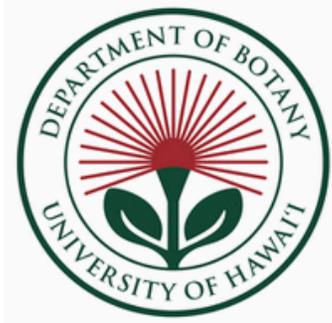# EMAPi 2015

13th International Conference

## *Ecology and Management of Alien Plant Invasions*

20-24 September
Waikoloa Village
Hawai'i

# Conference Program and Abstracts

# Sponsors and supporters

Institute of Pacific Islands Forestry

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## SUNDAY 20 SEPTEMBER

| Time | Event |
|------|-------|
| 3:00 PM – 8:00 PM | On Site Registration, Naupaka lobby area |
| 3:00 PM – 8:00 PM | Poster Set up, Naupaka VI & VII |
| 3:00 PM – 6:00 PM | Speaker presentation drop-off and slide review, Naupaka III |
| 6:00 PM – 8:00 PM | Opening Reception, Paniolo Terrace |

*Hedychium gardnerianum*

Photo: Pat Bily

# Monday

**MONDAY 21 SEPTEMBER**

| | Naupaka IV | Naupaka I | Naupaka II | Naupaka V |
|---|---|---|---|---|
| 08:00 AM | Opening Ceremony (Pule) – Kamana Beamer | | | |
| 08:15 AM | Welcome – Curt Daehler | | | |
| 08:30 AM | **Plenary 1 Plant invasions and their ecosystem-level consequences along environmental gradients - Peter Vitousek** | | | |
| 09:20 AM | **Plenary 2 Vital lessons we need to learn from invasions - Regan Early** | | | |
| 10:10 AM | | | | |
| | Connecting science to management – case studies – Moderated by Peter Vitousek | Ecological studies – spread and limitations – Moderated by Curt Daehler | Mechanical and chemical control of invasive plants -Moderated by John Hay | Impacts of plant invasions – ecosystem processes and services – Moderated by Anibal Pauchard |
| 10:40 AM | The invasion of Kakadu National Park's wetlands: threat and response - Michael Douglas | Role of thermal characteristics in juvenile phenological development of native and introduced plants - Lenka Moravcova | Quantifying Outcomes Containing *Miconia calvescens* DC in the East Maui Watershed through the Adoption of Herbicide Ballistic Technology - James Leary | Meta-analysis of invasive species impacts on nitrogen cycling, revisited - Marissa Lee |
| 11:00 AM | Holding the line: A quarter-century of ginger abatement, what IPM has to offer conservation in Hawai`i - Patrick Bily | Factors influencing *Cytisus scoparius* (L.) Link and *Ulex europaeus* (L.) invasiveness in South Africa - Philani Mbatha | Can Airborne Laser Scanning enhance the ecological outcomes of large-scale *Salix cinerea* control? - James Griffiths | *Cinchona pubescens* invasion increases soil phosphorus in the Galapagos Islands - Heinke Jäger |
| 11:20 AM | Dynamic and management of exotic knotweed at landscape scale: impacts and perceptions - André Evette | Is coexistence between invasive *Microstegium vimineum* and native plants dependent on invasion history of the soil? - Chelsea Cunard | The effectiveness of control methods on giant goldenrod (*Solidago gigantea*) invasion - Robert Pal | Alien plant invasion alters carbon cycling in an Australian tropical savanna - Samantha Setterfield |
| 11:40 AM | Ecology and management of two invasive trees in Arizona riparian habitats. - John Brock | Of rivers and disturbances: what drives the spread of *Impatiens glandulifera* populations from river corridors? - Jan Čuda | Advanced control practices in the chemical eradication of invasive plants in Hungarian National Parks and Protected Areas (2009 – 2014) - Istvan Szidonya | The impacts of *Andropogon gayanus* (gamba grass) invasion on the fire danger index and fire management at a landscape scale - Natalie Rossiter-Rachor |
| 12:00 PM | | | | |

