ecosystem functioning. *Hovenia dulcis* Thunb. (Rhamnaceae), is a tree native to East Asia and invasive in southern South America across different forest ecosystems. This study aimed at assessing the effects of *H. dulcis* on richness, abundance and composition of regenerating species in Seasonal Deciduous Forest (SDF) by comparing invaded and non-invaded areas. To date, studies assessing the effect of *H. dulcis* on the regeneration of indigenous species do not exist. This approach contributes to understanding the mechanisms involved in *H. dulcis* invasion and its effects on invaded plant communities. The existence of correlations between abundance and richness of regenerating species with age and density of the invasive species, as well as with characteristics of canopy openness, litter thickness, slope, and soil moisture, was investigated in areas invaded by *H. dulcis*. Differences observed in canopy openness and litter thickness between areas invaded by *H. dulcis* and control areas suggest that *H. dulcis* is able to change environmental conditions on a local scale, resulting in potential positive feedback for the invasive species (Table 1). Although no differences were observed in species richness between areas with and without the invasive species, the differences registered in abundance and composition of regenerating species make the impact by *H. dulcis* on regeneration patterns in SDF fragments evident. The impacts caused by *H. dulcis* on SDF confirmed by this study and the regional extent of *H. dulcis* invasion, highlight the need for the development of a regional management program to protect the scarce remnants of SDF in southern South America.

Table 1. Abiotic parameters (mean **±** SD**)** measured in areas with and without *Hovenia dulcis* sampled in the Fritz Plaumann State Park (SC, southern Brasil). Different letters indicate significant differences (T test / Mann-Whitney-Wilcoxon test with Bonferroni method for correction; p<0,05) between areas with and without *H. dulcis*

Parameter	With *H. dulcis*	Without *H. dulcis*
Litter winter (cm)	3.9^a ± -0.8	3.7^a ± 0.8
Litter summer (cm)	3.1^a ± 0.7	3.7^b ± 0.6
Slope (%)	19.7^a ± 11.2	17.5^a ± 10.1
Canopy openness winter (%)	9.5^a ± 4.8	4.3^b ± 2.8
Canopy openness summer (%)	0.5^a ± 0.6	1.7^b ± 1.8
Soil moisture winter (%)	30.3^a ± 12.3	31.4^a ± 11.2
Soil moisture summer (%)	27.6^a ± 10.4	27.4^a ± 8.8

Functional trait differences between native and alien plant species in local communities of different habitat types

Jan Divíšek[1,2], Milan Chytrý [1], Brian Beckage[3], Nicholas J. Gotelli [4], Zdeňka Lososová [1], Petr Pyšek[5,6], David M. Richardson[7] and Jane Molofsky[3]

[1]*Department of Botany and Zoology, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic*
[2]*Department of Geography, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic*
[3]*Department of Plant Biology, University of Vermont, Burlington, VT 05405, USA*
[4]*Department of Biology, University of Vermont, Burlington, VT 05405, USA*
[5]*Department of Invasion Ecology, Institute of Botany, The Czech Academy of Sciences, 252 43 Průhonice, Czech Republic*
[6]*Faculty of Science, Department of Ecology, Charles University, 128 43 Praha 2, Czech Republic*
[7]*Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, Matieland 7602, South Africa*
e-mail: divisekjan@sci.muni.cz

There is an ongoing debate on how alien plant species become integrated into native communities and what makes them invasive. These questions were often addressed using functional trait analyses, which became an important tool in invasion ecology (Pyšek & Richardson 2007). Recently, Divíšek et al. (2018) showed that invasive plant species across all major habitat types in the Czech Republic (grasslands, ruderal and weed vegetation, rock and scree vegetation, wetlands, scrub vegetation and forests) are functionally different from both native and naturalized species, while the latter two groups are functionally very similar. Nevertheless, this comparison was done for habitat species pools, but we still do not know whether the observed differences also play a role at the fine scale of individual communities, in terms of square meters, where species actually interact. We hypothesize that alien species integrate themselves into the margin of the trait distribution if the trait values of alien species are considerably different from the mean values for the native community. If so, alien species are probably filling empty niches in the community. Conversely, if the trait values of alien species do not differ considerably from the mean value of the community, alien species are integrating themselves into the mean of the trait distribution and then they may be competing with other resident species. We addressed these hypotheses using vegetation plot data from the Czech National Phytosociological Database and the data on maximum height, specific leaf area and seed weight of each species. We applied randomization tests to test for functional trait differences between native and alien species in vegetation plots classified into the six above-mentioned habitat types. According to our very preliminary results, traits of alien species are in most plots statistically indistinguishable from the mean trait of native species in the community. However, there was always some proportion of plots where traits of alien species were further from this mean than expected at random, and these plots were considerably more frequent than those where alien species were significantly closer to the mean. This pattern seems to be consistent across all considered traits and habitat types. In future analyses, we will divide alien species according to the introduction-naturalization-invasion concept (Richardson et al. 2000) to non-invasive naturalized species and invasive species to explore trait differences between these two groups.

Divíšek J., Chytrý M., Beckage B., Gotelli N. J., Lososová Z., Pyšek P., Richardson D. M. & Molofsky J. (2018) Similarity of introduced plant species to native ones facilitates naturalization, but differences enhance invasion success. Nat. Comm. 9: 4631.

Pyšek P. & Richardson D. M. (2007) Traits associated with invasiveness in alien plants: where do we stand? In: Nentwig W. (ed.), Biological invasions. Ecological studies (Analysis and synthesis), Vol. 193, p 97–125, Springer, Berlin, Heidelberg.

Richardson D. M., Pyšek P., Rejmánek M., Barbour M. G., Panetta F. D. & West C. J. (2000) Naturalization and invasion of alien plants: concepts and definitions. Diversity Distrib. 6: 93–107.

Novel ecosystem functioning: from invasion to restoration of knotweed-invaded areas – a bee perspective

Fanny Dommanget, André Evette and Vincent Breton

Univ. Grenoble Alpes, Irstea, LESSEM, 2 rue de la papeterie, FR-38402 Saint-Martin d'Hères, France
e-mail: fanny.dommanget@irstea.fr

Asian knotweeds are considered among the 100 worst invasive plant species in the world. Introduced from South-Eastern Asia at the end of the 19th they are now widespread throughout the Northern hemisphere, and have been reported in Chile, Australia and New-Zealand. These bamboo-like geophyte species develop in monoclonous stands and spread rapidly along rivers and roadsides due to the high repsrouting efficiency of their rhizomes. They affect plant and animal biodiversity and substantially modify soil functioning. However their true impacts are questioned (Lavoie 2017) and some studies also report positive effects on pollinating insects (Davis et al. 2018). Indeed knotweeds are nectariferous species that can provide non negligible resources for pollinators.

Management of these species is problematic as most classical technics are fastidious and/or expensive. Therefore, managers try to develop alternative methods such as bioengineering. Habitually used for riverbank protection against erosion, bioengineering also promotes the rapid recovery of plant communities through plantation or seeding. Novel ecosystems arise from these interventions, mixing residual knotweed individuals (which are rarely eradicated) with the reintroduced native species. But how do such restored ecosystems function, regarding plant recruitment and pollinator communities?

The aim of this study which will start in spring 2020 is to compare knotweed-invaded sites to bioengineering-restored sites on the basis of plant and bee communities in order to evaluate the effect of such management actions. Reference sites will also be studied and should help to apprehend the effects of knotweeds on these major components of biodiversity functioning.

Fig. 1. Knotweed with pollinating insect.

Davis E. S., Kelly R., Maggs C. A. & Stout J. C. (2018) Contrasting impacts of highly invasive plant species on flower-visiting insect communities. Biodiv. Conserv. 27: 2069–2085.

Lavoie C. (2017) The impact of invasive knotweed species (*Reynoutria* spp.) on the environment: review and research perspectives. Biol. Invas. 19: 2319–2337.

Physiological and ecological niche differentiation between invasive and native *Carpobrotus* species: the key of its invasion in Europe?

Erola Fenollosa[1,2] and Sergi Munné-Bosch[1]

[1]*Department of Evolutionary Biology, Ecology and Environmental Sciences, Faculty of Biology, Universitat de Barcelona, Barcelona, Spain*
[2]*Institute of Research in Biodiversity (IRBio-UB), Universitat de Barcelona, Spain*
e-mail: efenollosa@ub.edu

Although invasive species constitute one of the main threats to global biodiversity, key factors determining the changes that occur in a species along the invasion process and their magnitude are still unknown, hindering predictions of their expansion. One of the main climatic drivers determining plant distribution is temperature, as it is one of the main environmental variables limiting plant growth, and therefore may play a crucial role on determining species expansion across different environments.

In this study, our aim was to understand the expansion of the aggressive invader *Carpobrotus* sp. in Europe using an ecophysiological approach. For this reason, we contrasted the invasive and native ecological niche and explored experimental response to temperature of individuals from both ranges in terms of different physiological markers. The comparison of native and invasive niches revealed an invasive niche expansion towards colder climates. Moreover, individuals from different ranges showed differential mechanisms facing low temperatures in terms of their photoprotective response, mainly in the photosynthetic pigment degradation, increase on the de-epoxidation state of the xanthophylls and the accumulation of the lipophilic antioxidant α-tocopherol, where native individuals showed increased sensitivity to chilling. *Carpobrotus* sp. have a great adaptive capacity to low temperatures in its invasive range which may explain the observed invasive climatic niche shift to colder climates.

Invasive plants negatively impact native, but not exotic, animals

Rebecca A. Fletcher, Rachel K. Brooks, Vasiliy T. Lakoba, Gourav Sharma, Ariel R. Heminger, Christopher C. Dickinson and Jacob N. Barney

School of Plant and Environmental Sciences, Virginia Tech, Blacksburg, VA, 24060, USA
e-mail: jnbarney@vt.edu

Despite our growing understanding of the impacts of invasive plants on ecosystem structure and function, important gaps remain, including whether native and exotic species respond differently to plant invasions. This would elucidate basic ecological interactions and inform management. We performed a meta-analytic review of the effects of invasive plants on native and exotic resident animals. We found that invasive plants reduced the abundance of native, but not exotic animals. This varied by animal phyla, with invasive plants reducing the abundance of native annelids and chordates, but not molluscs or arthropods. We found dissimilar impacts among 'wet' and 'dry' ecosystems, but not among animal trophic levels. Additionally, the impact of invasive plants increased over time, but this did not vary with animal nativity. Our review found that no studies considered resident nativity differences, and most did not identify animals to species. We call for more rigorous studies of invaded community impacts across taxa, and most importantly, explicit consideration of resident biogeographic origin. We provide an important first insight into how native and exotic species respond differently to invasion, the consequences of which may facilitate cascading trophic disruptions further exacerbating global change consequences to ecosystem structure and function.

National management strategy for *Heracleum mantegazzianum*, an example of how France wants to control widely spread IAP

Madeleine Freudenreich[1], Guillaume Fried[2], Emmanuelle Sarat[3] and Arnaud Albert[1]

[1]*French Biodiversity Agency (AFB), Research, Science-advice and Data Division (Dred), Vincennes, France*
[2]*French Agency for Food, Environmental and Occupational Health and Safety (Anses), Plant Health Laboratory (LSV), Montferrier-sur-Lez, France*
[3]*French Committee of the International Union for Conservation of Nature (IUCN), French Invasive Alien Species Resource Center (CDR), Orléans, France*
e-mail: arnaud.albert@afbiodiversite.fr

The EU Regulation no. 1143/2014 on invasive alien species (IAS) provides a set of measures to be taken by Member States in relation to IAS included on the Union list. Management is one of three distinct types of measures envisaged. According to Article 19 of this Regulation, Member States shall have in place effective management measures ofIAS which have been found to be widely spread in their territory.

In this framework, the French Biodiversity Agency (AFB) has identified seven invasive alien plants (IAP) that are widely spread in France: *Baccharis halimifolia*, *Elodea nuttallii*, *Heracleum mantegazzianum*, *Impatiens glandulifera*, *Ludwigia grandiflora*, *Ludwigia peploides* and *Myriophyllum aquaticum*. In connection with the French Environment Code, the National IAS Strategy and the French Biodiversity Plan, the AFB is developing national management strategies (NMS) for each of these IAP. The main goal of a NMS is to provide a decision support tool for regional co-ordinations and local managers in order to determine priority populations and interventions. Indeed, not all populations must be managed, not all populations can realistically be managed due to lack of means, and national eradication is no longer conceivable for widespread species. Choices thus have to be made on how and where to manage the existing populations. This poster uses the Giant Hogweed as a case of explanation for NMS.

First, a short and general description of the biology and ecology of the species is provided to obtain useful characteristics for management options. Secondly, a climatic niche modelling of the species is performed to identify potential distribution, based on the level of climatic suitability and the number of already established populations, allowing to define and coordinate measures between administrative regions, with different and adapted global management objectives. Thirdly, several criterions (spread risk, real impacts, etc.) are used to prioritize populations and sectors within these regions. Finally, local management objectives (eradication, control or containment) are proposed for each selected population, based on site conditions and technical feasibility. Moreover, current management interventions and existing local strategies are taken in account and mentioned in the national strategy, and an overview of the best management practices is provided. Related measures (surveillance, residuals, restoration, etc.) are also evoked.

To conclude, effective prioritization of species and pathways are prerequisites for the management of IAS, as recognized by the Convention on Biological Diversity. However, prioritization of colonized sites, mainly for widespread species, remains a big challenge in order to obtain a successful and concerted national management of species populations, with the aim of truly minimizing its adverse impacts on biodiversity and related ecosystem services, and for preventing further spread.

Effects of different alternative plants on the control of *Mikania micrantha*

Weidong Fu and Guoliang Zhang

Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences, Beijing 100081, China
e-mail: fuweidong@caas.cn

Mikania micrantha is a perennial invasive weed, which can seriously destroy the biodiversity in the invaded area. Biological substitution can not only effectively reduce the harm of *M. micrantha*, but also achieve ecological and economic benefits. According to the main habitat conditions of *M. micrantha* invasion, a variety of plants suitable for growing in the invaded area of *M. micrantha* were selected as alternative plants. In this research, we studied the effects of different plants on the prevention and control of *M. micrantha*. Plant height, biomass (fresh weight and dry weight), properties of root soil, chlorophyll content, leaf area, and the photosynthetic rate of alternative plants and *M. micrantha* were measured using pot experiments, in order to screen out the best alternative plants. The results showed that among the 15 alternative plants suitable for local habitats, *Mosla chinensis* and *Stylosanthes guianensias* had the best control effects on *M. micrantha*. When *M. chinensis* and *S. guianensias* were planted together with *M. micrantha*, the plant height and biomass of *M. micrantha* were the lowest of all the 15 groups. Further studies showed that *M. chinensis* and *S. guianensias* could inhibit the growth of *M. micrantha* without affecting its own growth. Compared with the control group, the leaf area, chlorophyll content and photosynthetic rate of *M. micrantha* showed a significant downward trend. The results of this study provide theoretical basis and technical support for the ecological control technology of *M. micrantha*.

Bidens decipiens Warnst. (= *B. connata* Muehl. ex Willd.) in Eastern Europe: new information about hybrid origin

Maria A. Galkina and Yulia K. Vinogradova

Tsitsin Main Botanical Garden of Russian Science Academy, Botanicheskaya 4, Moscow, Russia
e-mail: mawa.galkina@gmail.com

Bidens decipiens Warnst. is a hybrid between the native European *B. cernua* L. and the North American invasive *B. frondosa* L. It has been grown in Europe since the end of the 19th century and was found in Russia at the beginning of the 21st century (Galkina & Vinogradova 2017). This species is included in "The Plant List" as *B. connata* Muehl. ex Willd., but European specimens differ from the type variety (*B. connata* var. *connata*) from the natural distribution range – there are no ray flowers in the inflorescence, the first real leaves are less narrow than the American specimens, clearly petiolate, with less numbers of denticles along the margin; the denticles are big and irregularly located, and the outer bracts of involucres clearly phylloid, 3–6 cm long (Mayorov & Vinogradova 2013). Earlier, we studied the macromorphological features of *B. decipiens* individuals in Russia. Some morphological features were noted to be intermediate between invasive *B. frondosa* and the native *B. cernua* L. We hypothesized the hybrid origin of *B. decipiens* and tested it using the ISSR analysis. Our data confirmed that *B. decipiens* can be regarded as a complex of hybrids and backcrosses and *B. frondosa* and *B. cernua* are the parental species of this taxon (Galkina & Vinogradova 2017). However, it will be necessary to recognize paternal and maternal species of this hybrid. Therefore, we performed the analysis of the nucleotide sequences using the nuclear and chloroplast DNA sites of these taxa. We collected 30 samples of *B. decipiens, B. frondosa* and B*. cernua* in Russia and Belarus. *Bidens cernua* is distinguished from *B. frondosa* on some nucleotide substitutions in the ITS sequence; most samples of *B. decipiens* are characterized as ambivalent in most of these substitutions. This result reflects the heterozygosity and hybrid origin for *B. decipiens*. However, some samples from the Kaliningrad district and the sample from Moscow city only have ambivalent sequences in a few cases. Hence, these samples cannot be regarded as hybrids F1 and F2. These samples are very similar to *B. cernua*. We presume that the introgressions for these samples are due to backcrosses. Next, we analyzed the nucleotide sequences of the trnL-trnF intergenic noncoding spacer of chloroplast DNA. All *B. frondosa* samples have deletion from seven nucleotides as compared with *B. decipiens* and *B. cernua*. *Bidens decipiens* does not differ from *B. cernua* in trnL-trnF sequence. As a result, *B. cernua* is the maternal species and *B. frondosa* is the paternal species for *B.decipiens*.

Galkina M. A. & Vinogradova Yu. K. (2017) Hybridization of alien and aboriginal taxa of *Bidens* L. genus in Eastern Europe. Biol. Bull. 44: 406–411.

Mayorov S. R. & Vinogradova Yu. K. (2013) Formation of secondary distribution range and intraspecific variability of *Bidens connata.* In: 12th Reunion on Ecology and Management of Alien Plant Invasions, September 22–26, 2013, p. 119, Pirenopolis, Brazil.

Alien flora across European sand dunes

Silvia Giulio[1], Alicia Teresa Rosario Acosta[1], Carboni Marta[1], Juan Antonio Campos[2], Milan Chytrý[3], Mercedes Herrera[2], Javier Loidi[2], Jan Pergl[4], Petr Pyšek[4], Maike Isermann[5], John A. M. Janssen[6], Zygmunt Kącki[7], John S. Rodwell[8], Joop H. J. Schaminée[9] and Corrado Marcenò[2]

[1]*Roma Tre University, Viale Marconi 446, 00146 Rome, Italy*
[2]*University of the Basque Country (UPV/EHU), Bilbao, Spain*
[3]*Masaryk University, Brno, Czech Republic*
[4]*Academy of Sciences of the Czech Republic, Průhonice, Czech Republic*
[5]*Department of Ecology, Bremen University, Bremen, Germany*
[6]*Wageningen Environmental Research, Wageningen, The Netherlands*
[7]*Department of Vegetation Ecology, Botanical Garden, University of Wroclaw, Wrocław, Poland*
[8]*Lancaster University, Derwent Road, Lancaster, United Kingdom*
[9]*Wageningen Environmental Research, Wageningen, The Netherlands*
e-mail: silvia.giulio@uniroma3.it

The spread of alien species in new environments is one of the main drivers of biodiversity decline in a growing number of ecosystems worldwide. In Europe, it is expected to increase with socioeconomic activities and ongoing climate change, especially in coastal areas which are vulnerable, but highly important for human wellbeing. The coastal dunes of Europe are an ideal model system to analyse invasion processes in habitats across varying disturbance regimes, because they display contrasting diversity patterns along ecological and geographical gradients (Marcenò et al. 2018). Thus, we analysed, for the first time, the composition of alien flora of the coastal dunes at a broad biogeographical scale in pioneer habitats (shifting dunes and grey dunes) across the main European coastal regions (Atlantic, Baltic, Black Sea and Mediterranean coasts). The data were obtained from the European Vegetation Archive (EVA; Chytrý et al. 2016). We asked the following questions: (i) what is the level of invasion across the coastal dunes along Europe? (ii) what invasion trajectories of alien species reach these dune systems? (iii) what life forms are most frequent among the alien plants? and (iv) how different alien species distribute across the main gradients? We observed high levels of invasion, in particular by annual herbs and by generalist species that at the same time have subtle adaptations to specific habitats and coastal regions. Invasion levels did not vary sensibly across the habitats but did so across specific coastal regions, with the highest alien richness on Atlantic dunes and the highest relative frequency of few alien species on Black Sea dunes. North America was the main donor of alien plants and the Mediterranean basin was reconfirmed as being more of a donor than a recipient of alien plants. Overall, the study provides a comprehensive assessment of alien plant invasions in the coastal dunes around Europe, and may represent a contribution for priorities establishment in invasion management strategies, both at the European and inter-regional level.

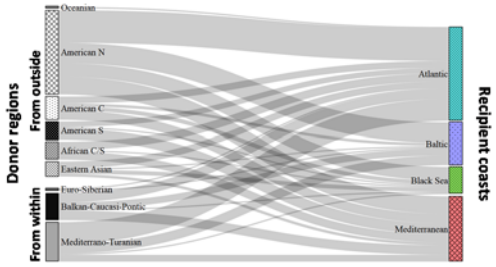


Fig. 1. Species exchange between donor and recipient regions.

Marcenò C., Guarino R., Loidi J., Herrera M., Isermann M., Knollová I. ... & Iakushenko D. (2018) Classification of European and Mediterranean coastal dune vegetation. Appl. Veg. Sci. 21: 533–559.

Chytrý M., Hennekens S. M., Jiménez-Alfaro B., Knollová I., Dengler J., Jansen F., ... & Ambarlı D. (2016) European Vegetation Archive (EVA): an integrated database of European vegetation plots. Appl. Veg. Sci. 19: 173–180.

Know your enemy: are biochemical substances the secret weapon of common ragweed (*Ambrosia artemisiifolia*) in the fierce competition with crops and native plant species?

Rea Maria Hall[1,3], Harry Bein[2], Bettina Bein-Lobmaier[2], Gerhard Karrer[3], Hans-Peter Kaul[1] and Johannes Novak[2]

[1]*Department of Crop Science; University of Natural Resources and Life Science Vienna, Austria*
[2]*Institute of Animal Nutrition and Functional Plant Compounds, University of Veterinary Medicine Vienna, Austria*
[3]*Department of Integrative Biology and Biodiversity Research; University of Natural Resources and Life Science Vienna, Austria*
e-mail: rea.hall@boku.ac.at

Ambrosia artemisiifolia L. (Asteraceae) known as common ragweed is an annual herbaceous species native to North America and is not only a troublesome agronomic weed but actually one of the most important inducers of pollen allergy. Due to its plasticity, it is highly adaptive behavior in terms of habitat requirements, growing conditions, herbicide tolerance and resistance in combination with its extremely high reproductive power, the importance of common ragweed as an agricultural weed and promoter of allergies will increase further.

Following the "enemy release hypothesis", the invasiveness of non-native species such as common ragweed can result from a loss of natural competitors due to the production of chemical compounds by the non-native species that unfavorably affect native communities. In this case, native plants may not be able to tolerate compounds released by non-native plants which have not co-evolved in the same environment. In particular, the genus *Ambrosia* produces and releases several types of organic compounds, which have a broad spectrum of biological activities and which could be major drivers in the successful invasion and competition process of common ragweed.

We aimed to (i) asses the chemical profile of the aboveground biomass of common ragweed, using four different extracts (i.e. H_2O, hexane extract, methanol extract and essential oil) which was prepared and analysed for their content substances, and (ii) determine the effects of different concentrations of these substances on germination and seedling development of three different crops (soybean, wheat, and rapeseed), native weedy species (*Chenopodium album*, *Senecio vulgaris*, and *Arabidopsis thaliana*) and on common ragweed itself. This was implemented as a laboratory experiment.

Results showed a range of 58 different compounds in the aboveground biomass of which many of them could be identified as growth inhibitors and/or neurotoxines. Accordingly, germination as well as seedling development was signficantly influenced by the chemical compounds in the extracts. The highest inhibitory effect on germination of crops, native weedy species, as well as common ragweed was observed with essential oils; the higher their concentration, the higher the effect. A second run of this trial in a greenhouse should further reveal (iii) the interaction effect of different substrate types and the extracts. The aim is to test if various substrates retard or promote the effectiveness of the chemical compounds on germination and/or seedling growth of the same plant species used in the laboratory experiment. The findings of this study can contribute in the development of new sustainable agricultural management approaches and can serve as basis for further research in a broad field of plant science, e. g. plant protection.

Regional adjustment of management options of common ragweed (*Ambrosia artemisiifolia*) along roadside verges in Bavaria

Rea Maria Hall, Gerhard Karrer, Lisa Zant and Miriam Aliabadi

Department of Integrative Biology and Biodiversity Research; University of Natural Resources and Life Science Vienna, Austria
e-mail: rea.hall@boku.ac.at

Common ragweed (*Ambrosia artemisiifolia* L.) is an invasive annual plant with highly allergenic pollen. Its spread often occurs on roadsides, where it builds stable and rapidly growing populations. The most sustainable way of controlling the population size of this species is to prevent seed production in order to deplete the soil seed bank. Populations on roadsides are submitted to regular mowing management, this can even exacerbate the situation by inducing re-sprouting after cutting or by accidentally spreading seeds along the road. From former experiments in Austria, we know that an important factor influencing the growth potential of common ragweed along roadsides is the presence and the composition of (native) competitors which can be very effective in prohibiting the successful emergence of ragweed seedlings.

Therefore, in a 3-year field trial five different cutting regimes differing in timing and frequency of cuts were tested on eight roadside verges in Bavaria, characterized by different climatic conditions and traffic densities. On the basis of soil seedbank samplings along these roadside verges as well as on the road embankments (July and October 2018), the study should reveal which cutting regime is most effective in the prevention of flower and seed formation of common ragweed.

In addition, a 3-year field trial on the competitive suppression of common ragweed by four different seed mixtures combined with three different cutting regimes was implemented at three different sites. First, results showed that the primary habitat of common ragweed is the roadside verge: 97.9% of all plants counted as well as 96.7% of all seeds found in the soil seed bank were concentrated on the first 1.5 m next to the lane, irrespective of the soil properties and the inclination of the embankment. Furthermore, it could be revealed that contamination of the soil seedbank with ragweed seeds as well as the viability of the seeds differed significantly between the sites. The first cutting treatments will start in May 2019 and the results of this study should contribute to a local adapted management system of common ragweed which can sustainably inhibit the further production and spread of seeds not only along road verges but also into surrounding areas.

Impact of land use on the distribution of invasive plants in urban river ecosystems: a case study from the Kłodnica Valley (Silesian Upland, Poland)

Robert Hanczaruk and Agnieszka Kompała-Bąba

Department of Botany and Nature Protection, Faculty of Biology and Environmental Protection, University of Silesia in Katowice, Jagiellońska 28, 40-032 Katowice, Poland
e-mails: roberthanczaruk@gmail.com, agnieszka.kompala-baba@us.edu.pl

Urban river valleys belong to the ecosystems most vulnerable to plant invasions. A model example is the Kłodnica valley – the main river of Upper Silesian Industrial Region (Silesian Upland, Poland). It flows through large and densely populated towns as Katowice, Ruda Śląska, Zabrze and Gliwice. It has been subjected to strong anthropopressure caused both by mining and metallurgical industry, as well as, heavy urbanization since the end of the 18th century. As a result of human activity, existing plant cover was seriously transformed or even completely destroyed. In place of riparian forests (*Fraxino-Alnetum*) and willow-poplar thickets (*Salicetum albo-fragilis*), secondary communities developed. According to Corine Land Cover 2018, we distinguished 13 classes of land use. We examined (i) the differentiation of vegetation of the Kłodnica valley along a section that differs in reference to anthropogenous pressure (i.e. land use), and (ii) the distribution of invasive herbaceous plants along the Kłodnica valley in terms of land use.

We recorded 23 plant communities that were constituted by 173 vascular species. Among them, 17 invasive plant species were recorded. Some species occurred in the floristic composition of plant communities, whereas species such as *Aster novi-belgii*, *Helianthus tuberosus*, *Impatiens parviflora*, *Reynoutria japonica* and *Solidago gigantea* formed some aggregation. *Solidago gigantea*, *Reynoutria japonica* and *Conyza canadensis* occupied the highest number of localities. The results of the non-parametric Kruskal-Wallis test showed statistically significant impact of the land use on the distribution of invasive herbaceous plants ($H = 11.83$; $p = 0.01$). The mean number of invasive plants was higher in urban (8.17), sport and leisure (5.00), as well as industrial areas (4.80) than in agricultural and forest lands (2.67).

The distribution of invasive alien species along the Kłodnica river valley shows the strong connection with the pattern of land use. The river was exposed to strong propagule pressure from human-altered ecosystems. The areas most prone to invasion were urbanized areas with features such as: high population density, industrial sites and allotment gardens, where the level of anthropogenic disturbances and resources availability was high. In contrast, extensively used agricultural areas reduced the spread of exotic taxa. Arable lands played a role as a buffer, limiting the encroachment of invasive species to the forest, which occur in the surroundings. Our results showed that the land use metrics allows to determine the level of invasion and predict the future spread of exotic taxa. Therefore, landscape characteristics should be included in the management strategies of alien species.

How does *Arundo donax* grow?

John Du Vall Hay

Departamento de Ecologia, Universidade de Brasilia, Brasilia, DF, 70910-900, Brazil
e-mail: jhay@unb.br

Arundo donax L. (giant cane) is a fast-growing tall grass that has been used as an energy crop in several countries around the world. It is considered to be one of the world's most invasive species due to its capacity to occupy space in different plant communities. Although there have been many studies of biomass production in *A*. *donax*, there is only one previous study on its allometric growth. The objective of this study was to compare allometric growth of *A*. *donax* collected in different locations within the Federal District of Brazil. At each site a minimum of 10 and a maximum of 20 stems were collected ranging from 0.22 to 7.04 m in height and 0.001 to 1.29 kg in dry weight. Other measurements made in the field were basal diameter (mm), diameter at 1 m (mm), number of nodes, and number of green leaves. If lateral sprouts were present, their number was counted. All individuals were regrowth from a previously cut clump, but the time since cutting was unknown. As in previous allometric studies of *A*. *donax*, the general equation for these data was a power function and height (R^2 = 0.9043) was a better predictor of biomass than basal diameter (R^2 = 0.6605). Although the fit of this general equation for the entire data set was excellent, when each collection was analyzed separately, the results showed that allometric growth at different sites was different as was allometric growth at the same site when data were collected in different seasons.

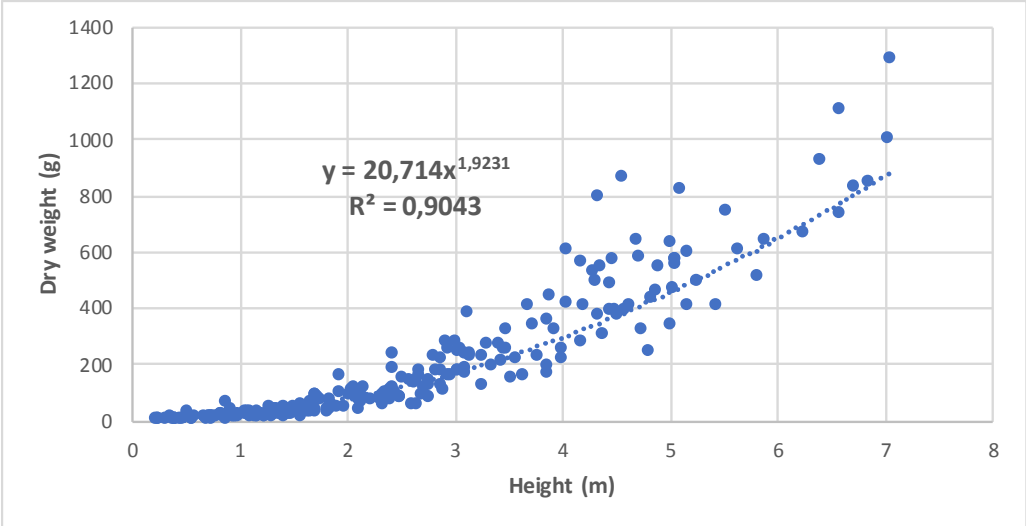


Fig. 1. Relationship between dry weight and height in *Arundo donax.*

Which traits explain the distribution patterns of alien *Lolium* species in Japan?

Momoko Hirata[1], Yoshiko Shimono[1], Takako Kiyoshi[2] and Tohru Tominaga[1]

[1]*Graduate School of Agriculture, Kyoto University, Kitashirakawa-oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan*
[2]*Institute of Livestock and Grassland Science, NARO, 768 Senbonmatsu, Nasu-shiobara, Tochigi 329-2793, Japan*
e-mail: hirata.momoko0310@gmail.com

Divergent linages of an alien species along different introduction routes would influence its post-invasion process.*Lolium* species are notorious weeds in croplands around the world and their seeds were introduced into Japan as contaminants of trading wheat. They spill out of wheat and establish at seaports. In addition, these species were introduced as a cultivar for forage. In Japan, *Lolium* species are distributed in croplands and sandy coasts. Previous studies showed that individuals in croplands are derived from forage, while individuals in coasts are derived from contaminants.

In this study, we investigated which traits cause the distribution patterns of *Lolium* species. We conducted reciprocal sowing experiments at two sites, a cropland and a coastal site. Populations derived from croplands yielded higher floret numbers than populations derived from sea coasts at the cropland site, but such advantages were not detected at the coastal site. Populations derived from sandy coasts showed higher survival rate than populations derived from croplands at the coastal site. Therefore, each population showed local adaptation. Timing of flowering was different between populations. In general, populations derived from croplands flowered late and they flowered two weeks later at the coastal site than at the cropland site.

Abiotic stress would be an important selective force in sandy coasts. Therefore, we compared the seed germination ability and seedling survival under a range of drought and salt conditions between populations. As a result, drought and salt tolerance of seeds and seedlings were not different between populations. Seed dormancy would also be an important trait in harsh environments, such as sandy coasts, because germination timing affects seedling survival. So, we conducted germination experiments. There were different dormancy levels between populations by dispersal forms, seeds separated from spikes or seeds remaining on spikes. Cropland populations showed high germination percentages irrespective of the dispersal forms, while coastal populations showed low germination percentages of seeds remaining on spikes. It is necessary to verify whether this difference in the dormancy causes different germination timing and survival rate in the field.

Managing invasive species in a complex social-ecological system: a system dynamics based insight-building tool for the Banni grasslands, India

Ankila J. Hiremath[1], Mihir Mathur[2], Kabir Sharma[2], Nirav Mehta[1], Ramya Ravi[1], Madhura Niphadkar[1] and Abi T. Vanak[1]

[1]*Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore, India*
[2]*DESTA Research LLP, New Delhi, India*
e-mail: hiremath@atree.org

In complex social-ecological systems, ecological changes caused by invasive species can also have unexpected socioeconomic and cultural consequences. Decisions on management of the invasive species must, therefore, take into account its varied impacts and the way in which it is perceived by multiple stakeholders involved. The Banni, once India's largest sub-tropical grassland, is one such social-ecological system. Banni, in western India, lies adjacent to the Rann of Kutch, a large salt desert. It has historically been home to traditional pastoralist communities, the *Maldharis*. In the 1960s, *Prosopis juliflora* (hereafter, *Prosopis*), a species native to the Americas, was introduced to Banni, ostensibly to check the ingress of the salt desert. *Prosopis* has now spread across more than half the Banni, replacing grasslands, reducing fodder availability, and harming the milk economy for Banni's pastoralists. In response, Banni's resident communities have developed a parallel wood-charcoal economy based on *Prosopis*. The growth of the charcoal economy has led to unforeseen consequences, including – and paradoxically – the intensification of milk production.

We developed a system dynamics model of the Banni, which brings together the inter-linked biophysical and socioeconomic components of the system (e.g. *Prosopis* and grassland area, livestock, biomass for charcoal, livelihoods, and rainfall). The model was developed through a participatory process. Workshops were conducted to elicit information, trends, stories, model structures, and mental models from the *Maldharis* of Banni as well as from researchers. The model is intended to serve as a learning tool that can help people gain insights (rather than forecasts) regarding alternative future scenarios for Banni. The model simulates the overall behaviour of the system, from 2018–2030. We used this model as the basis for a user-friendly 'insight-builder' tool. This tool – an Android App with pictures and interactive graphics – provides a way for stakeholders to explore the implications of potential management scenarios under different 'What-if' conditions, such as different management regimes of *Prosopis* and climate extremes (e.g. recurrent droughts). It gives the user the option to choose scenario parameters to simulate outcomes. The App could have greater outreach as compared to the system dynamics model. Through the App, we aim to engage with stakeholders to envision possible future scenarios for Banni and build consensus on the decisions that could lead to management that is consistent with the priorities of Banni's communities as well as official land managers.

Ammi majus as a new arable weed in the Czech Republic

Josef Holec, Michaela Kolářová, Jaroslav Šuk and Josef Soukup

Department of Agroecology and Crop Production, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, 165 00 Prague 6 – Suchdol, Czech Republic
e-mail: holec@af.czu.cz

Ammi majus L. (Apiaceae) is an annual plant native to the southern part of Europe and west Asia. As a neophyte, it can be found in many regions of the world, including both South and North America. It can be grown as an ornamental but it is more often used as a medicinal plant. Wild populations can also be found on arable land, being reported among serious weeds of selected crops in Italy, where it can be found as a weed in wide-row crops, such as maize, sunflower or sugar beet (Onofri & Tei 1994, Barberi et al. 1997). In Argentina, the plant colonizes abandoned fields (Boccanelli et al. 1999). It was collected in the territory of the Czech Republic in 1898 for the first time and it is currently classified as a casual neophyte (Pyšek et al. 2012).

We detected this species in 2017 on an arable field with vegetables in close proximity to Straky (Polabí region). *Ammi majus* occurred on 20 ha field comprising hundreds of individuals, most of which were fertile with fully developed seeds. The patchy occurrence and high density shows that the species was present at this site for several years, but we were not able to find other individuals in the neighbouring fields. *Ammi majus* can survive and reproduce under current climatic conditions in the Czech Republic and it can act as a weed in wide-row crops. Therefore, this species has the potential to spread in warmer regions with higher concentration of vegetables and sugar beet in crop rotations.

Barberi P., Silvestri N. & Bonari E. (1997) Weed communities of winter wheat as influenced by input level and rotation. Weed Res. 37: 301–313.

Boccanelli S. I., Pire E. F. & Torres P. S. (1999) Vegetation changes in field abandoned after a wheat crop. Pesq. Agropec. Brasil. 34: 151–157.

Onofri A. & Tei F. (1994) Competitive ability and thresholds levels of 3 broadleaf weed species in sunflower. Weed Res. 34: 471–479.

Pyšek P., Danihelka J., Sádlo J., Chrtek J. Jr., Chytrý M., Jarošík V., Kaplan Z., Krahulec F., Moravcová L., Pergl J., Štajerová K. & Tichý L. (2012) Catalogue of alien plants of the Czech Republic (2nd edition): checklist update, taxonomic diversity and invasion patterns. Preslia 84: 155–255.

Rosa multiflora in Prague 6 district: cultivated ornamental and escaping invader

Josef Holec, Markéta Kosánová and Josef Soukup

Department of Agreoecology and Plant production, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, 165 00 Prague 6 – Suchdol, Czech Republic
e-mail: holec@af.czu.cz

Rosa multiflora Thunb. (Rosaceae) is a shrub native to East Asia (China, Korea and Japan), preferring soils with higher nutrient content. In Central Europe, this species is cultivated for its ornamental flowers and it is a parental species for many ornamental *Rosa* hybrids. The relatively small fruits are eaten by frugivorous birds (such as *Turdus merula*) and the species can easily escape from cultivation. It is a problematic environmental weed in North America (Banasiak & Meiners 2009). Větvička (1995) refers to *R. multiflora* as an important cultivated species giving no information about its feral occurrence. Currently, it is classified as a casual neophyte (Pyšek et al. 2012) that can be found not only in cities, but also in the open landscape (Tichá 2004).

In 2017, we commenced monitoring in a part of the Prague 6 district – Suchdol, Sedlec, Lysolaje in north-western borders of the city of Prague in a close proximity to the Vltava River. In total, 54 plants of *R. multiflora* were recorded. We found both cultivated (30%) and escaped (70%) individuals. This indicates that *R. multiflora* can easily become feral in this region and currently feral plants are already more common than cultivated ones. In the group of feral plants that escaped from cultivation, 87% were mature flowering plants and only 13% were juvenile individuals in a vegetative stage. A relatively low share of juvenile individuals can be interpreted as lower intensity of invasion since the plant can colonise the site but it is not spreading very fast.

In the invaded region, *R. multiflora* mainly occurs in shrub vegetation with other woody species, often climbing on trees and taller shrubs. Feral individuals were found in ornamental woody vegetation (including the CULS campus) but also in semi-natural vegetation on the river bank. Thus, we recommend to avoid planting the original type of *R. multiflora* in areas where it can escape and invade natural vegetation and to select for cultivated varieties with a lower invasion potential.

Banasiak S. E. & Meiners S. J. (2009) Long term dynamics of *Rosa multiflora* in a successional system. Biol. Invas. 11: 215–224.

Pyšek P., Danihelka J., Sádlo J., Chrtek J. Jr., Chytrý M., Jarošík V., Kaplan Z., Krahulec F., Moravcová L., Pergl J., Štajerová K. & Tichý L. (2012) Catalogue of alien plants of the Czech Republic (2nd edition): checklist update, taxonomic diversity and invasion patterns. Preslia 84: 155–255.

Tichá S. (2004) Strategie šíření dřevin v pásových výsadbách [Strategy of spread of woody plants in linear plantings]. – In: Polehla P. (ed.), Hodnocení stavu a vývoje lesních geobiocenóz [The assessment of the state and development of forest geobiocoenoses], p. 148–151, Mendelova zemědělská a lesnická univerzita v Brně, Brno.

Větvička V. (1995) *Rosa* L. – růže. In: Slavík B. (ed.), Květena České republiky 4 [Flora of the Czech Republic vol. 4], p. 206–233, Academia, Praha.

Siam weed (*Chromolaena odorata*) invasion in Guinea-Bissau, West Africa

Bucar Indjai[1], Maria Cristina Duarte[2], Filipa Monteiro[2,3], Cristina Máguas[2] and Luís Catarino[2]

[1]*CEATA/INEP - Centro de Estudos Ambientais e Tecnologia Apropriada, Instituto Nacional de Estudos e Pesquisa, Bissau, Guinea-Bissau*
[2]*Centre for Ecology, Evolution and Environmental Changes (cE3c), Faculdade de Ciências, Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Lisbon, Portugal*
[3]*LEAF- Linking Landscape, Environment, Agriculture and Food, Instituto Superior de Agronomia (ISA), University of Lisbon, Lisbon, Portugal*
e-mail: cmhanson@fc.ul.pt (Cristina Máguas)

Chromolaena odorata (L.) R. M. King & H. Rob (Siam weed, Asteraceae) is recognized as one of the worlds worst invasive tropical plants. It is a perennial herb or shrub, native to North and Central America that became invasive throughout the tropical regions of Africa, Asia and Oceania. Two biotypes are recognized in Africa (the Asian/West African biotype and the Southern African biotype). In West Africa, after the accidental introduction in 1937 in Nigeria, it spread to other countries in the region, presently occurring in the upland zones of almost all countries.

In Guinea-Bissau, the presence of *Siam weed* was recently documented for the first time, but its presence seems to date back to the end of 1990's. At first, the species was recorded in the south-western part of the country, probably arising from Guinea Republic, in which its presence was documented for several years. Data gathered in the last months point to a considerable spread of *C. odorata* in Guinea-Bissau, from south to the north, but this seems to be in an early phase. With this work, we aim to provide more systematic information of this early invader, the species habitat characteristics, and introduction time and history

Although the presence of the species was noted for several years, it has only recently expanded and become problematic. *Siam weed* is said to be invasive in young fallows, hampering land clearing, and in the last few years it has been noted to "suffocate" other plants becoming troublesome for several crops. Since the country is suitable for the Asian-West African biotype, it is likely that the invasion will continue. Therefore control measures are needed in order to prevent its expansion and avoid harmful consequences.

Induced damage effect on *Rhododendron ponticum* chemistry composition

Indre Jakaityte and Dylan Gwynn-Jones

Institute of Biological, Environmental and Rural Sciences (IBERS), Aberystwyth University, Wales, United Kingdom
e-mail: inj1@aber.ac.uk

Invasive *Rhododendron ponticum* is infamous for its toxic properties due to its characteristic compounds grayanotoxins (GTXs) that make the plant unpalatable. The plant is also rich in secondary metabolites that act as a defence against herbivores. Due to the lack of herbivory activity, *R. ponticum* has an advantage against the native species to flourish, subsequently reducing native biodiversity of the Snowdonia National Park in North Wales.

There has been little research done on the damage effect on the chemistry of *R. ponticum*. However, intensive clearing that is being carried out in the park causes severe damage to the plant. *R. ponticum* has the capacity to regenerate rapidly through vegetative growth. It is hypothesized that regenerated plants may contain altered chemical composition as a result of induced abiotic stress, thus becoming more aggressive and toxic competitors to native species.

This is the first study that investigates damage induced changes in *R. ponticum* chemistry composition and its seasonal chemical variation. This study compared contents of chemical compounds found in leaves of *R. ponticum* trees severely damaged at three different times during the growth season (May, June and July) and not damaged trees. Additionally, the study analysed seasonal variation of chemical composition by sampling the trees monthly for a year.

Preliminary results of chemical analysis of GTXs from the first six months of data post experimental initialization demonstrate a significant seasonal variation of total GTXs in both treated and control trees. In addition, total GTXs contents were affected by the damage in some months, but not others, suggesting a potentially delayed response to damage. Total GTXs in control trees decreased during the summer demonstrating seasonal variation of GTXs and revealing *R. ponticum* potentially increased vulnerability to herbivores, since GTXs increased in September. Whereas treated trees responded to the damage by maintaining high levels of grayanotoxins compounds. By understanding *R. ponticum* seasonal chemical variation and its response to induced damage, conservationists and ecologists will be better equipped with knowledge about the plant's management in order to achieve successful eradication.

Establishment of early symbiosis in *Acacia longifolia:* does fire play a role?

Joana Jesus[1], Júlio Maciel[1], Rogério Tenreiro[1,4], Cristina Máguas[1,2] and Helena Trindade[1,3]

[1]*Universidade de Lisboa, Faculdade de Ciências, 1749-016 Lisboa, Portugal*
[2]*cE3c – Centre for Ecology, Evolution and Environmental Changes, Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisboa, Portugal*
[3]*CESAM – Centro de Estudos do Ambiente e do Mar, Faculdade de Ciências, Universidade de Lisboa, CBV, 1749-016 Lisboa, Portugal*
[4]*BioISI – Biosystems and Integrative Sciences Institute, Portugal*
e-mail: jguedesj13@gmail.com

Invasive species can cause considerable damage in ecosystems. In Portugal and in other coastal areas in the Atlantic coast, *Acacia longifolia* is one of these species. Native from Australia and Tasmania, it was introduced for ornamental purposes and nitrogen fixation to enrich soils. However, it competes with native species for natural resources, outgrowing them and changing the soil characteristics. One of the factors that drive *A.longifolia* dispersion is fire, by promoting seed germination. In the initial plant growth stages, nodules are structures formed *de novo* in the roots and arise due to symbiosis established with nitrogen-fixing bacteria (NFB), mainly from the Rhizobiaceae family. These bacteria are responsible for nitrogen fixation inside the nodules, as they develop in bacteroids inside the plant cells. These NFB can also be called plant growth promoting bacteria (PGPB), given the direct impact they cause in plants. Although a characteristic trait of acacias is promiscuity in symbiotic partners, the extent of how this is related to invasiveness is not clear. Considering this, native legumes can be a source of rhizobia for the invaders, but it can also be possible that some symbionts are already "buried" in seeds.

This study aimed to (i) understand how fire influences nodule development and functioning, (ii) identify the major microorganisms involved in early symbiosis and what is their succession following a fire, and (iii) compare bacteria found in nodules and in the seeds. To perform this, root nodules from 20-60 cm long young plants of *A. longifolia* were collected in the field (before and after a fire). The surface was sterilized and plated in nitrogen-free medium to isolate endogenous bacteria. Additionally, seeds were also plated after surface sterilization. A collection of *ca.* 180 bacterial isolates was obtained from the nodules and seeds. Genomic fingerprinting of isolates was performed by PCR amplification with csM13 and $(GTG)_5$ universal primers and assessment of diversity was based on dendrograms with Pearson similarity coefficient and UPGMA. 16S rRNA gene sequencing of representatives from the main genomic clusters is also underway to identify the relevant bacterial genus/species involved in this symbiosis and enlighten the role of seeds as a reservoir for *A. longifolia* symbiotic partners.

Can archaeophytes' distribution patterns help us understand the neophytes?

Nejc Jogan

Dept. of Biology, Biotechnical Faculty UL, Večna pot 111, SI-1000 Ljubljana, Slovenia
e-mail: nejc.jogan@bf.uni-lj.si

When comparing the densities of archaeophyte and neophyte species, a clear impression is that the distribution patterns are similar and mostly linked to urbanization. Of course, the floristic data gathered since 18th century are distributed very randomly in time and space, therefore the uneven temporal and spatial floristic coverage of the territory offers a dataset full of gaps. Only for the last four decades, when systematic floristic mapping began taking place, the availability of information has become slightly better. This is also the time period when a number of (not only) invasive neophytes started to increase quickly, and on the other hand, a number of archaeophytic groups such as arable field weeds started decreasing. Archaeophytes and neophytes are plants of foreign origin and in different time periods they entered our flora so we could have expected some comparable patterns of floristic incorporation that would result in comparable distribution patterns.

For the territory of Slovenia, we compared the distribution patterns of archaeophytes and neophytes to other selected geographical patterns that could have been somehow related, for example,the density of Balkan species, endemics, phanerophytes, hydrophytes, high mountain taxa, ratio of widespread species, invasive alien species (IAS), ferns, therophytes, the number of red data list species, protected species, level of floristic uniqueness, average indicator values for temperature, pH and humidity, minimum altitude, maximum altitude and altitudinal span within quadrant and also an average age of floristic data in the quadrant.

Highest positive linear correlation with archaeophyte numbers was (as expected) calculated for neophytes (0,81), therophytes (0,75), total species number (0,71), red data list taxa (0,635), average indicator value for temperature (0,58), number of phanerophytes (0,52) and hydrophytes (0,53), number of widespread species (0,47); highest negative correlation was recognized with altitude span within quadrant (-0,41), number of pteridophytes (-0,41), and the minimal and maximal altitude within a quadrant (both -0,48). Regarding neophyte numbers, the highest positive correlation was with the number of therophytes (0,67), number of IAS (0,54), hydrophytes (0,56), total number of taxa (0,54), average indicator value for temperature (0,45), red data list species (0,49); highest negative correlation for altitude span within quadrant (-0,42), and the minimal and maximal altitude within a quadrant (-0,43 and -0,48, respectively). Evidently, despite the overall similarity in density patterns of archaeophytes and neophytes, there are some slightly different factors connected to their distribution. Not to say that the causal connection is always clear-cut.

The temporal quality of available floristic records do not allow us to unequivocally claim that the number of archaeophytes is declining , but it is very clear that the number of neophytes is increasing and so the ratio of recorded archaeophytes vs. neophytes. In quadrants with predominantly older data (e.g. average data age more than 50 years), the ratio is around 7 and in recently mapped quadrants the ratio is around 5.

For interpretation of such differences we have to bear in mind the differences in processes of selection and introduction of archaeophytes and neophytes. Most important is that archaeophytes originate mostly from Eurasia, a very limited number were introduced intentionally due to their usefulness and others mostly as hitch-hikers (e.g. segetal weeds from Near East). On the other hand, the biggest number of neophytes were brought from other continents or more remote areas of Asia, majority of whichwere brought intentionally for decorative purposes (a motive almost unknown for archaeophytes), so the spectrum of their biological potential is much wider and also the intensity of their introduction (i.e. regarding number of taxa and frequency of introductions). Despite similar density patterns currently, in the future invasive neophytes will achieve bigger secondary ranges.

Shrub establishment favoured and grass dominance reduced in acid heath grassland systems cleared of invasive *Rhododendron ponticum*

Gruffydd Lloyd Jones[1,2], Max Tomlinson[1], Rhys Owen[2], John Scullion[1], Ana Winters[1], Tom Jenkins[3], John Ratcliffe[4] and Dylan Gwynn-Jones[1]

[1]*IBERS, Aberystwyth University, Penglais Campus, Aberystwyth, Ceredigion. SY23 3DA, UK*
[2]*Snowdonia National Park Authority, National Park Office, Penrhyndeudraeth, Gwynedd. LL48 6LF, UK*
[3]*Forest Research, Thoday Building, Deiniol Road, Bangor, Gwynedd. LL57 2UW, UK*
[4]*Natural Resources Wales, Maes y Ffynnon, Penrhosgarnedd, Bangor, Gwynedd. LL57 4DE, UK*
e-mail: glj18@aber.ac.uk

Rhododendron ponticum L. is a damaging invasive alien species in Britain, favouring the moist, temperate climate, and the acidic soils of upland areas. It outshades other species and is thought to create a soil environment of low pH that may be higher in phytotoxic phenolic compounds. We investigated native vegetation restoration and *R. ponticum* regeneration post-clearance on heathland sites within Snowdonia National Park, Wales. One site had existing *R. ponticum* stands while three were restoring post-clearance. Each site also had an adjacent, uninvaded control for comparison. We assessed whether native vegetation restoration was influenced post-invasion by soil chemical properties, including pH and phytotoxic compounds, using *Lactuca sativa* L. (lettuce) bioassays supported by liquid chromatography-mass spectroscopy (LC-MS^n). Cleared sites had higher shrub and bare ground cover, and lower grass and herbaceous species cover relative to adjacent uninvaded control sites; regenerating *R. ponticum* was also observed on all cleared sites. No phenolic compounds associated with *R. ponticum* were identified in any soil water leachates, and soil leachates from cleared sites had no inhibitory effect in *L. sativa* germination assays. We therefore conclude that reportedly phytotoxic compounds do not influence restoration post *R. ponticum* clearance. Soil pH however was lower beneath *R. ponticum* and on cleared sites, relative to adjacent uninvaded sites. The lower soil pH post-clearance may have favoured shrub species, which are typically tolerant of acidic soils. The higher shrub cover on cleared sites may have greater ecological value than unaffected grass dominated sites, particularly given the recent decline in such valuable heathland habitats. However, the presence of regenerating *R. ponticum* on all cleared sites highlights the critical importance of monitoring and re-treating sites post initial clearance.

Asphodelus fistulous, a newly discovered plant invader in South Africa: assessing the risk of invasion and potential for eradication

N. Jubase[1], Jorge L. Renteria[2], David Maphisa[1,3] and Ernita van Wyk[4]

[1]South African National Biodiversity Institute, South African National Biodiversity Institute, Private Bag X7, Claremont, 7735, Cape Town, South Africa.
[2]Department of Environmental Science and Policy, University of California, Davis, CA, USA
[3]Department of Statistical Sciences, University of Cape Town, South Africa
[4]ICLEI – Local Governments for Sustainability, Cape Town, South Africa
e-mail: N.jubasetshali@sanbi.org.za

Naturalizing populations of *Asphodelus fistulosus* (onion weed), native to Europe, were recorded in South Africa for the first time during the early 1990s. This represents the first record of an invasive member of the Asphodelaceae family in South Africa. Initial records lodged in 2012 indicated the presence of two populations. Further surveys and public awareness raising initiatives led to the discovery of five more populations between 2012 and 2016. All known populations occur along roadsides but in other parts of the world the species has demonstrated the ability to spread into adjacent native vegetation and crop fields. Population sizes vary from 4m^2 to 486m^2 and plant density varies from13 plants/m^2 to 4310 plants/m^2. Randomized fixed plots were used to monitor the response of *A. fistulosus* populations to mechanical and chemical control and to track spread over time. Results over a four-year period suggest that suppression of reproduction is possible (age at reproduction is six months) and both mechanical and chemical control were effective. As the plant is highly detectable and control methods are effective, we believe existing naturalized populations can be extirpated with persistent effort. There is substantial uncertainty in terms of knowing whether all naturalized or cultivated individuals have been found. This limits the suitability of the species as a national eradication target. However, based on the invasive risk it poses and given encouraging results from extirpation effort as shown in this study, we conclude that site-specific extirpation is a feasible management goal for this species.

Survival time of rhizomes of invasive *Reynoutria* taxa when above-ground shoot production is prevented by covering with geotextile

W. Kaczmarek-Derda[1], A.-K. Holm[1,2], L. O. Brandsæter[1,2], K. A. Solhaug[2] and I. S. Fløistad[1]

[1]*Norwegian Institute of Bioeconomy Research (NIBIO), Biotechnology and Plant Health, Department Invertebrate Pests and Weeds in Forestry, Agriculture and Horticulture, Høgskoleveien 7, Ås, Norway*
[2]*Norwegian University of life Sciences (NMBU), Norway*
e-mail: wiktoria.kaczmarek@nibio.no

Japanese knotweed (*Reynoutria japonica*), giant knotweed (*R. sachaliensis*) and their hybrid (*R.* ×*bohemica*) are tall, robust perennials arising from strong, woody below-ground shoots that form a dense rhizomatous system. The species native to Asia are invasive weeds in many European lands, including Norway. *Reynoutria* infestations threaten biodiversity by changing the habitat and species composition and are common along railway lines, roads and riverbanks. Since the species primarily reproduces clonally in Norway, the most important control measure is preventing the spread of vegetative fragments. Knowledge about how long the rhizomes can live in soil is crucial to develop control methods, monitoring locations after control and handling of infested soil masses.

Two field studies were established in autumn 2015 in southeastern Norway (59°N 10°E) to investigate survival time of rhizome systems in *Reynoutria* taxa. Experiment 1 (Exp. 1) examined the survival time of intact rhizome systems when above-ground shoot production was prevented by covering with geotextile, while Experiment 2 (Exp. 2) investigated if fragmentation of rhizomes, either alone or combined with removal of below-ground shoot clumps before covering can reduce the survival time of the rhizomes. In Exp. 1, five stands of *R. japonica* and *R*. x *bohemica* were cut down. Shoots were counted within 2 × 2 m quadrats before the stands were covered with geotextile. In each stand, one of these quadrats were uncovered in early June 2016, 2017 and 2018. A new quadrat was uncovered each year. In Exp. 2, a stand of *R.* x *bohemica* was cut down and divided into nine treatment rectangles (4 × 6 m), each containing two counting quadrats (2 × 2 m) where shoots were counted at the start of the experiment. The treatments in Exp. 2 included a) cutting + covering, b) cutting + fragmentation (50 cm depth) + covering and c) cutting + fragmentation (50 cm depth) + removal of shoot clumps + covering. Half of the counting quadrats were uncovered in 2016, the other half in 2017. In both experiments (Exp. 1 and 2), the shoots that had sprouted under the cover were counted and harvested at the day of uncovering. The quadrats were left open for one month, and the regrown shoots were counted and harvested before the quadrats were covered again. The harvested plant material was dried at 60°C for one week for dry matter (DM) determination.