Morning refreshments

Lunch

| | Naupaka IV | Naupaka I | Naupaka II | Naupaka V |
|---|---|---|---|---|
| **01:15 PM** | **Plenary 3: Is a "model group" focus the key to progress in plant invasion science? - David Richardson** | | | |
| | Connecting science to management – case studies -Moderated by Susan Cordell | Ecological studies – herbivory – Moderated by Curt Daehler | Genetics and evolution of invasive plants – Moderated by Jaco Le Roux | Impacts of plant invasions – ecosystem processes and services – Moderated by Anibal Pauchard |
| **02:10 PM** | Breaking down barriers to effective Albizia management; the Big Island's big weed problem. - Springer Kaye | Effects of isolation on damage by above- and below- ground enemies of an invasive thistle - Peter Kotanen | Recent advances in genetic characterization of plant invasions: case studies from Cucurbitaceae and Boraginaceae - David Clements | Effects of the invasive vine *Vincetoxicum rossicum* on ecosystem multi-functionality - Stuart Livingstone |
| **02:30 PM** | Simulations of management to control African grass in cerrado: Effects of clipping and fire under different environmental conditions - Carolina Musso | Parallel evolution in an invasive plant: effect of herbivores on competitive ability and regrowth of *Jacobaea vulgaris* - Tiantian Lin | Invasive plants that hybridize: Challenges in cattail identification and in estimating hybridization rates - Pamela Geddes | The invasive *Lupinus polyphyllus* and pollination in natives – effects mediated through pollinator behavior and changes in pollinator population sizes - Anna Jakobsson |
| **02:50 PM** | Rapid death of a dominant native tree, caused by an introduced pathogen, facilitates transformation of native forest to alien forest in Hawaii – R. Flint Hughes | Invasiveness of *Phragmites australis* as a function of population dynamics, physiology, karyology and response to herbivory: a common garden experiment - Hana Skalova | Limiting invasive *Ruellia simplex* via breeding sterile cultivars and developing efficient control in natural areas - Rosanna Freyre | Alien tree invasion into grassland ecosystems: impacts on rangeland condition and livestock carrying capacity - Thozamile Yapi |
| **03:10 PM** | | | | |
| | Connecting science to management – general principles and approaches – Moderated by Susan Cordell | Ecological studies – reproduction – Moderated by Curt Daehler | Symposium: The genomics of invasion - Moderated by Jane Molofsky | Symposium: Plant invasions and management strategies: New perspectives from China - Moderated by Peng Shaolin |
| **03:30 PM** | Variable non-native species impact across occurrence gradients offers possibility for site-specific population management - Lisa Rew | Pollination and rhizobia mutualists limit the invasion success of one (*Spartium junceum*) but not another (*Genista monspessulana*) alien legume - Sjirk Geerts | What we still don't know about invasion genetics - Loren Rieseberg | Use of exotic plants to control *Spartina alterniflora* invasion and promote mangrove restoration - Shaolin Peng |
| | **Naupaka IV** | **Naupaka I** | **Naupaka II** | **Naupaka V** |