For Exp. 1, preliminary results showed that the number of shoots increased within all stands in 2016 and 2017, but decreased within four out of five stands in 2018, compared to the start of the study in 2015. The mean dry matter of shoots one month after uncovering decreased, by more than 70% in 2017 and by approximately 98% in 2018, compared to 2016. The increase in shoot number may be an effect of the cutting at the start of the experiment. For Exp. 2, without fragmentation, the number of shoots one month after uncovering increased in 2016, but decreased in 2017, compared to at the start in 2015. The treatments that included fragmentation reduced the number of shoots in both years. All treatments resulted in a higher decrease of shoot biomass in 2017 than in 2016. Fragmentation contributed considerably to reduced regrowth in 2016, especially when combined with removal of shoot clumps, but the differences were less pronounced in 2017.

The experiments show that the rhizome systems survive longer than two years and none of the treatments allowed for complete control of *Reynoutria* taxa within this period. However, a longer duration of covering resulted in a higher reduction of new shoots and dry matter. Covering combined with fragmentation and removal of shoot clumps contributed most to the reduction of regrowth.

Genetic variation of the invasive *Ambrosia psilostachya* in Europe is biased by clonal propagation

Gerhard Karrer[1], Rea Maria Hall[1], Valerie Le Corre[2] and Matthias Kropf[1]

[1]*Department of Integrative Biology and Biodiversity Research; University of Natural Resources and Life Science Vienna, Gregor Mendel Street 33, A-1180 Vienna, Austria*
[2]*INRA, UMR1347 Agroécologie, Dijon, France*
e-mail: gerhard.karrer@boku.ac.at

Western ragweed (*Ambrosia psilostachya* DC.) is native to North America and naturalized in Europe. This perennial species is reproducing clonally by root sprouts which enable the species to invade 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 genetic and demographic structure of the invasive populations is still unexplored. Therefore, we sampled 61 populations throughout Europe and analysed genetic diversity and population genetic structure based on 15 microsatellite loci.

Our results indicate meaningful genetic differentiation among populations of *A. psilostachya*. Allelic richness (Na) within populations varied between 1.5 and 4.7. With a populational Fst-value of 0.20, 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-hierarchical AMOVA indicating that approx. 80% of genetic variation occur within populations. We found a significant deviation from the Hardy-Weinberg Equilibrium in all populations which was confirmed by the unbiased estimate of excepted heterozygosity (uHe = 0.46) indicating high homozygosity levels. Thirty-four populations showed at least one monomorphic locus, particularly, the Northern populations which were characterized by approx. 70% homozygote loci. In general, populations originating from the same region showed reduced genetic distance compared to populations from remote regions. In eight populations, we found at least one clone which also occurred in one other population, indicating an exchange of clones between these populations. Two of those populations that exchanged clones were rather nearby (0.3 and 7 km, connected by continuous anthropogenic disturbance and a river bed, respectively). The others were far from each other (162 km and 106 km, disconnected across the Adriatic Sea and along the southern Adriatic coastline, respectively.). While the first case can be interpreted as post-introductory expansion by obvious vectors, the second cases can be explained either by very rare far distance shoot fragment dispersal or by concerted introduction from identical sources. In addition, significant clonal structures were detected from genetic data in 55.7% of all populations studied.

JOINT AMBROSIA ACTION: Interreg-Project V-A Austria-Hungary to fight common ragweed (*Ambrosia artemisiifolia*)

Gerhard Karrer[1], Peter Zinggl[2], Anita Szeiber[3] and András Vér[4]

[1]*University of Natural Resources and Life Sciences Vienna, Gregor Mendel Street 33, A-1180 Vienna, Austria*
[2]*Government of the Province of Burgenland, Eisenstadt, Austria*
[3]*Government Office for the Győr-Moson-Sopron County, Hungary*
[4]*Széchenyi István University Győr-Moson-Sopron, Hungary*
e-mail: gerhard.karrer@boku.ac.at

The pollen of ragweed (*Ambrosia artemisiifolia* L.) is known to be a particularly aggressive allergen which causes tremendous economic loss each year. While Hungary has already been affected for a long time and thereby successfully established control measures both in organizational and legal terms, in Austria the plant has only increasingly spread in the last 20 years. Since the spread takes place via Eastern neighbouring countries, the province of Burgenland is particularly strongly affected. However, neither a regulated procedure for detection and control of ragweed, nor any collaboration with Hungarian authorities currently exists on the Austrian side. This imbalance in the capacity for action of administrative systems constitutes a major challenge for the border region. As ragweed does not stop at the border, this problem can only be combated by acting together.

The project has set the objective of establishing a sustainable institutional cooperation on the issue of ragweed control between the Austrian and Hungarian administrative systems and research institutions. This enables a know-how transfer that benefits both sides and improves the quality of public service and thereby also quality of life for the population.

In the framework of this survey and research, fundamental data will be collected (main output 1: cross-border cooperation of universities in the frame of the research activities) on the basis of which coordinated recommendations can be made in order to control and to prevent the spread. A cross-border data exchange about pollen loads and ragweed population loads is first made possible by establishing ragweed reporting systems in both countries that exchange regularly relevant data. The establishment of a bilateral ragweed task force with experts of both countries lays the foundations for a long-lasting institutional cooperation (main output 2: sustainable cross-border cooperation of administrative bodies).

Long term experience with ragweed detection and eradication based on the rigid legal basis are provided by Hungarian colleagues to Austrian authorities of the federal state of Burgenland which aim at setting up a legal basis of ragweed monitoring and extirpation. Experienced specialists from the University of Natural Resources and Life Sciences in Vienna as well as from the Széchenyi István University in Mosonmagyaróvár compiled optimal strategies to defeat ragweed with respect to the constraints of habitat type specific management options. A beta-version of the new monitoring and management system of Burgenland was installed in 2018 and will be improved in 2019. The final version and its legal basis is planned for the beginning of 2020.

Germination of *Lupinus polyphyllus* depends on cutting date and seed morphology

Yves P. Klinger[1], R. Lutz Eckstein[2], Annette Otte[1] and Kristin Ludewig[1]

[1]*Institute of Landscape Ecology and Resource Management, Research Centre for Biosystems, Land Use and Nutrition (iFZ), Justus Liebig University Giessen, Heinrich-Buff-Ring 26-32, D-35392 Giessen, Germany*
[2]*Department of Environmental and Life Sciences, Biology, Karlstad University, SE- 651 88 Karlstad, Sweden*
e-mail: yves.p.klinger@umwelt.uni-giessen.de

The legume *Lupinus polyphyllus* is among the 15 most common non-native plant species in Germany. As an ecosystem engineer, it is capable of altering nitrogen turnover and vegetation structure of invaded sites. It was introduced to the Rhön Biosphere Reserve in the 1930s in spruce woods and along newly built roads and has persisted in the region since then. Its large-scale spread into species-rich mountain meadows began after the annual mowing schedule was postponed for the protection of ground-nesting birds. Studies showed that the area invaded by *L. polyphyllus* doubled between 1998 and 2016 (Klinger et al., submitted). Overall, management in the Biosphere Reserve is currently not adequate to control the invader and little is known concerning the optimal cutting date to avoid seed maturation.

We analyzed the effect of the cutting date on the germinability of *L. polyphyllus* in order to develop management recommendations. To this end, we collected lupine seeds from five locations in the Rhön Biosphere Reserve during six weeks and let each seed batch germinate in climate chambers. We assessed easy-to-distinguish seed traits such as seed color and seed hardiness at each harvest date, these ranged from green and soft seeds to black and very hard seeds. Based on this information, we assessed germination percentage, mean germination time (MGT), and synchrony of germination of *L. polyphyllus* seeds.

Our results showed that germination behavior of *L. polyphyllus* seeds varied between the cutting dates. While on the first cutting date, when lupine seeds were soft and green, germination percentage was low (9%), during the second and third week of our experiment, lupine seeds showed high (16–26%) and rapid germination (MGT: 98 days). During the last week, after *L. polyphyllus* seeds had turned black and hard, germination percentage was low (13%) and germination rapid (MGT: 74 days), indicating physical dormancy. Furthermore, the germination of *L. polyphyllus* was highly asynchronous over all weeks and locations, indicating that *L. polyphylus* is a “pessimist” concerning germination. Overall, our results underline that *L. polyphyllus* stands should be managed during flowering and when seed pods are already present on the plants, mowing should be undertaken when the seeds are still green and soft.

The role of alien species in plant communities that developed in the ruderal habitats of the Silesian Uplands (Southern Poland)

Agnieszka Kompała-Bąba[1], Wojciech Bąba[2], Agnieszka Błońska[1] and Robert Hanczaruk[1]

[1]*University of Silesia in Katowice, Faculty of Biology and Environmental Protection, Department of Botany and Nature Protection, Jagiellonska 28, 40-032 Katowice, Poland*
[2]*Jagiellonian University*, *Institute of Botany, Department of Plant Ecology, Gronostajowa 3, 30-387 Kraków, Poland*
e-mail: agnieszka.kompala-baba@us.edu.pl

We studied urban and rural communes situated in the Silesian Uplands (southern Poland). In total, 2227 vegetation and soil samples were obtauned in ruderal habitats located in towns in habitats such as built-up and industrial areas, abandoned fields, gardens, cemeteries, urban parks, lawns, road, tram and railway tracks. The aim of this study was to (i) show the participation of alien species in the floristic composition of distinguished vegetation patches, and (ii) to determine how species traits are selected along environmental gradients. As a result of classification, 26 repeated vegetation units were delimited. The floristic composition of these units significantly differed in reference to participation of native and alien species. Native synanthropic species (apophytes) prevailed in the floristic composition in almost all of the examined plant communities. Some alien species, such as *Solidago canadensis, Conyza canadensis, Solidago gigantea, Matricaria maritima* subsp. *inodora,* and *Erigeron annuus*, occurred most frequently in vegetation patches (i.e. more than 300 patches and at least in 20 plant communities). Alien species whose origin dates back to 15th century (i.e. archaeophytes), such as *Berteroa incana* and *Ballota nigra*, had a higher abundances in phytocoenoses that developed on trampled places (e.g. on unmowned lawns, roadsides, near the fences, along park edges, allotments or cemeteries), and well-developed patches with *Leonurus cardiaca* were found near fences and in previous rural habitats. In some patches, alien species (*Solidago canadensis, S. gigantea, Helianthus tuberosus* or *Reynoutria japonica*) that arrived in Poland after the 15th century and became permanently established in natural and seminatural habitats (kenophytes) had a relative abundance of more than 50%.

The RLQ analysis enabled us to distinguish five responsive groups of species that reflects fertility (N, P, K, MgO, N tot) and disturbance gradients. The first group comprised perennial plants with larger leaf surfaces which connected them with fertile habitats and these species started to flower late during the growing season. Some species could produce fewer but heavier seeds, whereas others could produce more diaspores that are lighter and these species had the ability to spread laterally which enabled them to acquire more space. Species such as *Solidago canadensis, S. gigantea, Reynoutria japonica, Asterx salignus,* and *Helianthus tuberosus* resemble this group. In contrast, the second group comprised species with more retentive/conservative traits which was connected with lower fertility and a later disturbance. These species had a smaller stature and leaf surface area, flowered earlier during the year, and produced many light diaspores. The third group comprised some annuals, e.g. *Conyza canadensis*, *Sisymbrium officinale* and *Hordeum murinum*, which germinate in late summer or autumn and they produce vegetative rosettes and accumulate over a wide range of climatic conditions. They can grow rapidly during spring and thus take advantage of the available environmental resources. The fourth group contained perennial species, some of which can form a persistent seed bank that produces large numbers of light diaspores with a low terminal velocity. This selection facilitates species to find suitable conditions for establishment and maintenance in urban areas. These species colonized former wastes dumps and sites that are susceptible to erosion. Lastly, the fifth group comprised annual and biennial species that produce a large number of seeds with a high terminal velocity or they possess the ability to spread laterally (e.g. *Artemisia annua, Atriplex patula, Impatiens parviflora*).

Perennial ornamental plantations as a source of plant invasion: long-term trends in species compositions

Josef Kutlvašr[1,2], Jan Pergl[1], Adam Baroš[3] and Petr Pyšek[1,4]

[1]*Department of Invasion Ecology, Institute of Botany, Academy of Sciences of the Czech Republic, Zámek 1, CZ-252 43 Průhonice, Czech Republic*
[2]*Department of Applied Ecology, Faculty of Environmental Sciences, Czech University of Life Sciences Prague Kamýcká 129, CZ-165 00, Prague – Suchdol, Czech Republic*
[3]*Department of Cultural Landscape and Sites, Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Květnové náměstí 391, CZ-252 43 Průhonice, Czech Republic*
[4]*Department of Ecology, Faculty of Science, Charles University, Viničná 7, CZ-128 44 Prague, Czech Republic*
e-mail: Josef.kutlvasr@ibot.cas.cz

Ornamental plantations are typical for a broad range of human-made habitats such as gardens, parks or urban spaces. Nowadays,the so-called low-maintenance perennial beds are becoming popular in horticulture and urban planning. Due to a low level of management and a good record of the time of establishment and planting, they provide a suitable study system for analyzing individual species' survival and how this depends on their traits. As such, monitoring the population processes (survival, reproduction and spread) can provide detailed information on the naturalization and community assembly processes within the scope of one of the most important source of alien plants – horticulture.

We studied perennial flowerbeds in the Czech Republic with a known initial composition at the time of establishment between 2006–2010 and compared this with the state in 2016. The flowerbeds were initially planted in a publicly accessible part of the garden for ornamental purposes and harboured diverse species compositions. We tested the effect of biological traits of species (height, vegetative and generative reproduction, and specific leaf area) on their survival and spread, and analysed the changes over time in species composition, richness and diversity.

We found that the height of plants and generative reproduction had a positive effect on the survival of individual taxa. Taxa taller than 1 m with massive and regular generative reproduction survived best. *Aquilegia* sp., *Aster dumosus, Knautia macedonica* and *Silene coronaria* spread most easily into neighbouring areas. In terms of flowerbed compositions and their 10 years dynamics, highly diverse assemblages were most stable, and the most successful group of taxa were those of Mediterranean origin.

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Optimising the long-term management of invasive species affecting biodiversity and the rural economy using adaptive management

Bárbara Langdon[1,2], David Burslem[3], Paul Caplat[4], Thomas Cornulier[3], Laura Fasola[5], Alessandra Fidelis[6], Julio Lancelotti[7], Lía Montti[8], Martín Nuñez[9], Steve Palmer[3], Aníbal Pauchard[1,2], Euan Phimister[3], Priscila Powell[10], Ignacio Rodriguez[11], Ignacio Roesler[12], Justin Travis[3], Claudio Verdugo[13], Xavier Lambin[3] and the CONTAIN Consortium

[1]*Laboratorio de Invasiones Biológicas (LIB), Facultad de Ciencias Forestales, Universidad de Concepción, Chile*
[2]*Instituto de Ecología y Biodiversidad (IEB), Chile*
[3]*Institute of Biological and Environmental Sciences, University of Aberdeen, Scotland*
[4]*School of Biological Sciences, Queen's University of Belfast, Ireland*
[5] *Dirección Regional Patagonia Norte, Administración Parques Nacionales, Argentina / CONICET/ Aves Argentinas-Asociación Ornitológica del Plata.*
[6] *Departamento de Botânica, Instituto de Biociências (Rio Claro), Universidade Estadual Paulista, Brazil*
[7] *Centro Nacional Patagónico (IPEEC-CENPAT), Argentina / CONICET*
[8] *CONICET-Instituto de Investigaciones Marinas y Costeras, Universidad Nacional de Mar del Plata, Buenos Aires / Instituto de Ecología Regional (IER-CONICET), Argentina*
[9] *Grupo de Ecología de invasiones (INBIOMA-CONICET), Universidad Nacional Del Comahue, Argentina.*
[10] *Instituto de Ecología Regional, Universidad Nacional de Tucumán, Argentina / CONICET*
[11] *Centro de Humedales Rio Cruces (CEHUM), Universidad Austral de Chile, Chile*
[12] *Laboratory of Ecology and Animal Behavior, Faculty of Exact and Natural Sciences, University of Buenos Aires, Argentina / IEGEBA-CONICET/Aves Argentinas-Asociación Ornitológica del Plata*
[13] *Instituto Patología Animal, Facultad de Ciencias Veterinarias, Universidad Austral de Chile, Chile*
e-mail: barbaralangdon@gmail.com

A large number of highly damaging invasive non-native species (INNS) have become established in South America. They affect native species, ecosystems and livelihoods. Many INNS are now so widespread that eradication is not an option. Their spread must be contained and their density reduced, in the long-term, in those areas where taking no action is not acceptable. This must be done as cost effectively as possible, considering questions as: by how much should INNS density be reduced, What harm would be caused in the future if no action was taken? How should the desired reduction be achieved?, Where should the species be reduced? A further important consideration is that INNS are mobile. They have been able to spread when they first invaded and can re-invade areas from which they have been removed through dispersal.

This project aims to design and introduce to stakeholders a user-friendly decision tool that hopefully will become widely used in Latin America. To make sure that the approach is relevant for different contexts in Latin America, work will be done with example species that have large impacts, and for which data already exist (invasive pines, privet, and mink). Plausible scenarios for data-poor pine species, exotic grasses and carnivorous wasps, which impact local communities in Brazil, Argentina and Chile will also be modeled. The most effective strategic management will be found using sophisticated computer simulations considering species ecology, dispersal and intervention costs in a spatial context. Where new data would most effectively reduce uncertainty on the best course of action will be identified. The problem this project aims to tackle is complex, and it will be embedded in a process of co-operative adaptive management, so that managers continually improve their effectiveness by confronting different models to data. The project will also be used as a way to build research capacity in Latin America, by training early career researchers and PhD students by means of research visits, continuous collaboration and workshops. This project will have a tangible positive and immediate impact on people and biodiversity in Latin America by delivering a step-change in the management of problematic INNS.

The invasive potential of forestry species in South Central Chile: first steps towards management planning

Bárbara Langdon[1,2], Aníbal Pauchard[1,2] and Ramiro O. Bustamante[2,3]

[1]*Laboratorio de Invasiones Biológicas (LIB), Facultad de Ciencias Forestales, Universidad de Concepción, Victoria 631, Barrio Universitario, Concepción, Chile*
[2]*Instituto de Ecología y Biodiversidad (IEB), Chile*
[3]*Laboratorio de Ecología Geográfica, Facultad de Ciencias, Universidad de Chile, Santiago, Chile*
e-mail: barbaralangdon@gmail.com

Tree invasions are a threat to biodiversity conservation and although it is difficult to predict the future spread of invasive tree species, there are tools available which could allow some estimations. The last report on Chilean Forest Resources, shows that commercial plantations reach 2,447,591 ha, with *P. radiata* (1,469,718 ha), *E. globulus* (563,813 ha), *Eucalyptus nitens* (246,726 ha), *Pinus ponderosa* (27,775 ha), and *Pseudotsuga menziesii* (16,222 ha) among the main planted species. The same report indicates that according to annual plantation surface, *P. radiata* is still the most planted species, followed by *Eucalyptus* species, located mostly in the South-Central Regions of Chile.

We aimed to (i) assess whether forestry species, such as *Eucalyptus globulus, Eucalyptus grandis, Eucalyptus nitens, Pinus contorta, Pinus ponderosa, Pinus radiata and Pseudotsuga menziesii*, used with commercial purposes in South-Central Chile, conserve their niche in the new environment, and (ii) estimate the invasion stage of each species. Bioclimatic variables and occurrences at the native and the invaded (i.e. South-central Chile) ranges were used to elucidate whether climatic niche requirements are conserved (or not) in the invaded region, and whether the distribution has allowed a geographical equilibrium in the invaded range. Global and Regional (South-central Chile) Species Distribution Models (SDM) were constructed to discern what fraction of the fundamental niche is expressed in the invaded range. Results showed that the Global SDM has a significantly better fit than the regional or native SDMs. From the seven species assessed, none of them are at equilibrium with the environment, and only two of them, *Pinus contorta* and *Pseudotsuga menziesii*, conserve their climatic niche. The same trend is shown in the global-regional comparison. Populations from the studied species, are far from stabilizing, with a high proportion of them establishing outside the predicted areas.

According to our results, these forestry species are in an early stage of the invasion process in Chile, when comparing with the situation registered in other regions. This opens an opportunity to avoid major impacts, which should reduce managing costs. These results are fundamental keys to develop biosecurity tools, which will allow decision makers and managers to prioritize between species and areas to manage invasions, enhancing efficiency of management activities.

The impact of invasive alien plant species on the regeneration of European temperate broadleaf and mixed forests

Katharina Lapin[1] and Magdalena Langmaier[1,2]

[1]*BFW Wien, Seckendorff-Gudent-Weg 8, 1131 Wien, Österreich*
[2]*Universität für Bodenkultur Wien, Österreich*
e-mail: katharina.lapin@bfw.gv.at

Invasive Alien Species (IAS) can spread aggressively and become dominant in certain areas, thereby compromisng other species. The negative effects of certain IAS are considerable in many countries. IAS are considered as one of the main reasons of biodiversity loss worldwide and can cause major economic damage. In forests, the topic of combating invasive alien plants (IAP) is primarily a question of whether such species threaten or displace native habitats or species, or whether they prevent the rejuvenation of forests that are suited to their location.

Therefore, in this study, we aimed to obtain an overview of how and which IAP have impacts on the regeneration of trees in European temperate broadleaf and mixed forests. In order to address these research questions, we decided to investigate the Central European region in detail. For structure, we used the terrestrial ecoregions classification according to WWF and the Digital Map of European Ecological Regions. We are currently performing a literature review of the different terms pertaining to our research questions to determine how much research is being done in this area. The search is geared to the following questions: (i) which IAP has a direct and/or indirect influence on regeneration (i.e. artificial and natural regeneration) in the forests of Central Europe? (ii) The rejuvenation of which tree species in forests in Central Europe is endangered by IAP? (iii) Which mechanisms or characteristics of IAP affect rejuvenation? and (iv) What management measures and plans are in place to counter the impairment of rejuvenation by IAP and what costs are incurred as a result?

The terms were related to the research questions. Nine search queries with different combinations were performed, and a total of 3,825 hits were obtained. Through systematic literature review, we are reducing the number of research articles in each step, focusing more closely on the research questions. In the end, we hope to show which scientific expertise is currently available on this topic.

AlienScenarios: developing and applying scenarios of biological invasions for the 21st century

Guillaume Latombe[1], Bernd Lenzner, Céline Bellard, Franck Courchamp, Christophe Diagne Stefan Dullinger, Marina Golivets, Jonathan Jeschke, Ingolf Kühn, Brian Leung, Camiile Macnaughton, Dietmar Moser, Núria Roura-Pascual, Hanno Seebens, Zofia Taranu and Franz Essl

[1]*University of Vienna, CVL Division, Rennweg 14, 1030 Vienna, Austria*
e-mail: guillaume.latombe@univie.ac.at

Climate change, land-use change and biological invasions have been identified among the most important drivers of biodiversity loss. Changes in climate and land use have received much attention during the last decades, which resulted in readily available scenarios. In contrast, comparable approaches are completely missing for biological invasions, although recent research has shown that the numbers of alien species are rising unabatedly. Therefore, a thorough evaluation of plausible future trajectories of biological invasions is urgently needed to enable comprehensive assessments of biodiversity changes for the decades to come, to allow for better-informed decisions of policy makers and stakeholders, and to examine the future implications of different societal responses for biological invasions. In AlienScenarios, we will combine the strategic forward-looking methodology of scenario planning with advanced modelling approaches to construct, for the first time, plausible global mid-term (2050) and long-term (2100) futures of biological invasions and their impacts at different spatial scales and for a range of taxonomic groups.

In AlienScenarios, we will: (i) develop the first global, continental and regional scenarios and models for biological invasions for the 21st century; (ii) assess the effectiveness of regulation of invasive alien species; and (iii) evaluate the future impacts of biological invasions on the environment and human livelihoods

In summary, we will quantitatively elucidate the plausible range of future invasion trajectories, provide crucially needed data for pro-active alien species management and policy, and explore options for arriving at preferred futures through the adaptation of existing policies. Here, we present the current advancement of the AlienScenarios project with respect to the three points above.

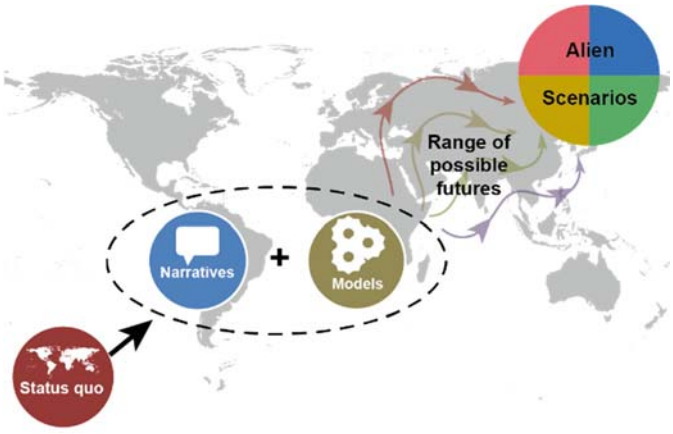

Fig. 1. Based on the current situation, qualitative narratives are described, from which quantitative models are derived. The combination of narratives and models define possible scenarios of biological invasion for the future.

Towards a better understanding of plant invasions in the boreal zone of European Russia: the inventory of Kostroma alien flora

Artem Leostrin

Komarov Botanical Institute, the Russian Academy of Sciences, St. Petersburg, Russia
e-mail: aleostrin@binran.ru

The data on alien plant invasions in the regional floras of European Russia are represented significantly uneven and this has been pointed out in the most recent research (Vinogradova et al. 2018). To fill this data gap and to satisfy current needs of invasion biology, a number of regional inventories should be carried out, particularly across the boreal forest zone. In the central part of European Russia, Kostroma is among the least developed regions, with natural and seminatural forest vegetation covering about 70% of the area. The ongoing inventory of alien plants in the Kostroma region is a project aimed to improve the understanding of current trends in plant invasions in the boreal zone of European Russia. The inventory is based on herbarium collections and published data covering the last 130 years of floristic records and intensive field work was implemented between 2011–2018.

To date, at least 250 alien vascular plant taxa were reported as naturalized in the Kostroma flora, of which 40 are invasive. Fifteen invasive alien species (IAS) have successfully spread across the entire region. The alien-rich sites were strongly associated with several urban areas, and railways seems to be the most important vector spreading neophytes. At the same time, the expansion of IAS is limited, presumably due to climatic factors as well as by the presence of suitable habitats. Primarily they inhabited coastal environments and abandoned arable lands, while forested areas remained sustainable for invasion. A large number of IAS that are common in more temperate regions of European Russia have not yet naturalized in Kostroma. This delay might be related to the slowing of IAS spreading along the south to north gradient. Thus, the boreal forest zone serves as a barrier sifting out the most successful IAS. Considering this, two questions should be answered: (i) are there significant differences in the distribution and naturalization of IAS in the adjacent biogeographical regions, namely boreal forests and hemiboreal ones, and (ii) what influences invasion success more, climatic factors or the urbanization rate in a region?

The main outputs of this project include: (i) the establishment of an extensive database of Kostroma IAS, (ii) revealing the regional spatio-temporal patterns and assessing impact of IAS, and (iii) improving regional nature conservation and policy making. This project also intends to focus on plant invasion patterns in the boreal zone of European Russia and to bring new insight on IAS spreading across latitudinal gradients. We presume that the low representation of boreal regions in Russian IAS inventory may lead to a biased assessment of the IAS spatial and temporal patterns in the boreal forest zone, and the Kostroma region may serve as a model area to study plant invasions in the southern limit of the boreal forest.

An integrative approach to assess how invasive plants affect ecosystem service multifunctionality

Theo E. W. Linders and Peter Manning

Senckenberg Biodiversity and Climate Research Centre, Frankfurt am Main, Germany
e-mail: theolinders@gmail.com

An increasing body of literature describes the many impacts that alien invasive trees have on both ecosystems and humans. A challenge in assessing these impacts is that some invasive alien species generate conflicts-of-interest, as they provide some benefits, while simultaneously having negative impacts on other ecosystem services. A multifunctionality approach, which assesses multiple impacts simultaneously, is therefore helpful in drawing informed conclusions about net impacts. Additional challenges in assessing impacts are that simultaneous positive and negative impacts can be separated in space and the people who are affected positively are not necessarily those who are impacted negatively. Furthermore, it is often unclear how impacts on the ecosystem properties translate into impacts on ecosystem services. To address these challenges, we propose a multifunctionality approach that helps bridge the gap between the assessment of invasion impacts and the development of sustainable management options.

We use *Prosopis juliflora* in Eastern Africa as a case study to understand how an invasion affects ecosystem service multifunctionality for different stakeholder groups. To achieve this goal we combined plot level data on the ecological impact of *P. juliflora* on multiple biodiversity and ecosystem service indicators, with quantitative stakeholder surveys. In the latter, we assessed the relative importance of ecosystem services for different stakeholder groups, as well as the benefit they gain from different supply rates of ecosystem services. Ecological- and stakeholder preference data are integrated with current and projected *P. juliflora* distribution maps to create landscape-scale multifunctionality maps for a range of stakeholder groups. This mapping procedure forms the basis of several future scenario simulations, in which different scenarios regarding invasive species management and *P. juliflora* spread are tested. Mapping the effect of an invader on current and future ecosystem service multifunctionality will highlight which ecosystem services are crucial to retain and in which areas management priorities are highest.

Mapping and monitoring water hyacinth (*Eichhornia crassipes*) in Sardinia (Italy) based on color-morphology features using Unmanned Aerial Vehicles

Vanessa Lozano[1], Giuseppe Brundu[1], Luca Ghiani[1], Alberto Sassu[2], Davide Piccirilli[1] and Filippo Gambella[1]

[1]*Department of Agriculture, University of Sassari, Viale Italia 39, 07100 Sassari, Italy*
[2]*Inspire s.r.l., Via XX settembre 33/10, 16121 Genova, Italy*
e-mail: gbrundu@tin.it

Invasive aquatic alien plants cause significant negative impacts in many inland waters worldwide. Importantly, *Eichhornia crassipes* can cause significant harm, including covering the water surface, obstruction of river channels, and depletion of oxygen. These effects can significantly impact native biodiversity, farmland irrigation and water transportation. Despite several control efforts, outbreaks of *E. crassipes* are common in rivers and irrigation or draining channels on the west coast of central Sardinia (Italy) with negative ecological and economic impacts.

This study was conducted within the framework of a project funded by the Sardinian Regional Authority (i.e. POR FESR Sardegna 2014–2020 - Asse 1- Azione 1.1.3, "MARS - Multiple Airdrones Response System"). The objective of this study was to develop an efficient method, using Unmanned Aerial Vehicles (UAVs), to map and monitor the change in cover of *Eichhornia crassipes* in the invaded area in Sardinia (Italy) to a more refined quantification of the phytomass for planning control interventions. The species was monitored in the same site from late winter to spring (2018-2019) using RGB, Red Edge and NIR cameras, installed on board of a UAV (*Phantom 4 pro, DJI)*. The high-resolution imagery, obtained from the different sensors, was evaluated in order to study the temporal variability, the covered area, and the distribution of the invasive plant. All images were analyzed using a pixel-based approach, for the classification of aquatic overlapping plants and partial obstruction in the water surface. As a preliminary result, we present the mapping of *E. crassipes*, highlighting the cost-effectiveness and replicability of this approach to detect the presence of this invasive alien species in aquatic environments. This method could be applicable to other waterways and offers the potential for the early detection of infestations of floating aquatic species where the applicability other survey methods might be difficult.

Fig. 1. On the left side the Unmanned Aerial Vehicle (Phantom 4 pro, DJI) used to monitor the invasion of *Eichhornia crassipes*. On the right side the high-resolution image, obtained from the RGB sensor in the study area (Sardinia, Italy).

Native and not-native weeds in globe artichoke fields under diverse cropping systems in Sardinia (Italy)

Vanessa Lozano, Giuseppe Brundu, Maria Teresa Tiloca and Luigi Ledda

Department of Agriculture, University of Sassari, Viale Italia 39, 07100 Sassari, Italy
e-mail: gbrundu@tin.it

Globally, both native and non-native weeds pose an important economic threat to crop production in agricultural areas as they compete for space, light, water and nutrients from the soil. The rate between native and non-native weeds in agricultural cropping systems has only been scarcely studied as the weed flora is more frequently considered as a single unit. However, pathways of introduction and spread and impacts might be diverse. Agricultural areas can be sites of introduction of new alien species, therefore it needs to be periodically monitored or they could act as reservoirs of alien species that can also invade adjacent semi-natural to natural areas, thus specific management plans are to be put in place.

This study was conducted in the framework of a project funded by the Sardinian Regional Authority (i.e. "CarBio – Carciofo Biologico: innovazione e sostenibilità di filiera"). The objective of the study was to assess the native and non-native weed flora in Sardinian globe artichoke fields, under different management types (conventional or alternative) along a temporal and geographic gradient. To estimate weed cover in the field, we established a network of 1 × 1 m control plots between the artichoke's rows which were GPS located, and this resulted in a total of 12 plots per field. The presence/absence and cover degree of all weeds were evaluated. The investigated fields are located in three main macro-areas of the island of Sardinia (Italy) in which globe artichoke cultivation represents the most important and economically relevant open field horticultural crop. We also evaluated weed flora diversity as a result of weed management changes in globe artichoke cropping systems. Specifically, we evaluated the following three management systems: (i) conventional cultivation, (ii) improved monoculture in which in globe artichoke cropping system was introduced no synthetic fertilizer supply and a short cycle of French bean (*Phaseolus vulgaris* 'Bronco', both for additional income and for N supply, and (iii) organic systems characterized by no synthetic fertilizer supply and an inter-row crop cover of pea (*Pisum sativum* 'Attika').

Taking into account *Cynara* growth cycle, floristic data were collected during three different periods of the year and species were monitored from late winter when inflorescence developed (BBCH code 50-9) to summer when globe artichoke was BBCH code 30-9 (leaf development) during the first growing season (2018–2019).

As a preliminary result, we present the full checklist of the recorded weed species and the seasonal differences of the coverage of native and non-native weeds. *Oxalis pes-caprae* is one of the most abundant alien species in the globe artichoke fields during the late winter – early spring season, despite the many attempts to control its spread. The research is in its initial phase, however, the data collected so far have highlighted significant differences among cropping systems which suggests the possibility of identifying optimal and sustainable strategies for the management of native and non-native weeds in *Cynara* fields, by developing more eco-friendly production systems.

Mapping *Anthriscus sylvestris* and *Myrrhis odorata* in Reykjavík, Iceland

Mervi Orvokki Luoma[1], Mariana Tamayo[1] and Snorri Sigurðsson[2]

[1]*Environment and Natural Resources, Faculty of Life and Natural Sciences, University of Iceland, Hringbraut 101, 101 Reykjavík, Iceland*
[2]*Department of Environment and Planning, Reykjavík, Iceland*
e-mail: mol5@hi.is (Mervi Orvokki Luoma)

Protecting urban biodiversity is a key priority for many cities around the world. However, promoting the success of all biodiversity regardless of origin or characteristics may lead to decline of native species. One invasive alien plant of concern in Reykjavík, Iceland is *Anthriscus sylvestris*, which has been spreading throughout Iceland. This invasive species often creates monocultures that replace other plant species, enhances soil erosion, and changes landscape aesthetics. In addition, the alien plant *Myrrhis odorata*, also from the Apiaceae family and with similar plant traits to *A. sylvestris*, is becoming more prevalent in Reykjavík. We began a study in 2017 to map the distribution of *A. sylvestris* and *M. odorata* in four open urban areas in Reykjavík (Laugarnes, Vatnsmýri, Elliðaárdalur, and Ægisíða). The aim of the project was to identify hot spot areas with high abundance of *A. sylvestris* and *M. odorata* as they may increase the risk of losing native plant species in those areas. Furthermore, we assessed whether there is an overlap in distribution between *A. sylvestris* and *M. odorata*. Surveys were conducted on foot using AllTrailsPro and ArcGIS mobile applications. These mobile applications were used to record the GPS locations of *A. sylvestris* and *M. odorata* and draw polygon shapes to indicate their distribution and extent. To date, 158 ha have been surveyed (across all four areas), of which *A. sylvestris* covered 10% (15.5 ha) of the study areas and was most abundant near pathways, riversides and streams. *Anthriscus sylvestris* is spreading throughout Reykjavík and is a serious concern in the wildlife nature reserve of Vatnsmýri and the popular outdoor area of Elliðaárdalur. *Myrrhis odorata* distribution was less common in all study areas except for Laugarnes, where it was double that of *A. sylvestris*, covering over 8% of the study area (1 ha). In Elliðaárdalur *M. odorata* was also present, covering approximately 0.5 ha of the area in 2017. In general, the distribution of the two plant species did not overlap. This is the first time that *A. sylvestris* and *M. odorata* are mapped in Reykjavík and this work is essential for developing a management plan for these species. Mapping the distribution of alien and invasive species, testing and adopting multi-approach techniques via adaptive management, and conducting long-term monitoring are essential in fostering a functioning, species rich urban ecosystem.

Fig. 1. *Anthriscus sylvestris* is growing along the river Elliðaár (July 16th, 2018).

Making friends with mad trees: sustainable management of an invasive species in the Banni grasslands

Nirav Mehta[1], J. Dinakaran[1,2], Abi T. Vanak[1] and Ankila J. Hiremath[1]

[1]*Ashoka Trust for Research in Ecology and the Environment, Royal Enclave, Sriramapura, Jakkur Post, Bangalore - 560 064, Karnataka, India*
[2]*Department of Botany, University of Delhi, Delhi, India*
e-mail: nirav.mehta@atree.org

Prosopis juliflora (Sw.) DC., a tree introduced to India in the 19th century from Central and South America, is now one of the most widespread invasive species across arid and semiarid grasslands and scrublands in India. *Prosopis juliflora* (hereafter, *Prosopis*) was introduced to the Banni grasslands, a ~2500 km^2 arid grassland region in Gujarat, western India, in the 1960s. Since then, it has swiftly become the major vegetation cover, having spread to about 60% of the landscape, and has come to be known locally as 'gaando bawal' (the mad babool). *Prosopis* has replaced grasslands and reduced fodder availability for milk-yielding livestock, thereby affecting livelihoods of traditional pastoralists who have historically used this landscape. In response to *Prosopis* invasion, local pastoralists have developed a parallel economy of harvesting this tree for fuel wood and for making wood charcoal. We assessed the rate of growth of *Prosopis* and measured the time for the plant to reach harvestable size, in 8 replicate plots (20 × 20 m) across Banni. We lopped all trees to ground level (as is done by *Prosopis* harvesters locally). Tree regrowth in lopped plots was monitored annually for 3 years to measure increment in stem diameter and height. We separately developed allometric equations by harvesting 55 *Prosopis* trees of various stem diameters and heights; these allometric equations were used to estimate annual biomass increments in the lopped plots. The total aboveground biomass of re-grown stems was of the order of 40 Mg/ha within 2 years post-lopping, and the stems reached harvestable size in about 3 years. This system of lopping allows for rapid re-growth and harvest, thus resulting in sustainable management of invasive *Prosopis* in the study area. Such management-by-utilization has helped mitigate the negative impacts of *Prosopis* on Banni's pastoralists, while simultaneously yielding a renewable source of energy and income.

Fig. 1. One of our eight experimental plots in April 2016, immediately after lopping (left) and in March 2017, about a year after lopping (right).

What explains higher invasion success among three alien pines in Southeastern Brazil?

Roseli Lika Miashike[1], Alessandra R. Kortz[1], Hilton Thadeu Zarate do Couto[2] and Vânia Regina Pivello[1]

[1]*LEPaC, Ecology Dept.-IB, Universidade de São Paulo, Rua do Matão, Travessa 14, São Paulo, SP, Brazil*
[2]*LEFS-ESALQ, Universidade de São Paulo, Piracicaba, SP, Brazil*
e-mail: lika_rlm@yahoo.com.br

Certain life-story traits of invasive plants as well a strong propagule pressure are related to their high invasion success. For pine trees, a high production of small- or large-winged seeds with low mass, and early age of reproduction, associated with a high reproductive success and dispersal effectiveness allow many species to be highly invasive worldwide. In the Brazilian cerrado – the richest savanna of the world – pine tree species are highly invasive in the southeastern part of this biome. A good example concerns São Paulo state, where silviculture is a key economic activity, mostly based on *Eucalyptus* and *Pinus* species. Three pine species have been most intensively planted in São Paulo, i.e. *P. elliottii*, *P. oocarpa* and *P. caribaea* var. *hondurensis*. While *P. elliottii* has become the most threatening invasive species in the southern cerrado, episodes of invasion by *P. oocarpa* and *P. caribaea* are still very few and have not been detected in São Paulo state, even though these three species are phylogenetically very close.

Here we focus on the three most planted pine tree species in Southern Brazil (*P. elliottii*, *P. caribaea* and *P. oocarpa*) to (i) test the hypothesis that some key attributes, such as seed viability, germinability, growth rate and propagule pressure drive the greater invasiveness of *P. elliottii*, and (ii) assess the possibility of the other two species becoming invasive. Our results show that seed viability, germinability and the initial development period (from germination until seedling still having cotyledons) of *P. elliottii* are not higher than those of the other two pine species. Still, compared to other pine species, *P. elliottii* showed the slowest stem growth, shortest stems and lowest dry biomass after 24 weeks since germination, as well as the highest seedling mortality rate. On the other hand, *P. elliottii* produced the highest amount of seed within the 14-month period, at least twice as high as the other two species. In addition, *P. elliottii* seeds were dispersed up to 150 m. There is a stronger propagule pressure observed for *P. elliottii* relative to the other two species, caused by several human mediated introductions. *Pinus oocarpa* and *P. caribaea* performed highly regarding the life-story characteristics evaluated in this study (viability, germinability, growth rate, biomass production). Therefore, it is possible that these two pine species might also become successful invaders in the cerrado. Our findings have important implications for managers to monitor the emerging of pine individuals in the native ecosystems, and for predicting potential invasions.

A first step towards the biological control of *Iris pseudacorus*

G. Minuti[1], S. Ngxande-Koza[2], J. A. Coetzee[2] and I. Stiers[1]

[1]*Ecology & Biodiversity, Department of Biology, Vrije Universiteit Brussels, Belgium*
[2]*Centre for Biological Control, Rhodes University, Grahamstown, South Africa*
e-mail: Gianmarco.Minuti@vub.be

Native to Europe, North Africa and western Asia, the yellow flag (*Iris pseudacorus* L.) has long been exported globally as a valuable ornamental and pond plant (Sutherland 1990), occasionally escaping cultivation and establishing itself as an invasive species. Outside of its native range, this emergent macrophyte tends to grow dense monospecific stands, displacing the local vegetation and altering the hydrology of aquatic ecosystems (Jacobs et al. 2011). To date, this species is considered invasive in Canada, part of the U.S., Chile, Argentina, Uruguay, South Africa, Japan, Australia and New Zealand (USDA 2013). Due to its potential ecological and economic impacts, in South Africa, it was recently listed as a category 1a invader for which management actions need to be prioritized (NEMBA 2014, Jaca & Mkhize 2015). Because mechanical and chemical control methods are regarded as unsustainable in the long term, a biological control program was initiated to tackle its invasion (Hill & Coetzee 2017). In this regard, we conducted a preliminary survey of yellow flag's native populations in Europe in order to identify its naturally co-evolved enemies and prioritize a set of candidate biocontrol agents to be investigated. A total of 12 locations (36 sampling sites) were visited between 2017 and 2018, covering different seasons and accounting for a variety of habitats across Belgium and Northern Italy. At each site, we collected invertebrates found on the plant and recorded their feeding behaviour in relation to our target as well as to the co-occurring native vegetation. Of the 61 species identified from our sampling, only two met the criteria applied for selecting the candidates. Further investigations focused on the iris flea beetle, *Aphthona nonstriata* Goeze (Coleoptera: Chrysomelidae), in an attempt to fill the knowledge gap regarding its biology. Controlled life-history observations highlighted the potential of this species to impair the growth and survival of *I. pseudacorus*. Adults are voracious leaf-miners, whereas the larvae bore and develop within the plant rhizomes, generating wounds that may be a vector for bacterial and fungal infections. Finally, a short-term no-choice feeding assessment was carried both on cut leaves and live plants. The results showed adult flea beetles feeding significantly more on our target compared to the other plants tested. A population of beetles are currently undergoing host-specificity testing within the quarantine facility of the Centre for Biological Control at the Rhodes University (South Africa), where it will soon be joined by our second candidate. Altogether, the information gathered through this research constitute a first fundamental step towards the biological control of *I. pseudacorus* in South Africa, and possibly elsewhere in the world.

Hill M. P. & Coetzee J. A. (2017) The biological control of aquatic weeds in South Africa: current status and future challenges. Bothalia 47: 1–12.

Jaca T. P. & Mkhize V. (2015) Distribution of *Iris pseudacorus* (Linnaeus, 1753) in South Africa. BioInvas. Rec. 4: 249–253.

Jacobs J., Pokorny M., Mangold J. & Graves-Medley M. (2011) Biology, ecology and management of yellowflag iris (*Iris pseudacorus* L.). EB203, Montana State University Extension, Bozeman.

NEMBA (National Environmental Management: Biodiversity Act 10/2004) (2014) Alien and Invasive Species Regulations. Government Notice 598, Government Gazette 37885, Pretoria.

Sutherland W. J. (1990) Biological flora of the British Isles: *Iris pseudacorus* L. J. Ecol. 78: 833–848.

USDA (2013) Weed risk assessment for *Iris pseudacorus* L. (Iridaceae) – yellow flag iris. Plant Protection and Quarantine, Animal and Plant Health Inspection Service, United States Department of Agriculture, Raleigh.

Impacts of *Arctotheca calendula* on plant-herbivore interactions in continental and insular habitats in the NW Iberian Peninsula

Nerea Montes[1,2], Jonatan Rodríguez[1,2] and Luís González[1,2]

[1]*Plant Ecophysiology Group, Department of Plant Biology and Soil Science, University of Vigo, 36310 Vigo, Spain*
[2]*CITACA, Agri-Food Research and Transfer Cluster, Campus da Auga, University of Vigo, 32004-Ourense, Spain*
e-mail: nereamontes21@gmail.com

Over the past few decades, biodiversity conservation awareness has led to an increase in the amount of research done on this topic. Different studies have shown the correlation between diversity loss and the introduction of invasive species. Some of them, focusing on plant-pollinator interaction networks. However, few studies are known to relate plant-herbivore interaction networks with invasive species and none with the capeweed, *Arctotheca calendula* (L.) Levyns. We hypothesize that if *A. calendula* reduces plant biodiversity, it can create, in a short-scale, heterogeneities in herbivore distributions in the NW Iberian Peninsula. The aims were to assess the distribution and frequency of herbivorous invertebrates, as well as the diversity of native plant species, for comparing the plant-herbivore interactions in invaded areas by *A. calendula* and adjacent native ones. To achieve these objectives, we did a total of 400 quadrat surveys at ten populations, in both continental and insular habitats, during spring 2019 (from March to June). Differences between native and invaded areas were observed, concerning invertebrates and plant species. Higher variety of herbivores and plant species were shown in native areas. Orders such as Hemiptera, Stylommatophora or Thysanoptera were dominant in *A. calendula* specimens, particularly Aphidae and Helicidae families. On the other hand, although individuals from the families Aphidae and Helicidae were found in the native areas, Aphrophoridae was the most abundant group. In terms of dissimilarities, few differences between the continental and insular populations of *A. calendula* were found. Overall, the results suggest that *A. calendula* attracts more and different taxa of herbivores than the native vegetation, but it also reduces plant diversity. However, interspecific competition seems to be a stronger force than herbivore pressure leading to plant diversity loss. Our study points to the need for invasion biology to include a plant-herbivore perspective to clarify the consequences of these changes.

Gatecrashers at the doorstep: towards a global inventory of alien plants in protected areas

Desika Moodley[1] and Petr Pyšek[1,2]

[1]*The Czech Academy of Sciences, Institute of Botany, Department of Invasion Ecology, CZ-252 43, Průhonice, Czech Republic*
[2]*Department of Ecology, Faculty of Science, Charles University, Viničná 7, CZ-128 44 Prague, Czech Republic*
e-mail: desikamoodley29@gmail.com

Plant invasions are increasingly attracting the interest of ecologists because of their worldwide environmental impacts and huge economic costs. Factors that drive plant invasions have recently become well understood, however, surprisingly little is known about the processes and mechanisms of invasions into undisturbed ecosystems harboured in protected areas (PAs). Estimating management costs requires an understanding of the relative invasion across PAs, however, the last global overview is from the 1980s and available data on species distributions is often incomplete and regionally poor. To close the knowledge gap on the 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 aim to (i) build a new global inventory of naturalized and invasive plant species in PAs, (ii) measure the level to which PAs suffer from invasions, and (3) investigate the relationship between the overall level of invasion in a region and in PAs located within that region. A list of PAs was extracted from the World Database on Protected Areas and invasion records were collated using literature, local databases and unpublished accounts. The Global Naturalized Alien Flora (GloNAF) database was used to measure the overall level of invasion in a region and its effect on PAs. We tested the hypotheses 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 a higher alien plant richness. While inventories of invasive alien plants will never be complete or flawless, it is a valuable baseline tool for both invasion science and management.

Differences in short-term seed-bank dynamics between alien species and their native congeners

Lenka Moravcová[1], Margherita Gioria[1], Hana Skálová[1] and Petr Pyšek[1,2]

[1]*Institute of Botany, The Czech Academy of Sciences, Zámek 1, CZ-252 43 Průhonice, Czech Republic*
[2]*Department of Ecology, Faculty of Science, Charles University, Viničná 7, CZ-128 44 Prague, Czech Republic*
e-mail: lenka.moravcova@ibot.cas.cz

By comparing naturalized alien species with natives, we can assess the role that seasonal and short-term seed bank dynamics play in the naturalization process, and whether the naturalized species are provided with an advantage following an introduction to the new region. Here, we performed standardized burial experiments to test differences in the seed survival dynamics of naturalized alien plant species in the Czech Republic (by definition, this set of species includes some invasive taxa that are a subset of naturalized species; Richardson et al. 2000, Blackburn et al. 2011) and their native close relatives (congeners) to minimize the variation and possible biases due to species' phylogenies, life histories and habitat affinities. The seeds of 13 congeneric pairs, selected to meet the above criteria, were collected in the field in the Czech Republic in the autumn of 2015, and used in a burial experiment in the common garden of the Institute of Botany in Průhonice. The collected seeds were initially tested for viability using germination tests and then buried in nylon bags in the soil. The seeds were excavated twice a year (in April and October, for a spring and an autumn sample, respectively). The fraction of germinated or decayed seeds, and non-germinated but viable seed, was determined in each sample. The experiment ran for three years (2016–2018). We found a slightly higher seed bank density in alien species in comparison with native species, the difference being more obvious during spring. Our results are the first to quantify, in such a detail and extent, the process of seed bank depletion and seasonal dynamics, and will allow for the possbility to discuss implications of the differences between alien and native species seed bank dynamics.

Blackburn T. M., Pyšek P., Bacher S., Carlton J. T., Duncan R. P., Jarošík V., Wilson J. R. U. & Richardson D. M. (2011) A proposed unified framework for biological invasions. Trends Ecol. Evol. 26: 333–339.

Richardson D. M., Pyšek P., Rejmánek M., Barbour M. G., Panetta F. D. & West C. J. (2000) Naturalization and invasion of alien plants: concepts and definitions. Diversity Distrib. 6: 93–107.

Invasiveness of Douglas fir in temperate European mixed forests during the seedling stage

Barbara Moser[1], Christoph Bachofen[1,2], Esther R. Frei[1] and Thomas Wohlgemuth[1]

[1]*Swiss Federal Research Institute WSL, Birmensdorf, Switzerland*
[2]*Environmental Systems Science, ETH Zürich, Switzerland*
e-mail: barbara.moser@wsl.ch

Douglas fir (*Pseudotsuga menziesii*) is the second most common non-native tree species in European forests and is regarded as a promising commercial alternative to spruce (*Picea abies*) due to its drought resistance. The expansion of Douglas fir in Central European forests is, however, critically appraised by nature conservationists, who fear negative effects on biodiversity and forest functions. In order to evaluate the inherent risk of uncontrolled spread of Douglas fir from stands with old, seed producing trees, we experimentally studied seedling heights and relative growth rates of 1–3 yr-old Douglas fir seedlings and compared their performance under different combinations of water, nutrient and light availability with that of seven native tree species: beech (*Fagus sylvatica*), sycamore (*Acer pseudoplatanus*), common oak (*Quercus robur*), sessile oak (*Quercus petraea*), silver fir (*Abies alba*), spruce (*Picea abies*), and Scots pine (*Pinus sylvestris*). The plants were grown in mesocosms subjected to full factorial treatments of water (P: ambient, i.e. 100%, vs. 50% precipitation), nutrients (N: 48/12/19.2 vs. 24/6/9.6 vs 12/3/4.8 mg N/P/K m^{-2} y^{-1}) and light (L: 80% vs. 60% sunlight).

In the first year of establishment, height growth of Douglas fir seedlings was larger than that of native conifers and lower than all broadleaved species independent of light, nutrient and water supply (Fig. 1). By the end of the third growing season, Douglas fir was still universally taller than silver fir and spruce (except under conditions of P_{100} x N_{low} x L_{60}), and smaller than sycamore and beech. Surprisingly, Douglas fir seedlings were gaining on common oak throughout the experiment and finally equalled their size under conditions of low nutrients combined with low precipitation and high light availability. At the same time, it outcompeted Scots pine under conditions of low nutrients as well as sessile oak under low nutrients combined with low precipitation. Results on relative growth rates in terms of above ground biomass will follow. Our results suggest that the competitive ability of Douglas fir and the concomitant risk of uncontrolled invasion depends on environmental conditions.

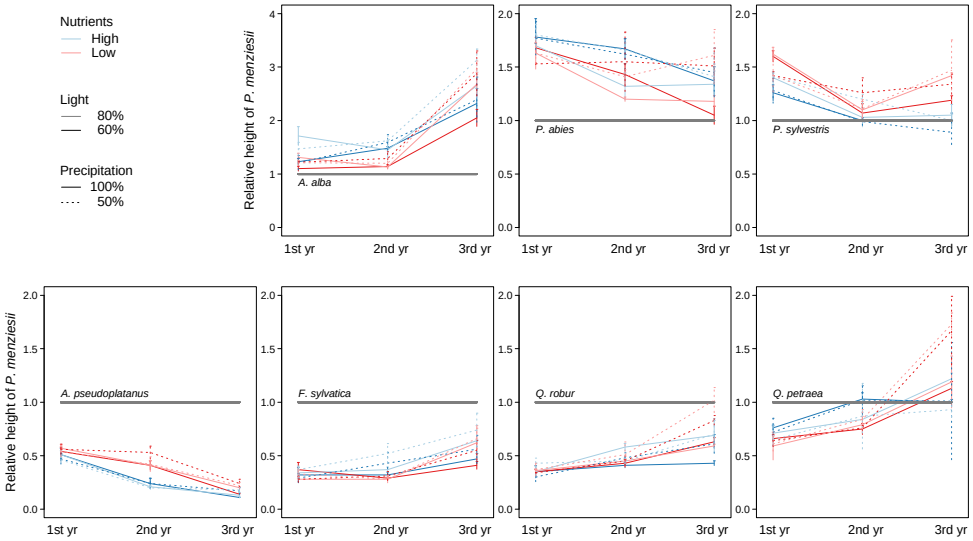

Fig. 1. Height growth of 1–3 yr-old Douglas fir seedlings relative to different native conifer and broadleaved tree species. All seedlings were grown from seed in mesocosms in a common garden located at WSL, Birmensdorf, Switzerland. The mesocosms were subjected to factorial combinations of nutrients, precipitation and light.

Impacts of alien plant taxa on humans in South Africa

M. C. Moshobane[1], C. J. Marks[2], C. R. Stephen[3] and P. N. Mothapo[4]

[1]*Biological Invasions Directorate, South African National Biodiversity Institute, Pretoria National Botanical Garden, 2 Cussonia Avenue, Brummeria, Pretoria, South Africa*
[2]*Division of Clinical Pharmacology, Department of Medicine, Faculty of Medicine and Health Sciences, Stellenbosch University, Cape Town, South Africa*
[3]*Department of Paediatrics, Faculty of Health Sciences, University of Cape Town, South Africa*
[4]*Department of Botany and Zoology, Stellenbosch University, Stellenbosch, South Africa*
e-mail: moshobanemc@gmail.com

Invasive alien species (IAS) cause considerable negative impacts on biodiversity, economy and public health. Most studies on IASfocus on the direct biodiversity and economic impacts they cause, but few focus on human health and socioeconomic impacts. Here, we provide an analysis of human poisoning received by the Poisons Information Helpline of the Western Cape (PIH), jointly run by the Poisons Information Centres (PICs) at the Red Cross War Memorial Children's Hospital and Tygerberg Hospital. The data collected were on reported human exposure and poisoning cases from native and alien plant species conducted over 2.5 years, between 2015–2017. During the 2 year period, the PIH received 826 plant-and fungi-related calls, with most calls received from Gauteng (47.1%) and the Western Cape (29.4%). Most calls were as a result of accidental ingestion (96.7%) and involved infants (55%), with fewer cases involving patients over 60 years (2.1%). Adults presented with minor to moderate toxicity, while infants showed no to minor toxicity. The most commonly reported known plant species were *Colocasia esculenta* and *Melia azedarach*, which accounted for (20%) of the cases. Of the ingested plants that were listed as unknown, most were due mushrooms and fungi (10%). It is essential to improve public awareness regarding invasive alien plant species in order to reduce poisoning incidences, particularly for those plants with highly attractive fruiting bodies.

Risk assessment and management strategy of giant ragweed and western ragweed in France

M. Mottet[1], L. Lelevier[1] and G. Fried[2]

[1]*FREDON France, Ragweed observatory, 11 rue Lacaze, 75014, Paris, France*
[2]*Anses, Plant Health Laboratory, Montpellier, France*
e-mail: marilou.mottet@fredon-france.org

Common ragweed (*Ambrosia artemisiifolia* L.) is a well-known invasive species in Europe that causes allergic reactions in many people. But what about other ragweed species existing in Europe? The French Agency for Food, Environmental and Occupational Health & Safety (Anses) has conducted risk analyses for two ragweed species (*Ambrosia trifida* L. (1) and *Ambrosia psilostachya* DC. (2)) in order to contribute to the prevention and management of their introduction and spread in France and in Europe. Considering the conclusions of these two risk assessments, a strategy has been set up in France.

Ambrosia psilostachya DC. (perennial ragweed) – The risks of reintroduction in the current state of international trade is relatively low for this species. Its pollen is potentially allergenic but no evidences of social damage are available. *A. psilostachya* should be monitored and preventive action would appear necessary in some places due to local dense stands that may impact sensitive habitats or grazing.

Ambrosia trifida L. (giant ragweed) – Preventing introduction from the area of origin is difficult due to the large volume of (crop) seeds for sowing imported from North America. Numerous suitable eco-climatic zones for the species are found throughout Europe in areas where cropping systems have developed which could facilitate the spread of the species . Due to the great difficulty of fighting *A. trifida* in non-agricultural environments and the allergenicity of its pollen, it is a proven threat to human health and to the environment. A. trifida should be monitored and preventive (import controls) and curative actions are necessary. Following these recommendations, a strategy has been set up in France to prevent the spread of this pest.

The risks associated with these two invasive species are very different. The risks associated to *A. trifida* are much higher. Accordingly, we recommend that *A. trifida* should be added to the list of invasive species in the dedicated European regulation. In France, three *Ambrosia* species are now regulated by law: *A. artemisiifolia*, *A. trifida* and *A. psilostachya.*

A project for the first checklist of the alien flora of Iran

Alireza Naqinezhad[1], Amir Talebi[1], Samereh Tirgan[1], Vanessa Lozano[2] and Giuseppe Brundu[2]

[1]*Department of Biology, Faculty of Basic Sciences, University of Mazandaran, P.O. Box: 47416-95447, Mazandaran, Iran*
[2]*Department of Agriculture, University of Sassari, Viale Italia 39, 07100 Sassari, Italy*
emails: gbrundu@tin.it, a.naqinezhad@umz.ac.ir

Iran covers an area of 1,648,000 km^2. It is a mountainous country of huge ecological diversity, ranging from 28 m below sea level on the southern shores of the Caspian Sea, to 5,770 m above sea level at Mt. Damavand. In addition, Alborz. Alborz and Zagros are the most prominent mountain ranges extending about 950 km in the northwest to northeast and 1,400 km in the northwest to southeast of Iran, respectively. Almost 62% of the territory is 1,000 m a.s.l. The country supports striking biological diversity which is further enhanced by its location at the interface of several geobotanical regions. The complex geology and topography and the contrasting climates generating humid and lush forests in the north and very hot deserts in central and south Iran, are the main drivers of the high floristic diversity with about 8,000 vascular plant species and a high proportion of endemism in Iran (30%). Three major bioclimatic zones (i.e. nemoral, meridional and tropical) with ten bioclimates defined by temperature and precipitation occur in Iran. Annual precipitation ranges from 28 mm in the deserts of southern Iran to ca. 2,000 mm in the Hyrcanian area of northern Iran. The mean temperatures of the coldest and warmest months vary from -13.3 °C in Firuzkuh (Alborz Mts.) to 47.5 °C in the Kerman desert.

In Iran, 26% of the land is used for agriculture. The main crops are wheat, barely, rice, citrus, fruit trees, olive trees and vegetables. The majority of Iran's cropping activities take place in the west, northwest, and northern parts of the country where annual precipitation exceeds 250 mm. However, irrigated agriculture is practiced in regions with precipitations as low as 200 mm year-1, or even below 100 mm year-1. The uncultivated land and hills are dominated by different types of vegetation including deciduous forests, *Artemisia* steppes and grasslands, woodlands and forest steppes, alpine and subalpine vegetation and savanna-like vegetation in the tropical part of the country.

Due to the high rate of endemism of the flora of Iran and its conservational value, with a remarkable occurrence of very diverse natural ecosystems and agricultural areas, and on the other hand due to the always increasing number of publications reporting new alien records, we decided to establish an international working group aiming to produce the first inventory of the non-native flora in Iran. In fact, so far, there is no comprehensive study on the non-native flora of Iran, but only single studies on single alien species and invaded habitats. This is reflected by the relative low number of records present in the major international databases, such as GLONAF and GRIIS, with, respectively only contain 35 and 117 records of alien plants for Iran.

The data collection for the dedicated database is based on a full screening and critical analysis of all the available literature, particularly *Flora Iranica* (Rechinger 1963-2015) and the *Persian Flora of Iran*, including herbarium data, bibliographic records, local floras as well as our own original field observations (since 2001, e.g. Naqinezhad & Naseri Larijan 2017). For each alien species the following information was collected: origin, status, invasive status, distribution in the main biogeographic regions of Iran, life form, habitat preferences, and introduction pathways.

This checklist will hopefully promote and support further investigations and prioritization and risk analyses for the identification of the most problematic invasive species.

Naqinezhad A. & Naseri Larijani N. (2017) *Ammannia coccinea* (Lythraceae), a new record for the Flora Iranica area. Phytol. Balcan. 23: 35–38.

Rechinger K. H. (1963–2015) Flora Iranica. Vols. 1–181. Akademische Druck u. Verlagsanstalt, Graz.

Origin and genetic variation of non-native trees in Europe and relevance for forest practice

Charalambos Neophytou[1], Elisabeth Pötzelsberger[1], Marcela van Loo[1,2] and Hubert Hasenauer[1]

[1]*Institute of Silviculture, Department of Forest and Soil Sciences, University of Natural Resources and Life Sciences (BOKU), Peter-Jordan-Str. 82, 1190 Vienna, Austria*
[2]*Department of Botany and Biodiversity Research, Faculty of Life Sciences, University of Vienna, Rennweg 14, 1030 Vienna, Austria*
e-mails: charalambos.neophytou@boku.ac.at, elisabeth.poetzelsberger@boku.ac.at

Non-native tree species play an important role in European forestry. Here, we explore the origin and genetic variation in space and time, observed in introduced populations of such species. Our first study species is Douglas-fir (*Pseudotsuga menziesii*), which has a prominent position in Central European forestry. Results show that a relatively small part of the native range served as seed source for most ofh 67 genotyped Douglas-fir stands spread across Germany and Austria. Hence, this part of the native range includes provenances with superior performance in Europe. Despite a high genetic diversity among adult trees, we observed a significant reduction of genetic diversity in the natural regeneration which we attribute to a limited number of reproducing adult trees. In the case of the tree of heaven (*Ailanthus altissima*), our second study species, we observed signatures of repeated founder effects in Eastern Austria, an area of early introduction. Additionally, In spite of a single maternal lineage characterizing all ten study stands, we observed a significant genetic structure among the populations. Our results support that genetic drift led to genetic differentiation, given that the effective population size was locally very small. Third, we present current results on the origin and genetic variation of the Northern red oak (*Quercus rubra*) introduced to European populations. We conclude that genetic drift is a major factor shaping the genetic variation in the introduced range. Since introduced populations constitute an important seed source, special caution should be exercised when establishing seed stands and seed orchards, but also during seed harvesting, in order to avoid genetic erosion after species introduction.

Factors affecting seed germination of the invasive species *Aster lanceolatus* complex and their implication for invasion success

Marija Nešić[1], Dragica Obratov-Petković[1], Dragana Skočajić[1], Ivana Bjedov[1] and Nevena Čule[2]

[1]*University of Belgrade - Faculty of Forestry, Kneza Višeslava 1, 11030 Belgrade, Serbia*
[2]*Institute of Forestry, Kneza Višeslava 3, 11030 Belgrade, Serbia*
e-mail: marija.nesic@sfb.bg.ac.rs

Aster lanceolatus Willd. complex is considered invasive in many European countries, including Serbia. This species is spreading uncontrollably along wet habitats as well as in ecosystems characterised by natural and anthropogenic disturbances. All these habitats function as corridors which facilitate seed dispersal. In order to prevent the spread of invasive plants, it is important to know the biology of invasive species, especially their reproductive ecology. In addition, reproduction affects the ability of plants to colonize new habitats.

In order to investigate the potential of generative reproduction of *A. lanceolatus* complex, seeds were collected across 13 different localities in Serbia. The influence of four fluctuating temperature regimes on seed germination was investigated. To test the influence of nitrate on seed germination, two KNO_3 concentrations were used: 0.005 M and 0.05 M solutions on four temperature regimes (15/6, 20/10, 30/15 and 35/20 ^oC), whilst distilled water was used for the control. For each treatment, three replicates of 30 seeds were placed in complete darkness or in a 14-hour photoperiod. The influence of the applied treatments were quantified as germinative capacity (GC), germinative energy (GE), and viability percentage. The seed viability was determined using the tetrazolium test.

The results showed that germination increased with increasing temperature. The optimum temperature regimes were 30/15^oC and 35/20 ^oC with approximately 88% germination. The overall effect of KNO_3 on germination was positive. The concentration of 0.05 M KNO_3 had a less pronounced stimulating effect compared to 0.005 M KNO_3. However, the inhibitory effect of both KNO_3 concentrations was expressed in darkness at the highest temperature. The tetrazolium test showed that seed viability was between 93% and 100% at all sites. *A. lanceolatus* complex seeds showed lower sensitivity to the lack of light during germination. Unexpectedly, the smallest decrease in seed germination from the treatment in darkness was observed at the 15/6^oC temperature in the treatment with 0.005 M KNO_3.

When the introduced species is found in a new habitat, it faces new climatic and habitat conditions, which can be challenging for stand establishment, and species spread further to new habitats. Considering that *A. lanceolatus* complex often occurs in disturbed sites, seed reaction to changes in temperature, nutrients concentration and light can be one of the determining factors that affect seed germination of this species and, thus, its spread. Although they varied across the localities, the germination parameters showed that generative reproduction could play an important role in the spread of this species. The ability of the seed to germinate in darkness could be significant for the germination ecology of this invasive species since it inhabits disturbed sites, where seed can be buried frequently.

Remote sensing derived landscape phenology for invasive annual grass mapping

Ty Nietupski[1], Becky Kerns[1,2], Hailemariam Temesgen[1] and Robert Kennedy[3]

[1]*Oregon State University, College of Forestry, 280 Peavy Hall, Corvallis, OR, 97331, USA*
[2]*USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR, USA*
[3]*Oregon State University, College of Earth, Ocean, and Atmospheric Sciences, Corvallis, OR, USA*
e-mail: Ty.Nietupski@oregonstate.edu

Many non-native plant species have been introduced to the semi-arid landscape of the United States' interior Pacific Northwest. However, some of the greatest ecological and economic impacts have resulted from exotic annual grass introduction. Cheatgrass (*Bromus tectorum*), an invasive annual grass, has been extensively studied and documented for its disturbance regime altering impacts, especially in sagebrush steppe ecosystems. However, other exotic annual grasses have been introduced to the region and have become abundant across the landscape. One such species is ventenata (*Ventenata dubia*). This species was first documented in eastern Washington in the 1950's and has subsequently spread throughout much of the western United States. Once thought of as a purely agricultural pest, ventenata has become recognized by land managers for its potential to colonize openings between forested areas, resulting in a more continuous and abundant fuel distribution. Concern has developed that changes to fire behavior, similar to those for cheatgrass, may occur. Land managers need spatially explicit information about populations of ventenata to address the effects of the invasion and its potential to change the landscape.

In the recent past, remote sensing products have been successfully used to identify and locate invasive plants across broad areas. Landscape phenology has been employed with remote sensing data to distinguish exotic species from native plants in some ecosystems. Sensors like MODIS have commonly been used for mapping invasive plant populations because of their high temporal resolution that allows for phenological characterization. However, the spatial resolution (250–1000 meters) of this sensor means that individual populations must be abundant in large patches in order to be identified. Another sensor commonly used to study similar land surface properties is Landsat, but the temporal resolution (16-day revisit) of this product is inadequate for capturing the annual phenological pattern. To help characterize phenological patterns at a 30-meter spatial resolution, we used spatio-temporal data fusion to generate a dense time series of observations of land surface reflectance. This data was used to extract phenological metrics for each pixel in the Blue Mountains Ecoregion of the interior Pacific Northwest. Using this information, along with other biophysical parameters, we modeled the presence and absence of ventenata across the region. In cases with adequate abundance, preliminary results showed that ventenata exhibited a unique phenological pattern when compared to other land cover types in the region, and incorporating phenological information resulted in improved model performance. The results of this project can be used to help land managers to plan for fire activity across this landscape in places where fine fuel biomass has increased in abundance or continuity as a result of this grass invasion.

Additive effect of urbanization and invasion by *Carpobrotus edulis* on the soil ecology in coastal areas

Ana Novoa[1,2,3], Jan-Hendrik Keet[4], Luís González[5], Yaiza Lechuga-Lago[5] and Johannes J. Le Roux[2,4,6]

[1]*Department of Invasion Ecology, Institute of Botany, Czech Academy of Sciences, 252 43 Průhonice, Czech Republic*
[2]*Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, Matieland, South Africa*
[3]*Invasive Species Programme, South African National Biodiversity Institute, Kirstenbosch Research Centre, Claremont, South Africa*
[4]*Department of Botany and Zoology, Stellenbosch University, Matieland, South Africa*
[5]*Laboratorio de investigación n21, Ecofisioloxía, Departamento de Bioloxía Vexetal e Ciencias do Solo, Edificio de Ciencias Experimentais, University of Vigo, Campus Universitario, As Lagoas Marcosende, Vigo, Pontevedra, Spain*
[6]*Department of Biological Sciences, Macquarie University, Sydney, NSW, 2109, Australia*
e-mail: novoa.perez.ana@gmail.com

Coastal dune areas are ecosystems of a high conservation and socioeconomic value and are strongly impacted by habitat destruction and biological invasions globally. Here, we assessed how human disturbance and invasion by *Carpobrotus edulis* affect these systems on the north-western coast of Spain, by comparing the soil characteristics (pH, conductivity, water content, nutrients and enzymatic activities), the diversity, structure and composition of the soil bacterial communities, and the fitness correlates of *C. edulis* and native plants (germination and early growth) between uninvaded and invaded soils from urban and natural coastal dune areas. We found that human disturbance impacts coastal dune areas by increasing the soil organic matter and water content, modifying soil nutrients and cycles, reducing the soil pH, increasing the diversity of the bacterial communities and affecting the establishment of the native plants in urban soils. The invasion of *C. edulis* further increases these impacts. These results show the dynamic and multiple dimensions of urbanization and invasive plant impacts in coastal dune areas.

Advancing the understanding of invasion ecology with pines

Susan Nuske[1], Paul Kardol[1], David Wardle[2], Marie-Charlotte Nilsson Hegethorn[1], Jane Smith[3], Aníbal Pauchard[4], Alex Fajardo[5], Duane Peltzer[6], Martin Nuñez[7] and Michael Gundale[1]

[1]*Swedish University of Agricultural Sciences, Department of Forest Ecology and Management, Umeå, Sweden*
[2]*Nanyong Technological University, Asian School of the Environment, College of Science, Singapore*
[3]*US Forestry Service, Pacific Northwest Research Station, Corvallis, USA*
[4]*Universidad de Concepción, Departamento de Manejo de Bosques y Medio Ambiente, Facultad de Ciencias Forestales, Chile*
[5]*Centro de Investigación en Ecosistemas de la Patagonia (CIEP), Ecosistemas Terrestres, Chile*
[6]*Landcare Research, Lincoln, New Zealand*
[7]*National University of Comahue, Centro Regional Universitario Bariloche, Neuquén, Argentina*
e-mail: susan.nuske@slu.se

Pine species have been introduced around the world for timber, soil stabilization and wind breaks. Selection for highly productive species and provenances has led to productive forestry, but also to species that can readily spread and become invasive in otherwise productive pasture land, or biodiverse native grass- or shrub-land. Our research uses *Pinus contorta* as a model species to investigate the mechanisms that underpin invasion ecology. Our international network of field sites enabled us to compare native ranges (USA and Canada) with the introduced and invaded ranges (New Zealand, Chile and Argentina). In order to disentangle the relative effects of genetics, abiotic nutrients and microbial community on seedling growth, we performed an experiment that combined sterilization treatments, provenances and measurements of soil nutrients and fungal communities of soil and roots while keeping environmental conditions stable in a growth chamber 'home-versus-away' design. Our research allows us to compare multiple hypotheses at once, advancing understanding of invasion ecology.

Predicting the distribution of invasive plants using climate and habitat suitability models

Dragica Obratov-Petković[1], Dragana Čavlović[1], Ivana Bjedov[1], Verica Stojanović[2] and Marija Nešić[1]

[1]*University of Belgrade-Faculty of Forestry, Kneza Višeslava 1, 11030 Belgrade, Serbia*
[2]*Institute for nature conservation of Serbia*
e-mail: dragica.obratov-petkovic@sfb.bg.ac.rs

Global climate changes are the most recognizable causes of change in plant biological cycle, plant distribution and degradation of plant communities. Degraded and devastated habitats are prone to newcomers, especially those which are close to water lines corridors. At the same time, riparian or wet habitats play a central role in the process of invasion and naturalization of alien plants.

We selected 10 of the most invasive plants which grow on riparian and wet habitats. The selected species are included in the Serbian preliminary list of invasive species as well as in invasive plant lists of seven respectable national lists for European countries. The aim of this study was to evaluate the impact of future climate change on habitat suitability and the distribution of invasive species. For each studied invasive species, we randomly selected 20 presence localities (i.e. co-ordinates where each species is recorded, either from literature or field surveying). Observed bioclimatic grid data were used in spatial resolution of 30", for 1961–1990 period. Each grid cell contains the predicted suitability conditions for the selected species. We used MaxEnt software (3.4.1 version) for modelling species niches and distributions by applying a machine-learning technique called maximum entropy modeling. Models of ecological niche, after climate characteristics, determinate the habitat suitability for certain species according to data of plant distribution. Variables for future simulation were calculated via output data of EBU-POM model for 2061–2080 period. Simulation of variables for future period was done according to the A2 scenario of IPCC.

The analysis provided by EBU-POM model and data from Republic Hydrometeorogical Service of Serbia ensign that according to climate scenario A2, the annual average temperature will rise up to 3.8°C, and annual average precipitation decline for up to 15%, for the territory of Serbia. According to the distributions of *Ambrosia artemisiifolia, Amorpha fruticosa, Asclepias syriaca, Aster lanceolatus* comlex, *Bidens frondosa,Echinocystis lobata, Erigeron annuus, Helianthus tuberosus, Reynoutria japonica* and *Solidago gigantea* on more than 100 localities and prediction variables, the map of current and future potential distribution for the period 2061–2080 was constructed. Predicted maps show the distribution of each invasive species as a result of climate change and therefore habitat conditions.

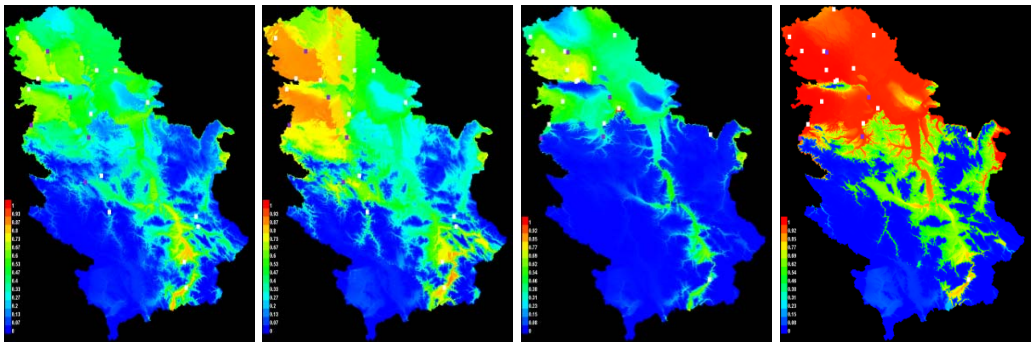

Fig. 1. Map of the projected habitat suitability for *Ambrosia artemisiifolia* and *Asclepias syriaca* according to A2 scenario (left- current distribution, right- future distribution).

Australian *Acacia longifolia* invasibility: geographic, climate and taxonomic scales in invaded ranges

Jorge Luis P. Oliveira-Costa[1], Rui F. Figueiredo[2] and Vânia R. Pivello[3]

[1]*Doctoral researcher/Department of Geography of the University of Coimbra, Portugal*
[2]*Department of Geography/Faculty of Letters of the University of Coimbra, Portugal*
[3]*Department of Ecology/Institute of Biosciences of the University of São Paulo, Brazil*
e-mail: oliveiracostajorge@gmail.com

An unresolved problem in the invasibility study of the Australian *Acacia longifolia* species is that many of its invaded ranges are characterized by coastal environment systems occuring in the boundaries between continents with a long history of human presence which are classified as 'temperate zones' when they are functionally a mix of specific climate conditions (oceanic, humid, subtropical, mediterranean, and other different types). More problematically, this climate zone is widely regarded as the ecological niche of *Acacia longifolia*'s invasive species distribution, because (i) the two *Acacia longifolia* species (*A. longifolia* subsp. *longifolia* and *A. longifolia* subsp. *sophorae*) occur predominantly in areas of coastal dunes with poor soils and ecosystems historically modified, and (ii) the temperate Australian regions where many of these species occur can also climatically support both native and non-native distributions of *A. longifolia*.

Here, we examine multiple lines of evidence to disentangle this issue on how ecological similarity is determined between different invaded ranges in order to explain the susceptibility to invasion by *Acacia longifolia*. First, to understand the invasibility of *A. longifolia*'s, what is the best climate resolution of analysis? Evidence in several studies established that the invasive *A. longifolia* taxa, most likely *A. longifolia* subsp. *longifolia*, is distributed in the Mediterranean and Humid Subtropical climates. Species occurrences further suggest that *A. longifolia's* prevalence increases from the coastlines to the inlands, expressing a non-human influence in the establishment and spread of *A. longifolia* in this scale of analysis. Second, what current/potential distribution in native range should we consider? Distribution patterns analysis established that, in Australia, '*Acacia longifolia*' fall within well-established bioclimatic envelopes but little is known about *A. longifolia* patterns of distribution ranges onother continents. Third, at the taxonomic scale, how much do we gain considering the subspecies level? Taxonomic differences of *Acacia longifolia* species from multiple invaded sites across the world are clearly distinguishable. Specifically, '*A. longifolia* subsp. *longifolia*' is distributed in a higher covered area, with wide eco-geographical conditions, and have significantly more available plant trait information than *'A. longifolia* subsp. *sophorae*'. Critically, the habitat susceptibility to invasion by *Acacia longifolia* species seems to occur much more frequently for *A. longifolia* subsp. *longifolia*. All these evidence are consistent with expected invasibility differences between invaded ranges by *A. longifolia*. Fourth, to tackle susceptibility without losing detail: Are these evidences able to tackle the habitat susceptibility by *A. longifolia* invasions at global scales?

All these reflections will be used to produce a detailed conceptual model to contextualize the susceptibility of invasion by *Acacia longifolia* in subtropical climatic regions and help to distinguish the different patterns that we encounter.

Biotic homogenization in the Andes mountains: assessing taxonomic, phylogenetic and functional dimensions caused by plant invasions and disturbance

Aníbal Pauchard[1,2], Alejandra Jiménez[1,2], Eduardo Fuentes-Lillo[1,2], Rafael García[1,2], Lohengrin Cavieres[3,2] and Ramiro Bustamante[4,2]

[1]*Facultad de Ciencias Forestales, Universidad de Concepción, Casilla 160-C, Concepción, Chile*
[2]*Institute of Ecology and Biodiversity (IEB), Universidad de Chile, Chile*
[3]*Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción, Chile*
[4]*Departamento de Ecología. Facultad de Ciencias, Universidad de Chile, Chile*
e-mail: pauchard@udec.cl

Homogenization of the world biota is occurring at an unprecedented rate with uncertain consequences for biodiversity at broad intercontinental scales, but also at local or regional scales. Mountains are of great significance for people and biodiversity but are becoming highly degraded and homogenized because of human activities and the introduction of non-native species. Homogenization not only encompasses a change in species composition, but species additions and extinctions can modify the phylogenetic structure of the community. More importantly, in terms of conservation, homogenization can modify the overall ecosystem function by changing the dominant species functional traits. This project aims to understand the current impacts on the biodiversity of mountain ecosystems, specifically in the taxonomic, functional and phylogenetic homogenization of the plant communities and how those processes are driven by climate, disturbance and the local non-native species pool. We are taking advantage of a long latitudinal gradient in the Mediterranean, temperate and subantarctic ecoregions of the Chilean Andes mountains from 32 to 53 degrees latitude south, ranging from almost sea level to 3,500 m.a.s.l. We use a standardized-systematic method of field data collection across two environmental gradients (elevation and latitude) to better understand how biological invasions are causing plant community taxonomic, phylogenetic and functional homogenization. We base our approach in the Mountain Invasion Research Network (MIREN) T-survey protocol and build a comprehensive dataset of environmental, plant community and life-history trait variables to address these questions, which will be complemented by a large scale seed-addition field-experiment in all sites. We hypothesize that across elevational and latitudinal gradients in mountain ecosystems, non-native species homogenize plant communities in their taxonomic, phylogenetic and functional dimensions, and that this process is driven by microclimates, disturbance and the lowland non-native species pools. We also expect that future scenarios associated with climatic warming, higher disturbance in the landscape and larger non-native species pools should increase taxonomic, functional and phylogenetic homogenization of plant communities. Here, we show preliminary results of our first year of this ongoing project and how we have adapted methodological approaches to study biotic homogenizations.

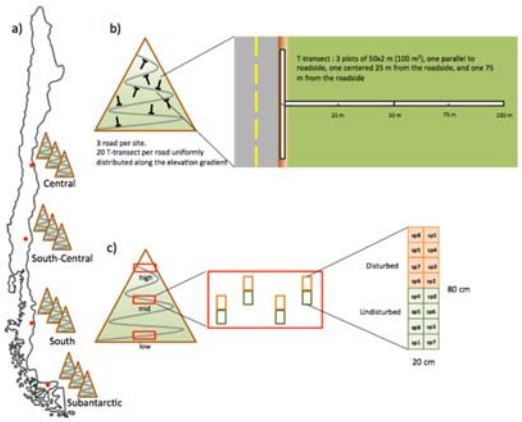

Fig. 1. Sampling design following the MIREN T-road survey (b). The study has four regions in Chile with 3 sites per region (a). The project also includes a seeding experiment at three elevations (c).

Detecting and mapping invasive Pinaceae remotely in the South Island High Country of New Zealand

T. S. H. Paul[1], J. P. Dash[1] and M. B. Scott[2]

[1]*Scion, 49 Sala Street, Private Bag 3020, Rotorua 3046, New Zealand*
[2]*Scion, P.O. Box 29237, Fendalton, Christchurch 8041, New Zealand*
e-mail: thomas.paul@scionresearch.com

Northern hemisphere Pinaceae are used very successfully as plantation trees in many southern hemisphere countries and provide significant economic benefits, but are also recognised for their invasiveness, and as transformational invaders in often highly valued environments such as the high country of New Zealand. As part of a successful management strategy, the level of invasiveness of certain species and their dispersal dynamics at specific sites, needs to be understood to predict the risk that existing populations create. Knowledge on the presence, abundance and demographics of invasive Pinaceae across the land is required for efficient control operations and long term successful management. To gain such knowledge, robust detection of infestations is required, whether it is obvious (e.g. dense and large trees) or difficult to spot (e.g. scattered small trees or in rarely visited sites) to inform targeted control of invasive conifers and to protect valuable environments. Our research aims to deliver methods for detection and mapping of invasive conifers at various spatial scales throughout New Zealand's varied landscapes and across a range of ecosystems, and at the same time inform research on understanding the ecology of invasive tree species better. As part of such a large project, we will present the results of a detailed study in an area known for its vulnerability to pine invasions.

Our study site is a large local Pinaceae infestation which originated from a 25 year old shelterbelt in the South Island high country of New Zealand. A comprehensive field survey was undertaken to provide ground truthing for remote detection and detailed information on structure and composition of the infestation representing a "first order" dispersal of trees, spreading from a known source (no secondary spread from newly established trees has yet occurred in the infestation). Multi-scale remote sensing data (airborne LiDAR sensor, ALS; and spectral imagery) were acquired from an unmanned aerial vehicle (UAV) and a fixed wing manned aircraft. Data fusion methods were developed to enhance the detection of invasive conifers and analysis techniques were deployed which enabled us to define the detection threshold for various sensors.

Our ground survey expanded across more than 800 ha. More than 17,000 trees were measured (Height range = 1 cm to 476 cm) and georeferenced providing spatially accurate information on abundance, maturity (coning) and size distributions. The full census allowed us to test the detection ability of our remote sensing approaches and we found that data from both platforms and using both logistic regression and random forests for classification provided highly accurate (kappa < 0:996) detection of invasive conifers. Our study showed that the data from both UAV and manned aircraft was useful for detecting trees as small as 1 m in height and enabled us to detect nearly every coning individual in the surveyed area. It also allowed us to describe the spread pattern accurately and mapping the densities across the topography of the study site. Both will enable us to test various hypotheses on wind dispersal patterns.

The results of the remote sensing work allowed us to remotely map, with a given accuracy, the full extent of the infestation as the basis for future control. Furthermore, the results provide confidence on the usability and cost efficiency of remote sensing approaches to detect invasive tree species early enough for effective control and management in New Zealand's High country.

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

Jan Pergl, Michaela Vítková, Martin Hejda, Josef Kutlvašr, Petr Petřík, Jiří Sádlo, Martin Vojík, Anna Lučanová and Petr Pyšek

The Czech Academy of Sciences, Institute of Botany, Průhonice 252 43, Czech Republic
e-mail: pergl@ibot.cas.cz

There is an ongoing debate on whether invasive alien species impose a greater threat to biodiversity compared to native species which are spreading in current landscapes heavily transformed by humans. However, a quantitative assessment on whether the impacts of these two groups of contrasting origins differ is missing. We measured the impacts of dominant invasive alien and native expanding plants in the Czech Republic, Central Europe, on plant communities (species composition and diversity) and soil ecosystem (physico-chemical properties and 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.

Here, we present first results from soil analyses in sites dominated by native vs alien species. We studied five native dominants (*Calamagrostis epigejos*, *Filipendula ulmaria*, *Phalaris arundinacea*, *Rubus idaeus* and *Urtica dioica*) and five alien dominants (*Impatiens glandulifera*, *Lupinus polyphyllus*, *Reynoutria* sp., *Solidago* sp. and *Telekia speciosa*). Seasonal nutrient availability and soil microbial activity were sampled three times during the vegetation season, for four weeks in each sampling period time. For nutrient availability, we used PRS ion exchange probes that measured NO_3^--N, NH_4^+-N, P, K, S, Ca, Mg, Mn, Al, Fe, Cu, Zn, B, Pb, and Cd. Microbial activity and soil fauna were analysed by burying bags with pure cellulose paper and three different mesh sizes to account for different size groups of fauna (0.1 mm – permeable to bacteria, fungi and protozoa; 1 mm – permeable to microflora, micro-and meso-arthropods; and 4 mm – freely permeable to soil fauna). The differences among the impacts of dominant native and alien plants will be discussed.

Parks as sources of invasion and refugia for threatened native species

Jan Pergl, Martin Vojík, Petr Petřík, Jiří Sádlo, Matěj Man and Petr Pyšek

Institute of Botany, Czech Academy of Sciences, Zámek 1, 252 43 Průhonice, Czech Republic
e-mail: pergl@ibot.cas.cz

Ornamental plants and human made habitats are traditionally studied separately from natural or semi-natural sites. Chateau parks act as sources of new alien plants recruiting from introduced ornamentals escaping from cultivation, but these habitats can also be threatened by invasive plants. To assess the role that chateau parks play in the invasion process, we studied parks as sources of new neophytes and as an environment providing protection for already present alien species.

We present results of a survey in 98 parks in the Czech Republic, that were located in urban areas, chateaus, palace gardens and countryside parks, in various landscape and socioeconomic contexts. Our study aims at (i) providing comprehensive information on spontaneously spreading alien taxa planted in parks or arriving from their surroundings, (ii) analysing their diversity, status, frequency and abundance, (iii) correlating the species data with socioeconomic factors and management practices used in the parks, and (iv) assessing the invasion potential of the taxa.

Our results show that (i) the number of escaping invaders and their population sizes are not as high as we expected, with many cultivated taxa in the parks; (ii) the parks are threatened by many invasive plants arriving from the surrounding urban landscapes; and (iii) many parks are refugia for threatened native species and vegetation. We found 242 alien taxa spreading from ornamental plantings in the parks, seven of them were cultivars of native taxa, 21 were new spreading alien taxa for the Czech Republic, and 26 were native taxa that were part of the garden planting out of their natural area. The most abundant species was the native *Hedera helix*, which often also behaves expansively in its natural habitats. The most abundant alien species were the invasive neophytes, *Impatiens parviflora* and *Robinia pseudoacacia*. The most common aliens recorded in the parks comprise naturalized and invasive species, which spread from the planting in almost 70% of cases, while the corresponding figure for casual aliens was only 18%.

Examining traits related to invasiveness in polar regions

Luis R. Pertierra[1], Inger G. Alsos[2] and Pedro Aragón[1]

[1]*Department of Biogeography and Global Change, Museo Nacional de Ciencias Naturales, Spain*
[2]*Tromsø Museum, Uit – The Arctic University of Norway, Norway*
e-mail: luis.pertierra@gmail.com

Biological invasions across all latitudes are a growing concern. Invasion processes at tropical and temperate regions are widely studied allowing for meta-analyses of invasive traits (Kleuven et al. 2010). However, there are fewer studies on the determinants of invasiveness at cold regions. Traits that promote invasiveness may largely vary due to the prevailing ecological limiting factors across regions. While temperate and tropical areas are subjected to a strong biotic competition, abiotic conditions of polar areas may be particularly stressful for plant invaders. Also, biological invasions are less numerous due to the relative isolation as well as relatively low human interference in polar regions. While there are few in-depth studies of their performance in relation to native species, the list of introductions is well documented (Frenot et al. 2006). Thus, we were able to analyse the prevailing patterns of traits associated with invasiveness in the most represented families Poaceae, Caryophyllaceae, and Asteraceae. We compiled and analyzed a list of traits from an extensive list of reported non-native plants historically found at nine representative islands of Arctic and Antarctic/Subantarctic regions. The number of sites colonized by a species is related to traits such as temperature and precipitation tolerance, plant height, seed production or human cohabitation. The observed patterns are discussed in light of global change scenarios, taxonomic relationships and cold areas regionalization.

van Kleunen M., Weber E. et al. (2010) A meta-analysis of trait differences between invasive and non-invasive plant species. Ecology Letters 13: 235–245.

Frenot Y., Chown S. L. et al. (2005). Biological invasions in the Antarctic: extent, impacts and implications. Biological Reviews 80: 45–72.

Examination of the global invasive relatedness among Poaceae alien species

Luis R. Pertierra[1], Pablo A. Martínez[2], Juan G. Rubalcaba[1] and Miguel A. Olalla-Tarraga[1]

[1]*Dpto. de Biología, Geología, Química y Física Inorgánica. Universidad Rey Juan Carlos. C/ Tulipán, s/n, 28933 Móstoles, Madrid, Spain*
[2]*Dpto. de Biologia. Universidade Federal do Sergipe. R. Cláudio Batista, s/n - Cidade Nova, Aracaju - SE, 49060-108, Brazil*
e-mail: luis.pertierra@gmail.com

Biological invasions are one of the major drivers of biodiversity changes worldwide, with direct consequences on the environment and human activities. Examining the evolutionary patterns and drivers of invasiveness can provide valuable knowledge towards the understanding and management of biological invasions. To this end, in the present study we compile existing knowledge on the consolidated invasive alien species among the grasses, Poaceae family, across global and national databases as well as dedicated published literature. We then cross these identities with phylogenetic information to examine their patterns of emergence in terms of their invasive character prevalence and evolutionary relatedness for the family as a whole and within different subclades. In our phylogeny, ~19% of grass species are currently catalogued as invasive, which is possibly among the highest prevalence for any single group of organisms. Remarkably, most subfamilies and tribes of grasses do contain invasive species, including basal groups. We identify hotspots of invasiveness at different phylogenetic scales such as the *Bromus* and *Lolium* clusters. We conclude that the invasive condition can be explained purely by neither random nor Brownian evolution, and thus we postulate that this could be attributed to the existence of labile traits. Both determinant and stochastic evolutionary features would be playing a role in their ultimate success. Moreover, we observe that the diversification rates for monophyletic clades positively influence the emergence of invasive species. Finally, we discuss our results according to potential invasive traits as key elements to the highly invasive success of the family. Interestingly, this signal varies significantly between Poaceae subclades with different biogeographic range occupancies, suggesting that the strength of conservative environmental filtering increases in cold tolerant specialist groups (e.g. Pooidea) where competitive traits would be less imposing.

Cadotte M. W., Hamilton M. A. & Murray B. R. (2009) Phylogenetic relatedness and plant invader success across two spatial scales. Diversity Distrib. 15: 481–488.
Pyšek P. (1998) Is there a taxonomic pattern to plant invasions? Oikos 82: 282–294.

Does abundance of ragweed differ between the two sides of former iron curtain?

Gyula Pinke[1], Tamás Kolejanisz[1], András Vér[1], Katalin Nagy[1], Ákos Bede-Fazekas[2,3], Bálint Czúcz[2] and Zoltán Botta-Dukát[2,3]

[1]*Faculty of Agricultural and Food Sciences, Széchenyi István University, H-9200, Vár 2., Mosonmagyaróvár, Hungary*
[2]*MTA Centre for Ecological Research, Institute of Ecology and Botany, 2163 Vácrátót, Alkomány u. 2-4., Hungary*
[3]*MTA Centre for Ecological Research, GINOP Sustainable Ecosystems Group, H-8237 Tihany, Klebelsberg Kuno u. 3., Hungary*
e-mail: botta-dukat.zoltan@okologia.mta.hu

The common ragweed (*Ambrosia artemisiifolia* L.) originating from North America became an important agricultural weed in the invaded areas, including Central Europe. Hungary is one of the most highly ragweed-infested countries, while in the neighbouring Austria, only the eastern and southeastern lowlands provide suitable agricultural habitats. According to general public opinion, common ragweed is now a Hungarian trademark, primarily due to the negligence of our farmers, but crossing the Austrian frontier, this plant turns to be fairly rare. It can be assumed that ecological conditions influence the abundance of common ragweed in similar extents in the two countries. Thus, if there are any differences in the degree of ragweed infestation between the two countries, we can hypothesize that land-use factors could be principally responsible.

In our study, we aimed to answer the following questions: Does the extent of ragweed infestation really differ in the border zones of the two countries? If yes, which variables explain these differences? By means of a collected farmer database, we surveyed 100 fields in four crops in both countries within approximately 30 km wide zones at both sides of the Austrian-Hungarian border. The crop species included sunflower, soyabean, maize and oil pumpkin. Altogether, 25 fields from each crop per country were sampled. The cover of ragweed was converted into binary data using different cut-off points and these binary data were analysed using binomial GLMs and model-based trees.

We found that although ragweed is present more often in Hungarian than Austrian fields, the frequency of high cover (above 5 or 10%) does not differ significantly between the two countries (however it is slightly higher in Austria). The difference in frequency of cover above 10% between the countries strongly depends on farming type, for example, in Hungary, such high ragweed cover was rather frequent in organic farms. The crop species also influenced the difference between the two countries – in maize or soybean, the high cover was more frequent in Austria, while in cereals it was more frequent in Hungary.

Invasive species impacts on the Galapagos flora, the *Cedrela odorata* case

Gonzalo Rivas-Torres[1,2,3,4], S. Luke Flory[5], Chris Wilson[5], Damian C. Adams[6] and Bette Loiselle[3,7]

[1]*Colegio de Ciencias Biológicas y Ambientales & Galapagos Academic Institute for the Arts and Sciences, Universidad San Francisco de Quito-USFQ, Ecuador*
[2]*Galapagos National Park scientific collaborator, Ecuador*
[3]*Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, FL 32611, USA*
[4]*Department of Geography, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, USA*
[5]*Agronomy Department, University of Florida, Gainesville, FL 32611, USA*
[6]*School of Forest Resources and Conservation, University of Florida, FL 32611, USA*
[7]*Center for Latin American Studies, University of Florida, Gainesville, FL 32611, USA*
e-mail: grivast@usfq.edu.ec

Non-native invasive plants on islands may result in novel plant assemblages with unique abiotic characteristics. Despite the ecological and conservation implications of the appearance of such ecological novelties, few studies have evaluated how native and non-native plant species perform under these new environmental conditions. Here, we present among others, the results of an experiment to investigate how germination, establishment, and growth of native and non-native plant species are affected by the invasive canopy tree *Cedrela odorata* in the Galapagos. *Cedrela* was introduced for timber more than 70 years ago and now covers ~1,600 hectares that present unique abiotic and biotic conditions in one inhabited island of the archipelago. Although the species is economically important as a primary timber source, invasions are thought to have significant ecological consequences. To evaluate the effects of *Cedrela* on the performance of native and invasive plants, we established replicated plots across a block of *Cedrela* dominated forest sites and removed *Cedrela* canopy trees from half of all plots. We found that the establishment and growth of native tree species, including *Scalesia pedunculata* an endemic canopy-forming tree that co-dominated *Cedrela* infested areas, were positively affected by removal of the invasive tree. Although removing *Cedrela* benefited some important native species, this treatment also promoted increased growth and establishment of other problematic invasive plants. Additionally, our multiyear work showed that *Cedrela* invasive strategies are particularly interesting and diverse, ranging from shade tolerant and low herbivore pressure, to the use of chemicals to reduce endemic seedlings growth (including *Scalesia*) which is a recently discovered strategy for invasive plants on the Galapagos islands.

Here, we not only provide useful information regarding the performance of plants with different origins under novel conditions caused by dominant invasive plants, but also present an analysis of the suitable management actions which is based on ecological and socioeconomic data and this may assist forest restoration efforts in highly invaded areas in Galapagos and elsewhere.

Do changes in plant-herbivore interactions determine the biotic resistance against *Carpobrotus edulis*?

Jonatan Rodríguez[1,2,3], Adolfo Cordero-Rivera[3] and Luís González[1,2]

[1]*Plant Ecophysiology Group, Department of Plant Biology and Soil Science, University of Vigo, 36310 Vigo, Spain*
[2]*CITACA, Agri-Food Research and Transfer Cluster, Campus da Auga, University of Vigo, 32004-Ourense, Spain*
[3]*ECOEVO Lab, E. E. Forestal, University of Vigo, 36005 Pontevedra, Spain*
e-mail: jonatan@uvigo.es

Plant invasions alter the composition of native communities by inducing negative effects on biodiversity-ecosystem functioning. Globalization facilitates the mobilization of alien species into non-native ecosystems resulting in new environmental situations and disrupting the taxonomic, behavioural and functional diversities. Native plant communities may be affected by competition with introduced plants. However, the effects of plant invasions on plant-herbivore interactions have been rarely studied. Here, we examined how plant diversity influences the occurrence of herbivores in ten coastal areas with the presence of *Carpobrotus edulis* in the NW Iberian Peninsula. The aims were to (i) evaluate the abundance of herbivorous invertebrates in different communities (invaded vs native), (ii) assess the effect of the biotic resistance on the performance of *C. edulis*, and (iii) explore the structure of the plant-herbivore interaction networks. We identified 18 different herbivorous invertebrates feeding on introduced and native plants, of which 12 fed on *C. edulis*. The herbivore species composition was affected by the invasive status and plots situated at a medium distance to the sea had more beta-diversity. Our results show that snails lead to an increase in the number of damaged flowers of *Carpobrotus* and hemipterans can affect the leaf thickness or hydration. Native areas had more specialized herbivorous species and higher values for network descriptors than invaded areas. We conclude that the feeding behaviour of the snail, *Theba pisana*, might act as a natural biological control by reducing the production of seeds in *C. edulis*. Overall, further research is necessary to understand the impacts of non-native plants as a result of invertebrates and implement long-term management strategies that are key to reduce the spread of *C. edulis*.

Improving herbicide application efficiency and efficacy for control of wilding conifers

C. A. Rolando, B. Richardson and T. Paul

Scion, 49 Sala Street, Rotorua, 3010, New Zealand
e-mail: carol.rolando@scionresearch.com

Wilding conifers, particularly *Pinus contorta* (Dougl.), *P. mugo* Turra, *P. nigra* Arnold and *Pseudotsuga menziesii* (Mirb.) Franco, present a national-scale weed problem in New Zealand with an estimated 1.7 million hectares of land infested. Currently, herbicides are the main tools used in the management of conifer infestations, ranging from isolated and scattered trees to dense canopy cover (Gous et al. 2014). Whilst herbicides are effective, current recommendations use very high rates and are, as a result, costly. There is potential to improve control recommendations by (i) increasing the targeting efficiency of application platforms, and (ii) understanding the dose-response relationships and factors driving uptake and translocation of key herbicides. We will present an overview of our research that directly addresses these two factors with an overall aim of increasing the efficiency of herbicide use and reducing unwanted environmental impacts.

One of the biggest challenges for conifer control is the ability to efficiently use herbicides where conifers are clumped and/or scattered, and canopy cover is between 30 to 70% of the infested land area. In such situations, broadcast herbicide spraying is not appropriate as there are too many off-target effects on vegetation. An aerial 'autoboom methodology' could provide a cost-effective method for precision herbicide treatment of scattered and clumped conifers with minimal off-targets effects. The aim would be for the aircraft to fly at a constant speed along pre-determined flight lines to provide an optimal path that passes over any target tree crowns. The tree crown envelopes and positions would be programmed into the aircraft's spray computer as target zones and as the aircraft passes over each target zone the boom, or sections of the boom, would automatically switch on and off. We conducted a preliminary trial to test the potential of such an aerial autoboom system and also evaluated the challenges and limitations on the implementation of this technology using aerial platforms. We will present our findings to date and outline the technology required to overcome the limitations we have identified in preliminary tests.

We are also investigating the use of multi-rotor unmanned aerial vehicles (UAVs) for conifer control. UAVs have the potential to achieve a level of precision beyond what is practical by helicopters, predominantly because of their slower operating speeds and lower spray release heights. We have faced many challenges working with UAVs and will present some of the work we have conducted in evaluating their targeting precision and spray coverage capabilities, particularly for spot spraying of conifers. At present, the downside of using UAVs is a small payload and low endurance, but the technology is rapidly improving and warrants further investigation for application to wilding conifer control.

As UAV-based herbicide application is an emerging technology for spot control, we have been investigating the relationship between herbicide dose and placement (foliar or bark) to better understand the amount of herbicide that is required to kill trees of different sizes. For this research, we tested the use and efficiency of a UAV (AGRAS MG-1) for foliar application of herbicides to the tree crown. An understanding of the efficacy of low volume foliar applications of herbicides for different tree sizes will enable us to fast track the potential to use these application platforms as tools for control of isolated conifers. We will present the results of our work and implications for further research on spot application of herbicides with UAVs and other aerial platforms for the control of invasive conifers.

Gous S., Raal P. & Watt M. S. (2014) Aerial spot treatment using an oil carrier to apply ester based herbicides for control of *Pinus contorta* and *P. nigra* in New Zealand. N. Z. J. For. Sci. 44: 23.

Action plan for invasive alien species management in the Landscape park Tivoli, Rožnik and Šišenski hrib near Ljubljana, Slovenia

Sonja Rozman

Institute of the Republic of Slovenia for nature conservation, Pobreška cesta 20, 2000 Maribor, Slovenia
e-mail: sonja.rozman@zrsvn.si

The purpose of the action plans is to minimise the negative impact of invasive alien plants on biodiversity, especially on the specific valuable natural features of the Landscape park Tivoli, Rožnik and Šišenski hrib. The Landscape park encompasses 459 ha of hilly, forested land and a city park Tivoli in the southwestern part of Ljubljana, the capital of Slovenia. Only the western part of the park is opened to agricultural land, however, on the North, South and East the area around the park is highly urbanised. The park is very popular among citizens for recreational and relaxation purposes. About two million people visit the park every year. Despite all the pressure on nature, there are still few biodiversity important sites well preserved. Two small transition mires with typical species are located at the foot of the hills. These transition mires are at the southern border of their European range. Classical locality of *Pseudostellaria europaea* is situated near the Tivoli city park.

Non-native species have been intentionally planted in the forest and especially in the city park. There are various collections of ornamental plants in the Tivoli city park. The urban area with many "green areas" surrounding the Landscape park is also a reservoir of alien plants. Animals, wind and people are the most common vectors for their spread. Therefore, invasive alien species present one of the most important threats to biodiversity of the Landscape park Tivoli, Rožnik and Šišenski hrib. Since the ice storm in 2014, when many trees were damaged and afterwards felled, invasive plants are spreading at an accelerated rate.

The action plan has been prepared through the LIFE ARTEMIS project. In 2017, alien plant inventory was compiled by volunteers. Training and the alien plant inventory manual were prepared for them. The experts from the project group supervised the inventory and helped the volunteers. The central IAS information system (www.invazivke.si) developed in the project was used for the collecting data. The inventory was created using selected transects near the paths. Priority species and areas for eradication and management were selected through the analysis of frequency of the species and importance of the area for biodiversity and its vulnerability. Stakeholders were invited to co-operate in the preparation of the action plan.

Across the whole area, 51 different alien species were detected, and at least five are widely spread, so eradication is no longer possible. On the other hand, seven species were detected in less than 10 locations, so their eradication is still feasible. Ten species which are not widely spread were selected for eradication action carried out with the help of the volunteers in 2018. For these species, the most effective methods for eradication with minimal side effects were chosen. Priority areas are Classical locality, transition mires and in the vicinity of the paths. For long term success monitoring, ten years and further is recommended.

Grošelj A., Kepic B., Podbrežnik A. & Danev G. (2015) Strokovni predlog za zavarovanje Tivolija, Rožnika in Šišenskega hriba. Zavod RS za varstvo narave, OE Ljubljana.

Marinšek A., de Groot M., Ogris N., Kutnar L., Verlič A., Kus Veenvliet J. & Rozman S. (2018) Poročilo o popisu tujerodnih rastlin v urbanem gozdu Krajinskega parka Tivoli, Rožnik in Šišenski hrib v sodelovanju s prostovoljci. Projekt LIFE ARTEMIS, poročilo o izvedbi akcije B4. Gozdarski inštitut Slovenije, Zavod RS za varstvo narave in Zavod Symbiosis, Ljubljana.

Parthenium hysterophorus in East Africa: a numerical review

Bernice Sainepo[1], Martin Tabe[2], Samuel Kiboi[3], Itambo Malombe[4], Mathias Becker[1], Thomas Heckelei[2] and Miguel Alvarez[1]

[1]*INRES-Plant Nutrition, University of Bonn, Karlrobert-Kreiten-Straße 13, 53115 Bonn, Germany*
[2]*Economic and Agricultural Policy, University of Bonn, Germany*
[3]*School of Biological Sciences, University of Nairobi, Kenya*
[4]*East African Herbarium, National Museums of Kenya, Nairobi, Kenya*
e-mail: bernicesainepo@gmail.com

Invasive species are considered one of the greatest threats to biodiversity, second only to habitat destruction. These invader species alter the ecosystem balance whereby they reduce species diversity and population. Consequently, there is a ripple effect on the ecological nexus which affects the ability of an environment to provide ecosystem services. Research in sub-Saharan Africa on *Parthenium hysterophorus* has become inclined to understanding the allelopathic nature of plant alien species, their distribution range, ways of control and management, competition with native species and their toxicology to the human health component among other numerous studies. Although, there are many papers released, evidence of duplicated work and ideas is still a prominent issue among the African research space, while some pertinent issues are still untouched or researched only on the surface in invasion ecology. This paper seeks to review studies over the last decade on parthenium hysterophorus, regions in which they have been conducted, their focus topic and consequently to identify the gaps in research of this alien species.

Published works (60) were collected, by running specific keywords independently or in combination (i.e. alien, invasive, parthenium hysterophorus). Key topics of the papers were identified based on their geographical focus. These topics include: allelopathy, distribution, competition, toxicology, management and control. While some compounds of *Parthenium* have been proven to cause dermatitis, there are also several medicinal applications for this plant species. Most of the consulted publications demonstrated a high competition ability, including allelopathic effects of *Parthenium* on crops and fodder plants.

The most important research gaps detected in this work are related to the lack of research on dispersal mechanisms, the effects of consumption by livestock and seasonal dynamics on *Parthenium* populations, degrees of invasion and biosecurity, and risk assessment of the weed. Moreover, none of the studies dealing with allelopathy considered possible auto-allelopathic effects.

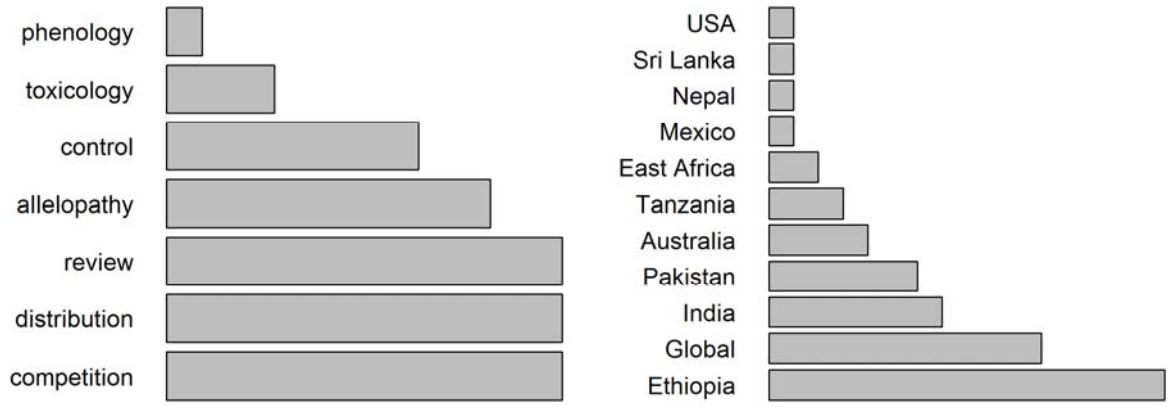

Fig. 1. Relative frequency of reviewed publications. Left: frequencies according to main topics. Right: frequencies according to geographical focus.

Influence of abiotic factors on growth and nodulation of *Acacia longifolia*

Carolina Sampaio[1], Sara Vicente[1,2,3], Margarida Ramos[1,2], Cristina Máguas[1,2] and Helena Trindade[1,3]

[1]*Universidade de Lisboa, Faculdade de Ciências, 1749-016 Lisboa, Portugal*
[2]*cE3c – Centre for Ecology, Evolution and Environmental Changes, Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisboa, Portugal*
[3]*CESAM – Centro de Estudos do Ambiente e do Mar, Faculdade de Ciências, Universidade de Lisboa, CBV, 1749-016 Lisboa, Portugal*
e-mails: htrindade@fc.ul.pt, carolinasampaio26@gmail.com

The genus *Acacia* is amongst the most aggressive invaders worldwide. This group of leguminous woody plants causes severe problems in habitats in which it is introduced. In Portugal, *Acacia* spp. is one of the most prolific plant invaders, specifically *Acacia longifolia* which was introduced to coastal areas in the late 19th century, early 20th century. Since then, the species has colonized agroflorestal and dune ecosystems, disrupting their functioning and altering the balance in native flora community. One of the key functional traits of invasive potential and colonizing capacity of these alien species lies in their ability to perform atmospheric nitrogen fixation. This process occurs inside newly formed structures, the nodules, as a result of a symbiosis established between the plant and nodulating bacteria, the rhizobia. The process of biological nitrogen fixation and the impact that *Acacia* spp. have on the habitats it invades, especially concerning the soil and the above and belowground communities is well documented. However, not much is known about how the characteristics of the soil itself, as well as how abiotic factors affects plant development and its influence on the process underlying the species invasiveness. This study intends to access how soil type (forest, agricultural and dune) subject to different conditions of irrigation and nutrition, (i) modulate *A. longifolia* development, and (ii) how it might influence plant nodulation. To achieve this, seedlings of *A. longifolia* were germinated in different soil types under four treatments (i.e. hydric comfort *vs* hydric stress, in combination with presence *vs* absence of nutritive solution). After twenty weeks, the growth and performance of the plants were evaluated by measuring: (i) shoot length; (ii) number and fresh weight of root nodules, phyllodes and roots, and (iii) total leaf area. The nitrogen fixation process was evaluated based on the isotopic composition of carbon and nitrogen, both in the nodules and phyllodes. The results demonstrate that which plants germinated in agricultural soil had a higher development, but fewer nodules. In turn, *A. longifolia* seedlings developed in dune soil had lower growth and a greater development of root nodules. Furthermore, a higher nutrient availability led to greater plant biomass, accompanied by less nodulation and atmospheric nitrogen fixation. Though, with the reduction of nutrient reinforcement, there was a greater fixation of atmospheric nitrogen, since phyllode $\delta^{15}N$ values were closer to zero in the absence of nutrient solution. This trend was transversal to soil type, and particularly evident in the dune soil. Thus, our results indicate the importance of soil origin and nutrition in the promotion of growth and nodulation of *A. longifolia*, as well as their interaction.

A National Resource Center to improve knowledge and management of IAS in France

E. Sarat[1,2], D. Blottiere[1,2], A. Dutartre[2,3], N. Poulet[2,4] and A. Albert[5]

[1]*IUCN France, 17 Place du Trocadéro, 75016 PARIS, France*
[2]*French IAS Resource Center, AFB & UICN France*
[3]*Indépendant expert, 21 Avenue du Médoc, 33114 LE Barp, France*
[4]*French Biodiversity Agency, Pôle Ecohydraulique, Allée du Professeur Camille Soula, Toulouse, France*
[5]*French Biodiversity Agency, Research, Science-advice and Data Division, 5 Square Felix Nadar, Vincennes, France*
e-mail: emmanuelle.sarat@uicn.fr, arnaud.albert@afbiodiversite.fr

Invasive alien species (IAS) are recognized as one of the leading causes of biodiversity loss worldwide. Through their multiple impacts, they threaten native species, natural habitats and ecosystem services, but also alterate economic activities and human health. Both in metropolitan France and overseas, examples of invasions are numerous: waterprimrose, American crayfish or Asian hornet; electric ant in New Caledonia, *Miconia* tree in French Polynesia, giant bramble in Reunion, etc. A large number of stakeholders are mobilized to organize surveillance, evaluate impacts, improve knowledge, define strategies and implement prevention and management actions in the field. The development of skills and the support of those stakeholders require a considerable effort to provide information, methodologies, tools for decision support, management insights and good practices.

To answer those needs, the IUCN French Committee and the French Biodiversity Agency set up a National Resource Center on IAS at the end of 2018. It targets all fauna and flora species of marine, freshwater and terrestrial ecosystems, and covers continental France and all the French overseas departments. Its main objective is to improve the effectiveness of prevention and management of biological invasions and to support national policies on the subject, in particular the national IAS strategy. It also develops management methods and training, gathers information, and disseminates knowledge and information on best practices to stakeholders, such as managers of natural habitats, NGOs, researchers, local authorities, businesses, public institutions, and state services. Available both in French and English, the Center's website provides general information on the subject, regular local, national and international news updates, as well as many legislative, technical and scientific resources. The main tools developed as well as the different networks of stakeholders supported by the IAS Resource Center will be presented.

The potential for gene technologies for management of alien plants

Andy W. Sheppard[1], Raghu Sathyamurthy[2], Kumaran Nagalingam[2] and Anu Choudhary[2]

[1]*CSIRO Health & Biosecurity, GPO Box 1700, Canberra, ACT 2601, Australia*
[2]*CSIRO Health & Biosecurity, GPO Box 2583, Brisbane, QLD 4001, Australia*
e-mail: andy.sheppard@csiro.au

Invasive alien plants managers are now on the cusp of a potential new era for biologically based control options with the advent of access to easy and accurate gene editing technologies. It is now possible to develop control agents that are small pieces of RNA of targeted changes to DNA either exogenously applied onto or endogenously incorporated into the target host and propagated through the invasive populations. Ground breaking new genetic approaches like RNAi and gene-drive open new possibilities for tackling intractable invasive alien plant species and resistant genotypes. In this poster, we will explain these technological approaches in the context of invasive alien plants and imagine the future possibilities for next generation invasive alien plant management technologies. Future possibilities for managing invasive alien plants are now possible in ways we wouldn't have dreamed of, even at the start of this millennium. As the chemical control era comes to an end, is this a chance for biologists to provide solutions to control invasive alien plants once and for all?

Biotic resistance or introduction bias? Immigrant plant performance decreases with residence times over millennia

Christine S. Sheppard and Frank M. Schurr

Institute of Landscape and Plant Ecology, University of Hohenheim, 70593 Stuttgart, Germany
e-mail: christine.sheppard@uni-hohenheim.de

Invasions are dynamic processes. Invasive spread causes the geographical range size of alien species to increase with residence time. However, with time native competitors and antagonists can adapt to invaders. 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 test (i) whether native communities more strongly reduce the fitness of immigrants with longer residence times, and (ii) whether the range size of immigrant species shows a unimodal response to residence time.

For 352 plant species in the Asteraceae family with a wide range of minimum residence times in Germany (6,000–18,000 years), we combined a common garden experiment with historical and macroecological analyses. In a multi-species experiment, we quantified the effect of native communities on fitness components of 30 annual Asteraceae. For these and other species, we then analysed how current range size depends on minimum residence time and other covariates.

Native communities reduced survival, reproductive output and fitness of Asteraceae. This fitness reduction was stronger for immigrant species with long residence times. We found a unimodal relationship between range size and residence time of Asteraceae in Germany, when including natives that immigrated after the last glaciation. Biotic resistance may limit the performance and geographical ranges of immigrant species over long time-scales. The initial advantages invaders have over natives thus may not persist over millennia, supporting the concept of an alien-native species continuum defined by gradual changes in eco-evolutionary processes. While our analysis controlled for major ecological, evolutionary and biogeographical factors, it is conceivable that the detected patterns are influenced by additional differences between natives and aliens. Experimental macroecology has a great potential to disentangle these processes and predict long-term invasion dynamics.

Sheppard C. S. & Schurr F. M. (2019) Biotic resistance or introduction bias? Immigrant plant performance decreases with residence times over millennia. Glob. Ecol. Biogeogr. 28: 222–237.

Grindelia squarrosa: economically useful or an invasive plant in Europe?

Myroslav Shevera[1], Oksana Kucher[1], Liudmyla Zavialova[1], Katarzyna Bzdęga[2], Teresa Nowak[2], Adrian Zarychta[2] and Barbara Tokarska-Guzik[2]

[1]*I.M.G. Kholodny Institite of Botany, National Academy of Sciences of Ukraine, Kyiv, Ukraine*
[2]*Department of Botany and Nature Protection, Faculty of Biology and Environmental Protection, University of Silesia in Katowice, Poland*
e-mail: barbara.tokarska-guzik@us.edu.pl

Grindelia squarrosa (Pursh) Dunal is a species of North American origin which was introduced to Europe as a medicinal plant at the beginning of the 19th century. At the turn of the 19th and 20th centuries, it was known from botanical gardens in Montpellier, Berlin or Kew. The first records of the species outside cultivation were reported from Belgium (1920), Lithuania (1946) and Ukraine (1949). From the middle of the 20th century, the species has been recorded in 16 European countries and recently also in Georgia (Fig.1). In some countries, the species has shown rapid spread over a short period of time. In the Ukraine, for example, in the years 1970-1980, the number of records increased from 26 to 53, while during the following 20 years *G. squarrosa* was recorded in 91 new sites. Current data (published and herbarium materials) document the occurrence of *G. squarrosa* in 301 localities. Further spread of the species is likely, especially in countries in which it has been recorded in a single or at few localities. Additionally, the traits of the species may further promote its spread. *Grindelia squarrosa* is one of those plant species that are very well acclimatized to conditions of low precipitation, low nutrient, high elevation and large variations in temperature. It is able to colonise various type of habitats, including arid ones. Due to its healing properties, the plant is grown on plantations (e.g. in Poland). More importantly, the species is considered a promising biofuel, which has characteristics in its properties close to biojet fuel. The plants may therefore potentially be cultivated for biofuel production in semiarid and arid lands. The advantages of using this biologically derived fuel could be substantial. Furthermore, uses of *G. squarrosa* as a substitute to abietic acid, may also include agrochemical, medicinal, and the naval stores industries. Considering both the biological characteristics of the species and its utility for humans, it is necessary to monitor the spread of the species jointly with the assessment of its impact on native biodiversity.

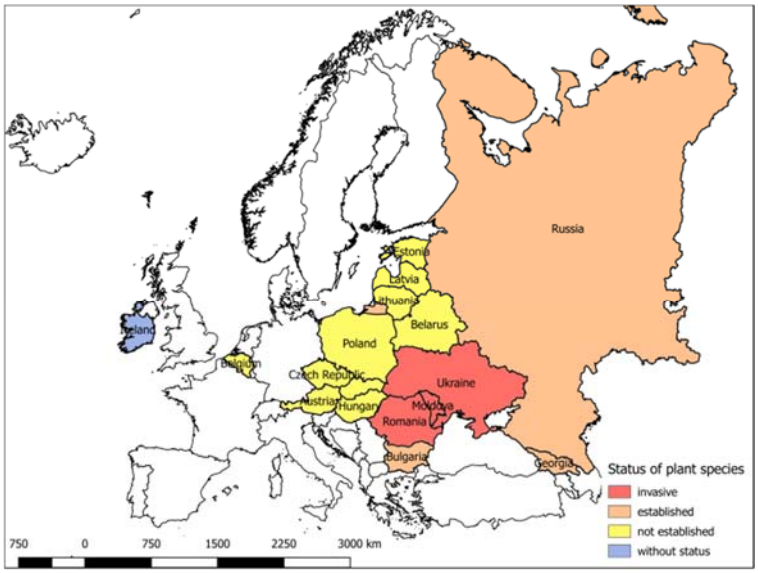

Fig.1. Occurrence of *Grindelia squarrosa* in Europe

Invasion of alien species through weed seed contaminants in grain commodities strongly affect local vegetation at international trading ports

Yoshiko Shimono[1], Mafumi Ikeda[1], Takeshi Nishi[1], Motoaki Asai[2] and Tohru Tominaga[1]

[1]*Graduate School of Agriculture, Kyoto University, Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan*
[2]*Tohoku Agricultural Research Center, NARO, 50, Harajikuminami, Arai, Fukushima, 960-2156, Japan*
e-mail: yotti@kais.kyoto-u.ac.jp (Yoshiko Shimono)

International trade of grain commodities is a major pathway for the unintentional introduction of alien plants because the seeds of various weed species contaminate grain commodities. These seeds spill out of grain commodities during unloading, transportation and usage, and some of them are naturalized in grain-importing countries. Although propagule pressure (the number of individuals arriving at a new location and the number of arriving events) is considered one of the most important driver of invasion success, little is known about the effects of weed seed contaminants on local vegetation at their introduction sites. Therefore, we analysed the relationship between the quantity of weed seeds included in grain commodities and their establishments at international trading ports which are primary introduction sites for the contaminating weed seeds.

We conducted vegetation surveys at 21 international trading ports in Japan, including 11 'grain importing ports (GIPs)' and 10 'non-grain importing ports (NGIPs)'. We also investigated weed seed compositions in grain commodities imported into Japan and a contamination percentage was calculated for each species based on our survey and previous studies on weed seed contaminants.

Vegetations at GIPs were clearly different from those at NGIPs. More alien species established at GIPs than at NGIPs. An indicator species analysis showed that more than 20 species belonging to the family Poaceae, Brassicaceae, Amaranthaceae, and Convolvulaceae were characteristic of GIP vegetation. These species showed high contamination percentages. On the other hand, only seven species were characteristic of NGIP vegetation and these species were not detected from grain commodities. Our study revealed that invasion of alien species through weed seed contaminants in grain commodities strongly affects local vegetation at international trading ports.

Combined effects on plant trait composition and soil properties by an alien tree species: perspectives from a black locust case study

Tommaso Sitzia[1], Thomas Campagnaro[1], D. J. Kotze[2], S. Nardi[3] and A. Ertani[3]

[1]*Università degli Studi di Padova, Dept. of Land, Environment, Agriculture and Forestry, I-35020 Legnaro, Italy*
[2]*Faculty of Biological and Environmental Sciences, Ecosystems and Environment Research Programme, University of Helsinki, Niemenkatu 73, FIN-15140, Lahti, Finland*
[3]*Università degli Studi di Padova, Dept. of Agronomy, Food, Natural Resources, Animals and Environment, Viale dell'Università 16, I-35020, Legnaro, PD, Italy*
e-mail: tommaso.sitzia@unipd.it

We present a study on the understory vegetation of neighbouring black locust and native tree woodlands, in pairs, across a vast northern Mediterranean lowland region under agricultural land-use abandonment. We use RLQ analysis to assess co-correlations between topographical, soil, stand, and land cover variables (R table) and species trait attributes (Q table), constrained by the relative abundances of understory vegetation species (L table). We also perform a partial RLQ to separate the effects of canopy dominance (native vs. alien) on understory trait distributions from those representing environmental conditions. The ordination diagram of the basic RLQ showed the overwhelming influence of canopy dominance, since nearly all of the black locust stands clustered at the top half of the plot (Fig. 1a). In the partial RLQ, where the effect of canopy dominance was removed, this clustering disappeared (Fig. 1b), the overall significance was maintained, but either the significance nor the contribution to total inertia of some variables were lost, namely the C:N ratio and available P in the soil, but also phenols which had a negligible contribution to total inertia in the partial RLQ (Fig. 1c).Our study shows that plant trait variability in the understory of alien vs. native tree canopies is mainly driven by three processes: soil N mineralization, light availability and edge disturbance intensity. The process of soil N mineralization must mostly be driven by the dominance of black locust in the canopy, given that this tree species contributes to an increase in the C:N ratio and available P and a decrease in phenols in the soil. Light availability and edge disturbance intensity were also associated, to some extent, to the canopy dominance by black locust vs. native trees, but less strictly, as is shown by the partial RLQ results. Perspectives for further research and management implications are discussed.

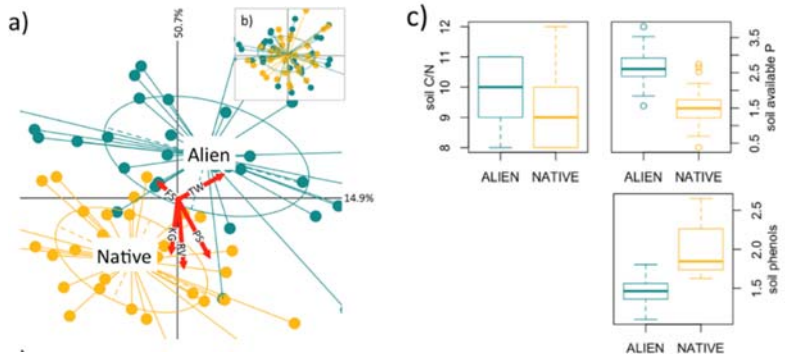

Fig. 1. Trait responses to alien vs. native tree dominance in the stand canopy (TW = overwintering, PS = self-pollination, RV = vegetative reproduction, KG = geophytes, FS = flowering during January-March). Sample scores (64 stands) of the first two axes of the basic RLQ (a) and partial RLQ (b). Samples are marked after the alien (cyan) vs. native (golden) stratification. The size and direction of the most significant plant trait effects are represented by red arrows. Boxplots (c) represent the distribution of soil properties mostly related to the alien vs. native stands.

Sitzia T., Campagnaro T., Kotze D. J., Nardi S. & Ertani A. (2018) The invasion of abandoned fields by a major alien tree filters understory plant traits in novel forest ecosystems. Sci. Rep. 8: 8410.

In search of traits driving plant invasion: growth, tissue chemistry and genome size of invasive and native *Phragmites australis* populations

Hana Skálová[1], Jan Čuda[1], Wen-Yong Guo[1,2], Magdalena Lučanová[1], Lenka Moravcová[1], Laura A. Meyerson[3] and Petr Pyšek[1,4]

[1]The Czech Academy of Sciences, Institute of Botany, CZ-252 43 Průhonice, Czech Republic
[2]Department of Bioscience, Faculty of Science, Aarhus University, Ole Worms Alle 1, DK-8000 Aarhus C, Denmark
[3]Department of Natural Resources Science, The University of Rhode Island, Kingston, Rhode Island, 02881 USA
[4]Department of Ecology, Faculty of Science, Charles University, Viničná 7, CZ-128 44 Prague, Czech Republic
e-mail: hana.skalova@ibot.cas.cz

The cosmopolitan reed grass, *Phragmites australis* (Poaceae), has become a model species for studying plant invasions. In our study we used 89 genotypes from Australia, Europe, and North America (with two groups including native and invasive populations introduced from Europe), South Africa and Far East; the plants were grown for two vegetation seasons in an experimental garden in Průhonice near Prague, Czech Republic. Based on a wide range of measured traits, the populations clustered into two distinct groups: one that includes populations from Europe and Far East together with the North American invasive, and the second including the North American native populations with those from Australia and South Africa. Populations within the former group exhibited superior performance in the following traits: they were more vigorous in terms of higher shoot number per pot, greater belowground biomass, and longer rhizomes, had greater specific leaf area (SLA), higher N and P concentrations in tissues, and greater investment into generative reproduction. The results indicate that invasion by Australian and African populations in the Northern Hemisphere seems unlikely at present due to a weak environmental match and/or genetic differences. However, it is not possible to exclude the further invasion of genotypes of European or Far East origin into Southern Hemisphere or other temperate regions. In terms of traits, monoploid genome size was the only significant variable that, in our experiment, clearly separated the North American native genotypes from those of European origin. The mean Cx value (the amount of DNA in one chromosome set) for source European native populations was 0.490 0.007 (mean SD), for North American invasive 0.506 0.020, and for North American native 0.543 0.021. Relative to North American native populations, the North American invasive had a smaller genome that was associated with plant traits favoring invasiveness.

Pyšek P., Skálová H., Čuda J., Guo W.-Y., Suda J., Doležal J., Kauzál O., Lambertini C., Lučanová M., Mandáková T., Moravcová L., Pyšková K., Brix H. & Meyerson L. A. (2018): Small genome separates native and invasive populations in an ecologically important cosmopolitan grass. Ecology 99: 79–90 (doi: 10.1002/ecy.2068)

Pyšek P., Skálová H., Čuda J., Guo W.-Y., Doležal J., Kauzál O., Lambertini C., Pyšková K., Brix H. & Meyerson L. A. (2019): Physiology of a plant invasion: biomass production, growth and tissue chemistry of invasive and native Phragmites australis populations. Preslia 91: 51–75 (doi: 10.23855/preslia.2019.051)

Effect of growing conditions on the germination of native and invasive *Impatiens* species

Hana Skálová[1], Lenka Moravcová[1], Jan Čuda[1] and Petr Pyšek[1,2]

[1]*Institute of Botany, The Czech Academy of Sciences, Zámek 1, CZ-252 43 Průhonice, Czech Republic*
[2]*Department of Ecology, Faculty of Science, Charles University, Viničná 7, CZ-128 44 Prague, Czech Republic*
e-mail: hana.skalova@ibot.cas.cz

Population dynamics of annual species, especially those with less abundant seed banks, depends on the recruitment from seed, a process in which a proper timing of germination is crucial. Previously, we studied the effect of growing conditions in the field on the germination of native and invasive *Impatiens* species (Balsaminaceae) in the Czech Republic. In the native *Impatiens noli-tangere* we found a strong effect of spring temperature at the original localities on the germination timing, with seeds from climatically colder localities germinating earlier. A similar but much weaker effect was found in the invasive *I. parviflora*, and the absence of any such effect was observed in *I. glandulifera*, a species whose invasion started later than that of *I. parviflora* (Skálová et al. 2011). In this study, we addressed the effects of cultivation temperature (garden vs greenhouse with increased temperature) and time of seed collection on the germination dynamics of these species. In *I. noli-tangere* the germination of seeds harvested later in the season was strongly delayed and a high proportion of seed were dormant. The effect of locality was detectable in all seeds, but the size decreased in seeds collected later in the season. *Impatiens parviflora* seeds from the greenhouse germinated earlier than from the garden and the effect was especially pronounced in seed collected later in the season. In addition, germination was not synchronised in the seeds collected from the garden later in the season. The effect of spring temperature in the original localities gradually diminished with time of collection. Delayed germination in seeds collected later in the season was observed also in the highly invasive *I. glandulifera*. Surprisingly, the effect of spring temperature in the original localities (i.e. early germination of seeds from colder localities) was observed and it was stronger for seeds collected later in the season. These results indicate strong population differentiation within the native species and ongoing differentiation in the invasives.

Skálová H., Moravcová L. & Pyšek P. (2011) Germination dynamics and seedling frost resistance of invasive and native *Impatiens* species reflect local climatic conditions. Persp. Plant Ecol. Evol. Syst. 13: 173–180.

Leycesteria formosa: an ornamental but potentially invasive species in Serbia

Dragana Skočajić, Mihailo Grbić, Marija Nešić, Ivana Bjedov and Dragica Obratov-Petković

University of Belgrade – Faculty of Forestry, Kneza Višeslava 1, 10030 Belgrade, Serbia
e-mail: dragana.skocajic@sfb.bg.ac.rs

A few years ago, the decorative species *Leycesteria formosa* Wall. appeared in garden centers and nurseries in Serbia. Native to southwestern China and the Himalayas, this deciduous shrub has also naturalized in some European countries. This species shows great adaptability to different site conditions although it prefers rich soils. It is a fast-growing species with a high number of shoots, easily propagated vegetatively by layering and root fragments which increases the possibility of its spread through human activities. In addition, this plant produces a high number of seeds which are dispersed hydrochorously and zoochorously by birds and mammals.

In order to examine the germination potentials, seeds were collected from parent trees in a private yard in Belgrade. A total of 4 × 50 seeds were placed in laboratory conditions (germination thermostat, germination temperature of 21±2°C and 16/8 photoperiod). Real germination and germination intensity were determined after 14 days, and germination energy after 5 days. The results showed a high germination percentage (98%) and germination energy (84%) two days after the beginning of the experiment. This points to the high degree of seed vitality and intensity of germination, which characterizes potential invasive plants.

Leycesteria formosa is listed as one of the 100 most invasive species in Macaronesia, while the EPPO Reporting Service (2014) points to the need for the monitoring of this species in Great Britain, Ireland, France and Azores. However, due to climate change, the conditions prevailing in the area of Belgrade are becoming quite similar to the ones in the areas from which the species is introduced and further increases the chances of this species to adapt to the new environment and increase its invasion risk. Currently, this species is not observed in natural habitats in Serbia, but its expansion can be expected through sales in nurseries and garden centers. In order to prevent the spread of *L. formosa* to urban and natural habitats, further careful observations are needed.

Effects of past land-use on invasions by alien plants in the Czech Republic

Martina Sychrová[1], Martin Musil[1,2], Jan Divíšek[1,3], Milan Chytrý[3], Jiří Danihelka[3,4], Marek Havlíček[2], Zdeněk Kaplan[4], Petr Novotný[4,5], Petr Pyšek[4,6], Hana Skokanová[2] and Jan Wild[4]

[1]*Department of Geography, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic*
[2]*Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Lidická 25/27, 602 00 Brno, Czech Republic*
[3]*Department of Botany and Zoology, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic*
[4]*Institute of Botany, Czech Academy of Sciences, Zámek 1, 252 43 Průhonice, Czech Republic*
[5]*Department of Teaching and Didactics of Biology, Charles University, Viničná 7, 128 00 Praha, Czech Republic*
[6]*Department of Ecology, Charles University, 128 43 Praha 2, Czech Republic*
e-mail: sychrova.martina@gmail.com

It is generally acknowledged that land-use structure and its changes influences levels of invasion by alien plants across the landscape. In this study, we asked how land-use changes over the last 180 years influenced spatial patterns of alien plant invasions in the Czech Republic. We hypothesize that (i) dynamically changing landscapes with a high level of disturbances host more alien or invasive species than those with long-term habitat continuity, and (ii) land-use changes resulting in more degraded landscape (e.g. increase in built-up areas or arable land) are associated with increased invasion levels.

To test these hypotheses, we used plant distribution data from the Pladias database. This dataset contains species occurrence records in 2370 grid cells (~ 6 × 5,5 km) of floristic mapping covering the area of the Czech Republic. Environmental data (e.g. mean annual temperature, annual precipitation) and historical land-use data (indices of land-use change) were used as explanatory variables of invasion levels, which were defined as the proportion of alien species among the total flora in each grid cell. Alien plants were considered either as one group or divided according to (i) the most advanced stage they have reached in the invasion process (naturalized and invasive species) or (ii) the residence time status (archaeophytes and neophytes). Historical land-use data were extracted from digitized topographical maps for the following periods: 1836−1852 (2nd Austrian Military Survey), 1876−1880 (3rd Austrian Military Survey), 1952−1955, 1988−1995, and 2002−2006. These data allowed us to quantify individual land-use changes (e.g. afforestation or expansion of built-up areas) in each grid cell and between each period.

The proportions of neophytes, naturalized and invasive species in the grid cells were best explained by the mean annual temperature followed by an increase in built-up area and a decrease in forest area. A weaker correlation was found with changes in the proportion of grasslands and arable land. The proportion of archaeophytes was best explained by a decrease in forest area, similar to neophytes, but also by an increase in the area of arable land. Our results corroborate the second hypothesis that the extension of human-made land-use types increases invasion levels. However, the correlations between the overall landscape change and the levels of invasion were very weak.

Expansion of halophilic and pseudo-halophilic alien species in Lower Silesia (SW Poland) as reaction for co-impact of salt deicing and climate changes

Ewa Szczęśniak[1], Zygmunt Dajdok[1], Marek Krukowski and Magda Podlaska[2]

[1]*Department of Botany, University of Wrocław, pl. Uniwersytecki 1, 50-137, Wrocław, Poland*
[2]*Department of Botany and Plant Ecology, Wrocław University of Environmental and Life Sciences, Wrocław, Poland*
e-mail: ewa.szczesniak@uwr.edu.pl

In Poland, the flora of halophytes is rather poor and originally associated with dunes or wet salt meadows along the coast of the Baltic Sea and with over a dozen inland sources of salt water. In Lower Silesia, halophytes are originally absent because there is a lack of natural open salt deposits, saline soils or sources of salt water. Up to the end of 20th century, only sporadic and ephemeral stands of a few halophilic plant species were recorded (e.g. *Glaux maritima* and *Puccinelia distans*).

As an effect of intensive salt deicing during the last 20 years, a group of plant species benefiting from this process appeared. The soil salinity is the highest in the beginning of vegetation season and strongly limits germination of native non-halophilic plant species. We documented 82 patches of vegetation associated with salty soils and distinguished two groups of halophytes.

The first group consists of obligatory or facultative halophytes native to Central Europe, preferring saline substratum or tolerating it (e.g. *Plantago coronopus*, *Spergularia salina*, *Puccinelia distans*, and *Polygonum aviculare* agg). These species start to grow in early spring and are limited to narrow patches (max. 50-80 cm wide) of shallow puddles along roads, with periodically standing salt water and long lasting salt content. Their community refers to association *Puccinellietum limosae* Soó 1933 of the class *Festuco-Puccinellietea* Soó ex Vicherek 1973, native to natural salt meadows in Poland.

The second group consists of alien drought resistant thermophilic plants, germinating 4-8 weeks later than the native species. High salinity eliminates previously germinating plants which enables these species to start growing without competitors. During germination, the salinity level is already low, and therefore these species are calledpseudo-halophilic species. They occupy dry and warm well drained roadsides and the middle lanes of highways. Over the past decades, we observed their rapid expansion; earlier they were eliminated by frosts. Almost all patches are dominated by one alien species, for example, *Dittrichia graveolens*, *Senecio inaequidens* or *Atriplex micrantha.*

In total, 137 species of vascular plants were noted in all samples, however the composition of the patches seems to be highly accidental and about 80% of the species occurs in less than 10% of patches. Almost all seedlings of sporadically noted plants observed in late summer and autumn did not survive the winter deicing season. Alien species comprised 30% of sporadically noted plants, 52% of constantly present, and 83% of dominating or co-dominating species. Halophytes or pseudo-halophytes were 3%, 47% and 66%, respectively.

Alien species diversity and composition in periurban and urban forest islands is affected by adjacent land use

Mirjana Šipek and Nina Sajna

University of Maribor, Koroska c. 160, Maribor, Slovenia
e-mails: mirjana.sipek1@um.si, nina.sajna@um.si

Introduction of alien species is considered as one of the major threats to native biodiversity after human influenced land use changes that cause fragmentation and habitat destruction. Diversity and composition of alien plant species (APS) differ according to specific land uses. APS are the most abundant in urban areas such as human settlements, industrial areas and in vicinity of transport infrastructures because roads are potential corridors dispersing APS propagules. Residential gardens are an important source of APS where numerous ornamental and edible plants are abundant and some of them could escape from cultivation, become naturalized and even invasive. The spread of APS into adjacent natural and semi natural habitats is influenced by settlement size and the distance to potentially invaded habitats. Especially small urban and periurban forest islands are under a high risk of invasion because of numerous house gardens and frequent road networks in the vicinity. Moreover, such forests are also under high disturbance pressure, which further increases the probability of invasions. Local inhabitants use forest fragments for forestry, recreational activities, cutting and harvesting of non-timber forest products, and finally, yet importantly, dumping garden waste in forest edges.

To analyse how adjacent land use influence diversity and composition of APS, we surveyed alien flora in 16 forest islands trapped in urban or rural matrix in NE Slovenia. We calculated the proportion of each land use adjacent to the forest island using Google Earth Pro. For forest islands in a rural matrix, we calculated the distance to the adjacent settlement to find a correlation with APS richness and proximity to the propagule source.

We found a positive correlation between APS richness and proportion of the residential area, while the trend was negative when the proportion of adjacent arable land was increasing. Further, a negative correlation was found between the proximity to settlements and the APS. The most common herbaceous aliens were *Phytolaca americana* L.*, Impatiens parviflora* DC.*, Erigeron annuus* (L.) Pers. and *Duchesnea indica* (Andrews) Th. Wolf, while the most common woody alien was *Robinia pseudoacacia* L. occurring in approximately 90% of forest islands regardless of adjacent land use type and other forest fragment features. In the understorey of plots near settlements, we found alien shrub species common for gardens such as *Prunus laurocerasus* L. and *Symphoricarpos albus* (L.) S.F.Blake. Our results show that urban and periurban forest fragments are under high risk of invasions and should be monitored in the future to prevent new establishments. Further, local inhabitants should be informed about activities that promote new invasions to minimize them, for example, depositing garden waste in nearby forests.

Dyderski M. K. & Jagodziński A. M. (2018) Drivers of invasive tree and shrub natural regeneration in temperate forests. Biol. Invas. 20: 2363–2379.

Gonzáles-Moreno P., Pino J., Carreras D., Basnou C., Fernández-Rebollar I. & Vilà M. (2013) Quantifying the landscape influence on plant invasions in Mediterranean coastal habitats. Landsc. Ecol. 28: 891–903.

Gonzáles-Moreno P., Pino J., Gassó N. & Vilà M. (2013) Landscape context modulates alien plant invasion in Mediterranean forest edges. Biol. Invas. 15: 547–557.

Medvecká J., Jarolímek I., Hegedüšová K., Škodová I., Bazalová D., Botková K. & Šibíková M. (2018) Forest habitat invasions: who with whom, where and why. For. Ecol. Manage. 409: 468–478.

Rhizome extracts of invasive *Fallopia japonica* and *F.* ×*bohemica* inhibit root growth and modify root tip ultrastructure of radish

Katarina Šoln, Nada Žnidaršič and Jasna Dolenc Koce

University of Ljubljana, Biotechnical faculty, Dept. of Biology, Večna pot 111, SI-1000 Ljubljana, Slovenia
e-mail: katarina.soln@bf.uni-lj.si

Japanese knotweed (*Fallopia japonica*) and Bohemian knotweed (*F.* ×*bohemica*) are invasive alien plants that according to the novel weapon hypothesis inhibit growth of their neighbours by allelopathy (Hierro and Callaway, 2003). The main target of knotweed´s allelopathic compounds is the primary root of a tested plant (Dolenc Koce and Šoln, 2018). The aim of our study was to evaluate the effect of knotweed rhizome extracts on morphological and biochemical characteristics of radish roots. Radish seeds were exposed to knotweed extracts in a range of concentrations (0.5%–10%). After seven days, biochemical markers of oxidative stress were examined, and morphological and ultrastructural characteristics of root cells were analysed using light and transmission electron microscopes.

Root growth of the treated radish was strongly inhibited, whereas shoots were not affected. Roots were shorter and thicker due to changes of cell shape and size in the cortex. Knotweed extracts exhibited a strong effect on the root cap cells: cell membrane, mitochondria and endoplasmic reticulum ultrastructure was affected and some cells were completely disintegrated. The ultrastructure of apical root meristem was also affected, one of the changes was increase in the amount of vacuoles. Biochemical characteristics of oxidative stress (enzymatic and non-enzymatic antioxidants, lipid peroxidation) changed according to the control treatment. Staining with diaminobenzidine showed the increased synthesis of hydrogen peroxide in roots.

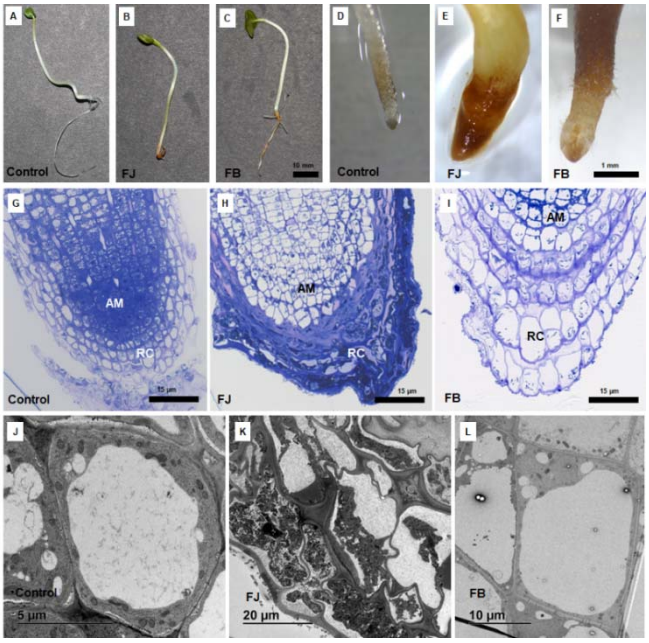

Fig. 1. Radish seedlings (A-C) and their roots (D-F), root histological structure (G-I) and root ultrastructure (J-L) of control and treatments with 10% *F. japonica* extract (FJ) and 10% *F.* ×*bohemica* extract (FB). Abbrevations: root cap (RC), apical meristem (AM).

Dolenc Koce J. & Šoln K. (2018) Phytotoxic effects of Fallopia japonica and F. ×bohemica leaves. Phyton 57: 47–57.
Hierro J. L. & Callaway R. M. (2003) Allelopathy and exotic plant invasion. Plant Soil 256: 29–39.

Native insect herbivory on Nootka lupine in Iceland

Mariana Tamayo

Environment and Natural Resources, University of Iceland, Sturlugata 7, 101 Reykjavík, Iceland
e-mail: mlt@hi.is

Nootka lupine (*Lupinus nootkatensis*) was introduced from Alaska (USA) to Iceland in 1945, becoming naturalized in the 1950s. Currently, this invasive plant occurs throughout Iceland and continues to spread, creating monocultures that change soil conditions and species diversity. Three Icelandic moths – the red-backed cutworm (*Euxoa ochrogaster*), broom moth (*Melanchra pisi*), and satyr pug (*Eupithecia satyrata*) – have shown host expansion to Nootka lupine. These moths are generalist herbivores, and both the broom moth and satyr pug can cause damage to various tree species, while the red-backed cutworm can be a horticultural pest. Data gaps exist on the interactions of these moths with alien and native plants in Iceland. In 2015, I began to assess the distribution and herbivory in southern Iceland of the red-backed cutworm, and subsequently that of the broom moth and satyr pug, on Nootka lupine (alien invasive plant, n=6 sites), and compared them to areas with lyme grass (*Leymus arenarius,* native plant, n=6 sites) and neighbouring horticultural crops (alien plants, n=6 sites). Larval surveys were conducted in late May-June (red-backed cutworm) and August (broom moth and satyr pug) by checking individual plants for herbivory and larvae for 20 minutes. Moreover, a 50 m transect line with randomly placed 0.25 m^2 quadrats were used to further assess plant cover and larval abundance of the red-backed cutworm. Adult surveys occurred in August for the red-backed cutworm using pheromone traps which attract male adults. Results indicate that between 2015–2017, the larval abundance of red-backed cutworms ranged from 0-31 larvae/site. Sites with Nootka lupine had the highest larval abundance, but it was not significantly greater than in sites with lyme grass. The abundance of male adults of red-backed cutworm varied greatly among years regardless of host plant. Overall, 65 males/site were found in 2015, whereas in 2016 and 2017 less than 1 male/site. Red-backed cutworm herbivory on alien plants included Nootka lupine, rutabagas (*Brassica napobrassica*), and carrots (*Daucus carota*). Herbivory also occurred on five native plants including lyme grass. Broom moth herbivory occurred on alien plants such as Nootka lupine, rutabagas, rapeseed (*B. napus*), carrots, and on at least seven native plants. This study highlights the importance of long-term monitoring to assess herbivory dynamics of native insects and their interactions with alien and native host plants, including agricultural systems.

IRS (International Ragweed Society) an international tool to help *Ambrosia* management

Michel Thibaudon[1], Roberto Albertini[2], Maira Bonini[3], Sevcan Celenk[4], Sandra Citterio[5], Lazlo Makra[6], Gilles Oliver[7], Olivier Pechamat[8] and Uwe Starfinger[9]

[1]*IRS President, RNSA, Brussieu, France*
[2]*Department of Medicine and Surgery, University of Parma, Italy*
[3]*Department of Hygiene and Health Prevention, Agenzia di Tutela della Salute della Città Metropolitana di Milano, Italy*
[4]*Uludag University, Department of Biology, Aerobiology Laboratory, Bursa, Turkey*
[5]*University of Milano – Bicocca, Department of Earth and Environmental Sciences, Milan, Italy*
[6]*Institute of Economics and Rural Development, University of Szeged, Hódmezővásárhely, Hungary*
[7]*RNSA, Brussieu, France*
[8]*FREDON France, Paris, France*
[9]*Julius Kuehn Institute, Braunschweig, Germany*
e-mail: michel.thibaudon@wanadoo.fr

One of the main causes of pollen allergy and pollen related asthma during the late summer in North America and Central Europe is ragweed (*Ambrosia* L.), a widespread monoecious genus in the Asteraceae. In Europe short or common ragweed (*A. artemisiifolia* L.) is the prevalent species of the genus. Ragweed pollen can be transported by wind over long distances (i.e. several hundreds or thousands of kilometers) and may cause allergy symptoms also in areas where the plant is not widespread. Ragweed has an enormous invasive potential through the production of large quantities of seeds with very high germination capacity. The weed damage in agriculture and potential effects on biodiversity add up to a huge negative impact. In Europe, short or common ragweed (A. *artemisiifolia* L.) is prevalent.

Actually, ragweed has a higher spread potential than most indigenous annual dicotyledonous and grass weed species in Central Europe. This situation requires regular monitoring of the plant and the implementation of an accurate control strategy involving not only farmers but also the staff managing natural areas, roadsides, building, municipalities and health authorities. Unfortunately, in many countries, the legal situation is far from sufficient to monitor and manage the spread of ragweed. It is therefore important that the public is aware of the plant and the problems caused by it.

The main topic of the IRS is to gather work from all over the world about phenology, pollen monitoring and management of *Ambrosia* in different places. IRS organizes a dedicated international congress in Europe every 4 or 5 years where researchers can present state of the art work on *Ambrosia* related knowledge to propose targeted preventive measures.

Karrer G., Starfinger U., Kazinczi G., Kudsk P., Simoncic A., Milakovic I., Sölter U., Verschwele A., Mathiassen S., Basky Z., Kömives T. & Leskovsek R. (2014) Recommendations to fight ragweed derived from the EU-project HALT AMBROSIA. In: Fried G. et al. (eds), 4th International Symposium on Environmental Weeds and Invasive Plants in Montpellier. Abstracts. May 19 to 23, 2014, p. 167, Montpellier SupAgro, Montpellier, France.

Sölter U., Starfinger U. & Verschwele A. (eds) (2016) HALT Ambrosia – final report and general publication of project findings. Julius-Kühn-Archiv Vol. 2016, No. 455.

Starfinger U. (2009) Can the general public help fight the invasion of an undesired plant invader? The case of *Ambrosia artemisiifolia*. In: Pyšek P. & Pergl J. (eds), Biological invasions: towards a synthesis. NeoBiota 8: 217–225.

Ventenata dubia: invasion potential and impact on native communities in North America's Inland Pacific Northwest

Claire Tortorelli[1], Meg Krawchuk[1] and Becky K. Kerns[2]

[1]*College of Forestry, Oregon State University, Corvallis, Oregon, USA.*
[2]*US Forest Service, Pacific Northwest Research Station, Corvallis, Oregon, USA.*
e-mail: claire.tortorelli@oregonstate.edu

In North America's Intermountain West, a recently introduced annual grass, *Ventenata dubia*, threatens to increase fuel accumulation and fire activity, potentially disrupting ecosystem function where it dominates previously uninvaded semiarid ecosystems. Its recent and rapid expansion into agricultural and natural areas has raised concern amongst land managers and ecologists since little is known regarding *Ventenata* invasion potential, the extent of its ecological impacts, or how these differ from other invasive annual grasses in the region. We investigated environmental drivers of *Ventenata* invasion and impacts on plant communities across the Blue Mountain Ecoregion in the Pacific Northwest of the United States to help address this knowledge gap. We sampled *Ventenata* abundance, plant community composition and structure, and environmental variables including canopy cover, soil and topographical characteristics, and burn severity from 110 plots within and surrounding seven recently burned areas across the ecoregion. To evaluate the relationship between environmental variables and *Ventenata*, and to compare plant community composition and structure between burned and unburned areas, we used linear models and non-parametric analyses including nonmetric multidimensional scaling and multi-response permutation procedures.

Our results show that *Ventenata* is associated with a wide range of abiotic environments and myriad plant community types including forests, shrub-steppe, and meadows, suggesting that *Ventenata* has widespread biotic and abiotic tolerances. Such broad tolerances are often linked to a high invasion potential. Of these environments and plant community types, we found *Ventenata* to most heavily invade basalt parent materials, elevations between 1300 m and 1600 m, and stiff sagebrush (*Artemisia rigida*) plant communities that were not heavily invaded by other exotic annual grasses. Our results highlight these ecosystems as being at a high risk for invasion and suggest that *Ventenata* is invading previously uninvaded communities, thus exacerbating landscape-scale invasion impacts. Although *Ventenata* was not associated with large shifts in community composition between invaded and uninvaded communities, burning in concert with invasion had severe impacts on community structure in stiff sagebrush ecosystems, where, five years post fire, nearly all prominent shrub species were absent and *Ventenata* dominated. Invasion may facilitate the spread of wildfires in fire-sensitive stiff sagebrush communities, potentially transforming unique shrub-steppe ecosystems into annual grasslands. The replacement of keystone shrub species with dense annual grasses could have severe implications for hydrologic cycling, habitat quality, and soil stability in these ecosystems that historically demonstrated resistance to invasion and disturbance. Further research is required to fully understand the ecological impacts of *Ventenata* invasion, but results from this study provide insight into current impacts on plant community composition and structure which could be used to prioritize sensitive ecosystems for management, helping to mitigate potential ecological losses.

Predictive propagule pressure reduction from biosecurity inspection

Raphaël Trouvé[1,2] and Andrew Robinson[1]

[1]*School of Ecosystem and Forest Sciences, University of Melbourne, 500 Yarra Blvd, Richmond, Victoria 3121, Australia*
[2]*CEBRA & School of Mathematics and Statistics, University of Melbourne, Victoria 3010, Australia*
e-mail: raphael.trouve@unimelb.edu.au

The introduction of invasive plants with global trade is one of the most important socioecological challenge worldwide. One major option to reduce the introduction of invasive species is border inspection (i.e. reducing the risk at point of entry). Biosecurity inspection has most often been framed as an acceptance sampling problem at the consignment-level, i.e., inspecting each incoming consignment until we are confident that its infestation rate is below a chosen threshold. However, at the pathway-level, we currently lack a method to interpret the effect of inspection in terms of a risk assessment model (risk = probability of invasion times consequences).

Here, we provide an analytical framework and derive an explicit formula to predict propagule pressure reduction that arise from inspecting a pathway. The risk reduction from inspection arises from two processes (i) a reduction of the number of consignments allowed to enter the country due to non-compliance and (ii) a reduction in the mean infestation rate in the consignments allowed to enter the country compared to the mean infestation rate outside the country, as the inspection will preferentially filter highly infested consignments.

We illustrate our approach on several plant invasion pathways to Australia and New Zealand. We show that the risk reduction factor associated with an inspection can vary by more than one order of magnitude among pathways. Theoretical analysis reveals that we can predict the effectiveness of an inspection from the characteristics of the pathway (mean infestation rate and variability in infestation rate among different consignments of the pathway). Reframing biosecurity inspection within the framework of the risk assessment model not only allows optimizing the allocation of sampling effort for inspection, but it also allows comparing inspection effects with other potential risk reduction measures.

Using an invasive legume to engineer healthy agricultural soil: from mechanisms to models of a potential win-win situation

Florian Ulm, Cristina Cruz and Cristina Máguas

Faculdade de Ciencias da Universidade de Lisboa, cE3c - Centre for Ecology, Evolution and Environmental Changes, Campo Grande, C2, 1749-016 Lisbon, Portugal
e-mail: ulm.florian@gmail.com

Mediterranean basin ecosystems are under increasing pressure from invasive species and especially ecosystem-engineers, such as woody legumes, are a major threat to ecosystem functioning and biodiversity, as they can profoundly alter soil nutrient cycles. As many Mediterranean soils are highly oligotrophic and nutrient limited, alterations in these cycles can be detrimental for the native vegetation, which is adapted to low nutrient input and exhibits low growth rates. On the contrary, invasive woody legumes, such as *Acacia* spp., which are highly invasive in Portuguese dunes and adjacent agricultural landscapes, grow rapidly, increase soil organic matter (SOM) levels, change soil nutrient cycles and create monospecific stands that fully replace the native vegetation.

However, the alterations have also been shown to be initially beneficial for nearby plants by increasing available N, SOM and soil microbial activities in general. This leads to increased foliar N and plant growth rates in nearby native plants and is a positive effect that is juxtaposed with the negative consequences of competition for other nutrients. Not only the native vegetation, but also agricultural fields, are under pressure from invasion and exhibit similarly low SOM levels. This creates a vicious cycle, as one of the consequences of low SOM is increased nutrient leaching, benefitting *Acacia* plants in adjacent strips of unused land.

Here, we propose a potential win-win situation in which we present the feasibility of using *Acacia* derived biomass as soil amendments in an agricultural setting, thus making use of its extraordinary biomass accumulation capacity. We close local nutrient cycles by modelling existing biomass using field based and remote sensing technology, compost the biomass to remove the seed bank, and successfully use the resulting amendment for food production. Also, we show how this applied work can help to deepen the understanding of invasion impacts on soil level.

Genetic diversity and geographic origin of *Ailanthus altissima*: Europe versus Vienna (Austria)

M. van Loo[1], D. Lazic[2] and M. H. J. Barfuss[1]

[1]*Department of Botany and Biodiversity Research, University of Vienna, Rennweg 14, 1030 Vienna, Austria*
[2]*University of Natural Resources and Life Sciences, Peter-Jordan Strasse 82, A-1190, Vienna, Austria*
e-mail: marcela.van.loo@univie.ac.at

Tree-of-heaven (*Ailanthus altissima* (Mill.) Swingle) is a dioecious pioneer tree species, which reproduces both sexually and asexually. Early sexual maturity, prolific fruiting, ready germination, adaptability to infertile sites and rapid growth rates make *A. altissima* an intensely spreading tree in many countries where it has been introduced. According to historical records, first seeds were sent from Peking (China) to Paris in the 1740s (Hu 1979). The tree-of-heaven soon became a popular planted species also in other European cities. Consequently cities became the place where the establishment and naturalization of this tree species principally started. At present, this tree grows throughout the majority of European countries.

In our study, we focus on the comparison of 289 *A. altissima* trees, collected mainly in large cities across 31 European countries and 389 trees from Vienna (Austria), in which we analysed patterns of genetic variation and structure in order to identify the geographic origin and dispersal patterns. In both comparisons (Europe vs Vienna), trees planted in botanical gardens and in urban parks, and naturalised along roads and rivers were genotyped using both nuclear DNA (Dallas et al. 2005, Kurochochi et al. 2015) and plastid DNA markers (Liao et al. 2014). We found three different plastid haplotypes present in European samples, whereas only one was present in Vienna, indicating a common geographic origin from north-eastern China. Within Vienna and across Europe, similar patterns of genetic structure (five identical genetic clusters) have been revealed allowing us to hypothesize that (i) the introduction area in China comprises several differentiated populations, and (ii) cities may harbor large genetic diversity and genetic pattern comparable to large areas and thus should not be underestimated in studies of invasion biology (based on results from Vienna, where sexual reproduction was more pronounced than asexual reproduction).

Dallas J. F., Leitch M. J. B. & Hulme P. E. (2005) Microsatellites for tree of heaven (*Ailanthus altissima*). Mol. Ecol. Not. 5: 340–342.

Hu S. Y. (1979) *Ailanthus*. Arnoldia 39: 29–50.

Kurokochi H., Saito Y. & Ide Y. (2015) Genetic structure of the introduced heaven tree (*Ailanthus altissima*) in Japan: evidence for two distinct origins with limited admixture. Botany 93: 133–139.

Liao Y. Y., Guo Y. H., Chen J. M. & Wang Q. F. (2014) Phylogeography of the widespread plant *Ailanthus altissima* (Simaroubaceae) in China indicated by three chloroplast DNA regions. J. Syst. Evol. 52: 175–185.

A natural hybrid of *Impatiens* in the introduced range: *Impatiens balfourii* × *parviflora* in Ticino canton in Switzerland

Johan van Valkenburg[1], Edu Boer[1] and Nicola Schoenenberger[2]

[1]National Plant Protection Organization, National Reference Centre, Geertjesweg 15, 6706EA, Wageningen, the Netherlands
[2]INNOVABRIDGE Foundation, Contrada al Lago 19, 6987 Caslano, Switzerland
e-mail: j.l.c.h.vanvalkenburg@nvwa.nl

In a nature reserve, in Ticino canton in Switzerland, amidst a mixed population of non-native *Impatiens parviflora* and *I. glandulifera* aberrant plants of *I. parviflora* were observed. An herbarium voucher and seeds were collected and seedlings subsequently raised in a greenhouse. Molecular analysis for ITS region and chloroplast markers revealed the plants to be a hybrid between *I. parviflora* and *I. balfourii*, another non-native *Impatiens* species occurring in the Ticino canton. *I. parviflora* is the mother plant of the hybrid. No out crossing nor reduced fertility was observed in F2 and F3 generations, raised in a greenhouse. Nuclear genome size, as measured by flow cytometry with propidium iodide, did not indicate polyploidy and the ITS region remained 100% uniform. Therefore a homoploid hybrid speciation event is assumed

We have proven, by raising an F2 generation twice and even an F5 generation, that the hybrid is fertile. Our molecular study revealed that outcrossing in F2 and F3 generation did not occur. However, the sizeable populations in Arbedo and Gudo in the absence of *I. balfourii* and the fact that at Carasso both parental species co-occur but no hybrids were found hints to a rare hybridization event resulting in a fertile lineage. Some of the reported findings are only based on observations and an experimental set-up would greatly improve our knowledge of the Impatiens hybrid. The assumed breeding system clearly needs further laboratory and greenhouse experiments. Habitat preferences and competitive ability of the *Impatiens* hybrid needs to be studied both in the field and in controlled garden experiments.

van Valkenburg J. L. C. H., Schoenenberger N., van de Vossenberg B. T. L. H., Man in 't Veld W. A., Westenberg M. & Boer E. (2019) A natural hybrid of Impatiens, in the introduced range, demonstrated by sequence analysis of the nuclear ribosomal DNA-gene repeat. Bot. Lett., doi: 10.1080/23818107.2019.1584863.

The use of the Australian mite, *Aculus crassulae*, as a biocontrol agent for *Crassula helmsii* in Europe

Sonal Varia, Suzy Wood, Corin Pratt and Sean Murphy

CABI Europe - UK, Bakeham Lane, Egham, Surrey, TW20 9TY, United Kingdom
e-mail: s.varia@cabi.org

Crassula helmsii or Australian swamp stonecrop is an invasive aquatic weed native to Australia and New Zealand which has been invading Europe since its introduction in the early 1900s. It was first introduced from its native range as an ornamental pond plant and is now spreading across Western Europe, especially in the United Kingdom where it is most widespread. With few available control options, due to its ability to tolerate extreme environmental conditions and regrow from small fragments, biological control could be an effective and sustainable method of control for this weed. Surveys in the native range had previously identified the Australian gall-forming mite, *Aculus crassulae* (Acari: Eriophyidae) as a species of interest due to the host specificity of species in the Eriophyidae family and its distinctive impact in field populations of *C. helmsii*. *Aculus crassulae* was found to feed and reproduce exclusively on *C. helmsii* in laboratory testing and therefore was not deemed a risk to European species. In 2018, after six years of safety testing under quarantine conditions and after undergoing an extensive pest risk analysis (PRA), permission was granted to release *Aculus crassulae* from quarantine as a biocontrol agent of *C. helmsii*. Since its release from quarantine, the mite has demonstrated its ability to overwinter and survive under UK conditions using field-based, mesocosm studies combined with laboratory-based studies and 2019 will see the first full year of releases into *C. helmsii* populations in England and Wales. The release of *A. crassulae* represents only the fourth application of a weed biological control agent in the EU and the third in the UK.

How vulnerable to plant invasions is an arctic-alpine tundra under long-term human impact in the Krkonoše Mts, Czech Republic?

Michaela Vítková[1], Jan Čuda[1], Jan Pergl[1] and Petr Pyšek[1,2]

[1]*Institute of Botany, Department of Invasion Ecology, The Czech Academy of Sciences, CZ-25243 Průhonice, Czech Republic*
[2]*Department of Ecology, Faculty of Science, Charles University, Viničná 7, CZ-12844, Czech Republic*
e-mail: michaela.vitkova@ibot.cas.cz

The arctic-alpine tundra in the Krkonoše Mts (the Czech Republic) is an extremely fragile ecosystem highly sensitive to human disturbances and presence of alien species. Since the 16th century the area was used for extensive summer grazing, resulting in the development of agricultural settlements and increase of road networks. At the end of the 19th century, tourism started to play a major role and farming above the timberline gradually ceased. The main negative factors caused by tourism include eutrophication around chalets and other touristic facilities, as well as, trampling, soil erosion, and changes in soil chemistry along roads paved by foreign alkaline material (dolomite, melaphyre or their mixture. During 1996–2011 it was removed and replaced by indigenous siliceous material) followed by the introduction of alien plant species.

We investigated the effect of altered environmental conditions on the spread of alien species in this unique ecosystem. We used unpublished species inventories from the 1970s (by Jana Husáková) and revisited the same trails, about 80 km long (leading through the arctic-alpine tundra and sampled up to 2 m from the trailside) in 2005 and 2013-2014, and areas around five mountain chalets in 2014-2016. The soil changes were studied in detail on seven transects leading from natural vegetation, through the trail, trailside- and ecotone communities into the pristine arctic-alpine tundra in 1998 and 2018. We measured soil pH, moisture regime, organic matter and supply of 15 soil nutrients (NO_3^--N, NH_4^+-N, P, K, S, Ca, Mg, Mn, Al, Fe, Cu, Zn, B, Pb, and Cd) using ion-exchange PRS® probes. Our study plots are included into LTER site "Arctic-alpine tundra".

Preliminary results show that the soil properties substantially changed due to human impact. Much drier soils with low organic matter, but much higher pH and base saturation (mainly calcium and magnesium), created a new environment suitable for alien, synanthropic and low-altitude plant species spreading into unique plant communities of the tundra around trails and mountain chalets. We recorded 16 aliens in total, two archaeophytes and 14 neophytes, of which three are invasive in the Czech Republic. Two species, *Heracleum mantegazzianum* and *Angelica archangelica,* were recorded only in 1970s at the altitude of 1285 m a.s.l. The most invasive species is *Rumex alpinus,* which typically spreads from eutrophicated soils around chalets further along trails and watercourses into the pristine vegetation. We observed rapid vegetation changes during the past 40 years, the number of plant species increased from 196 to 270 in total. Native weak competitors (e.g. *Nardus stricta, Calluna vulgaris*) that are intolerant to trampling and high nutrient supply disappeared or reduced their covers and were replaced by tall-statured aliens and apophytes, which accounted for 69% of the altered trailside vegetation. Our results suggest that utilization of foreign alkaline material for stabilization of many trails in the 1970s had a greater impact on biotic and abiotic characteristics in the arctic-alpine tundra compared to landscape features or trail history, and this encouraged the spread of alien species even in such harsh climatic conditions.

Two shades of grey: xerophytes from garden beds as invaders of native vegetation?

Martin Vojík[1,2], Martina Kadlecová[1], Josef Kutlvašr[1,2], Kateřina Berchová-Bímová[1] and Jan Pergl[2]

[1]*Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Kamýcká 129, Praha – Suchdol, 165 00, Czech Republic*
[2]*Institute of Botany, Department of Invasion Ecology, The Czech Academy of Sciences, CZ-252 43, Průhonice, Czech Republic*
e-mail: vojik@fzp.czu.cz

Public parks and private gardens are sources of new potentially invasive plants, escaping from ornamental garden beds, lawns and hedges. The majority of studies are focused on invasions from plantings in mesic habitats via traditional spreading vectors (transport, watercourses, railways, etc.). Invasions in dry semi-natural and natural habitats are largely overlooked, even though semi-natural dry grasslands are often directly connected with gardens and plantings in warmer areas of Central Europe. The identification of potentially invasive xerophytes and description of their ecology can help prevent their further spread.

The objective of our project is a comprehensive study of the potentially invasive alien species, *Stachys byzantina* and *Lychnis coronaria*. Both species are escaping from cultivations and form stands that reduce the diversity in the herb layer of ornamental plantations and, after escaping, also in their close surroundings. It is therefore possible that these species with a high invasive potential (i.e. escape from cultivation was recorded throughout the Czech Republic) can continually reach natural biotopes and create viable naturalised populations with high impacts on the environment.

The study is aimed at the identification of (i) reproductive traits rate and mode of spread, germination of seeds, generative reproduction, vegetative regeneration and growth rate, and (ii) cytological variability of the plants using flow cytometry (ploidy levels and genome size).

Based on the obtained information, we want to consider the ability to invade dry semi-natural and natural habitats for the model species. Our preliminary results based on diploid populations show that seed germination of *L. coronaria* is very high (98%) and germination of *S. byzantina* is about 40%. Seeds of both study species are resistant to low temperature (up to -16°C) and both species have fast growth speeds with vegetative spread via forming daughter shoots.

Control of the invading species *Ambrosia confertiflora* and *Parthenium hysterophorus* with Aminopyralid herbicide

Tuvia Yaacoby

R H Smith Institute of Plant Sciences and Genetics, Faculty of Agriculture, Food and the Environment Robert H. Smith, Hebrew University of Jerusalem, Rehovot, Israel
e-mail: tuvia.yaacoby@mail.huji.ac.il

Ambrosia confertiflora DC. (Bur ragweed) and *Parthenium hysterophorus* L. (Santa Maria feverfew**)** are known as the greatest aggressive and allergenic weeds in the world. *Ambrosia confertiflora* is a hard to kill perennial weed, especially when the plant already formed many root rhizomes, *A. confertiflora* is enormously spread in several regions of Israel, infesting agricultural lands, natural ecosystems, rights of ways, and populated living districts. *Ambrosia confertiflora* was introduced to the Hefer valley (the coastal plain of Israel) along the Alexander river banks during the late 1990s and since then, it has continued spreading to other country sites. *Parthenium hysterophorus* was found in Bet She'an valley in a fishpond bank during the late 1980s. Both species were introduced to Israel via importation of animal feeding grains from the USA. While the dispersal of *A. confertiflora* is extremely fast, *P. hysterophorus* was found to be in slow dispersion for almost 25 years, and only in the last 5 years it began to invade out of its original establishment area. Field experiments that were carried out during the last 15 years in order to limit the distribution of *A. confertiflora*, showed that the repeated applications of glyphosate products and herbicides that contain 2,4-D failed in controlling the plant and only caused temporary injury. Mature plants of *A. confertiflora* that have more than 150 shoots/m^2, requests better systemic ability in order to get maximal efficacy. We showed previously that Shotgun® (Imazapyr) succeeds to eradicate *A. confertiflora* plants while leaving lasting residues in the soil. Considering the recent ban of Imazapyr by the EU authorities and the public debate over the use of glyphosate, we considered the use of other herbicides. Aminopyralid is the active ingredient (ai) in the herbicide Milestone® registered and marketed in the USA and produced by Corteva Agriscience™. It is a member of pyridines acid (pyridine carboxylic acid) group of chemicals mainly used for the control of broadleaf (annual and perennial) species. Aminopyralid is a highly systemic herbicide, intended for selective post emergence weed control application.

In order to improve the control of both species, several experiments with Milestone® have been carried out across different sites in Israel. Aminopyralid is very efficient in controlling herbaceous and woody deciduous plants. Milestone® is not toxic to mammals, birds, aquatics and other living in the marine environment. Milestone® is used in the USA EPA's action plan of programs that allows reducing the risk to the environment, by using such "eco" herbicides. In experiments performed with aminopyralid as part of a research project of the Min of Agriculture's Chief Scientist, we found that using Milestone®, either by spraying on top of developed plants or by very low concentrations of the diluted substance applied as moistening of 2 individual leaves of a plant, caused aboveground wilting as well as underground rhizomes control. *P. hysterophorus* is a noxious annual infesting field crops, subtropical orchards (avocado), dates and rights of ways in the inland worm areas. The weed was controlled effectively in date palm infested heavily with Milestone® causing no damage to the palm trees in Bet She'an region.

Table 1. Influence of several aminopyralid concentrations applied on 2 leaves of *Ambrosia confertiflora* on shoot:root ratio.

Treatment	Herbicide concentration (%)	Shoot:root ratio
aminopyralid	0.25	0.26
aminopyralid	0.5	0.30
aminopyralid	1.0	0.41
aminopyralid	2	0.57
Imazapyr	2	0.40
control		0.24

Effects of invasive *Cenchrus spinifex* on nitrogen pools in sandy grassland

Ting Zhang, Wei-dong Fu, Rui-hai Zhang, Zhen Song, Chao Bai, Cheng-cheng Huang and Guo-liang Zhang

Institute of Environment and Sustainable Development in Agriculture, *Chinese Academy of Agricultural Sciences*, *Beijing 100081, China*
e-mail: zhangguoliang2003@caas.cn

Cenchrus spinifex is an invasive plant found in large areas of northern China. In this study, we focused on analyzing the effects of *C. spinifex* on soil nitrogen and plant nitrogen pools in Horqin sandy grassland. In addition, a pot experiment with ^{15}N tracing techniques was designed to study the biological nitrogen fixation ability of *C. spinifex,* compared with two native grasses (*Elymus dahuricus* and *Agropyron cristatum*). The total soil nitrogen pool in the *C. spinifex* invaded-area compared with those in bare and native plant *Roegneria kamoji* areas significantly increased by 47.5% and 20.8% while the soil ammonium nitrogen decreased significantly by 25.6% and 25.2%, respectively. The plant shoot nitrogen pool decreased significantly by 12.8% in *C. spinifex* compared with the native plant *R. kamoji*. Atom% ^{15}N, atom% ^{15}N excess and atom% ^{15}N weighting excess of *C. spinifex* were all significantly lower than those of *E. dahuricus* and *A. cristatum*. The nitrogen utilization of *C. spinifex* and *E. dahuricus* were 48.5% and 47.0%, respectively, and no significant differences were observed. The *C. spinifex* nitrogen-fixing percentage was 60.2% compared with *E. dahuricus*. These results suggested that the adaption to sandy grassland of this invasive weed might be due to its high efficient utilization of nitrogen, leading to successful colonization and spread in Horqin Steppe.

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