Afternoon refreshments

# Monday

| | Naupaka IV | Naupaka I | Naupaka II | Naupaka V |
|---|---|---|---|---|
| 03:50 PM | Applying a geographically differentiated approach to the management of invasive plant species in South Africa - David Le Maitre | Australian Acacia seed banks: Wattle lot they got! - Matthys Strydom | Genomic processes and invasion: intraspecific admixture and hybridization as substrates for evolutionary change. - Jane Molofsky | Evolution of anti-herbivore defense in invasive plants: a meta-analysis - Xiaoyun Pan |
| 04:10 PM | Does flow regime predict alien plant invasion in a gravel floodplain ecosystem? - Tyler Brummer | Genetic analysis of reproductive modes of invasive yellow flag iris and Russian knapweed - John Gaskin | Karyological diversity and invasion in the genus Phragmites - Laura Meyerson | Allelopathy by exotic invasive plants can alter nitrogen cycling through effects on soil ammonia-oxidizing archaea (AOA) and ammonia-oxidizing bacteria (AOB) - Bao-Ming Chen |
| 04:30 PM | Using ecological networks to evaluate impacts of an invasive plant and planning biocontrol - Elizabete Marchante | Tuber development and growth rates of two varieties of an invasive liana, *Dolichandra unguis-cati* in Australia - Joshua Buru | Environmental heterogeneity causes divergence, but not cross-generational carryover, of epigenetically regulated gene expression in a clonal grass. - Johannes Le Roux | Plant diversity, soil biota and resistance to exotic invasion - Huixuan Liao |
| 04:50 PM | Accounting for density dependence in weed-biocontol systems - Sarah Swope | Reproduction of *Kalanchoe pinnata*, a study of the mating and dispersal process in the invasion of a Mexican Seasonal Tropical Dry Forest. - Salvador Gonzalez de León | Rapid evolution of an invasive pine consistently results in increased invasiveness across six replicated and independent invasions - Rafael Zenni | From biological control agent to invasive species: An approach to risk assessment using *Cryptolaemus montrouzieri* as a model species - Haosen Li |
| 5:10 PM – 7:10PM | **Poster Reception** – Odd-numbered posters attended by presenters – Naupaka VI & VII | | | |

**EMAPi 2015**

TUESDAY 22 SEPTEMBER

| | Naupaka IV | Naupaka I | Naupaka II | Naupaka V |
|---|---|---|---|---|
| 08:00 AM | **Plenary 4: Working smarter, not harder: Disturbance ecology and the management of invasive species - Katriona Shea** | | | |
| 08:50 AM | **Plenary 5: Inquiry based approach to invasive plant management -one land manager's perspective - Rhonda Loh** | | | |
| 09:40 AM | | | | |
| | Engaging the Public – Moderated by Christy Martin | Biocontrol on Islands - Moderated by Tracy Johnson | Detection and rapid response – Moderated by Lisa Rew | Symposium: Cactaceae as alien species –lessons for management – Moderated by Ana Novoa |
| 10:10 AM | Environmental conflict and its resolution: The case of invasive alien species management in Cape Town, South Africa. - Laura Caetano | Biological control of weeds in the Pacific: current status and future prospects - Michael Day | The theory and practice of incursion response - John Wilson | Invasive Opuntioid Cacti in Western Australia - Sandra Lloyd |
| 10:30 AM | A code of conduct on plantation forestry and invasive alien trees - Giuseppe Brundu | International Collaboration Delivers a Weed Biocontrol Programme for the Cook Islands - Quentin Paynter | IBIS: International Biosecurity Intelligence System for Early Warning, Better Planning and Rapid Response - Justin Trefry | The status and impact of *Opuntia stricta* in East Africa and its control - Arne Witt |
| 10:50 AM | Empowering communities to address invasive species: working at the neighborhood level for action on albizia trees in Hawaii. - Franny Brewer | The status of weed biocontrol in Vanuatu - Sylverio Bule | The PPQ Weed Risk Assessment Process – Anthony Koop | Impacts of *Opuntia stricta* on biodiversity, ecosystem function and social perceptions in Kruger National Park, South Africa - Llewellyn Foxcroft |
| 11:10 AM | Incorporating passive surveillance into management of pests and weeds - Oscar Cacho | The gregarious caterpillars of *Euselasia chrysippe* as potential biological control for *Miconia calvescens* in Hawai'i and the Pacific - Kenneth Puliafico | Dogs and Drones: Improving surveillance options to delimit plant invasions for eradication - Hillary Cherry | The exceptional success achieved with biological control of *Cylindropuntia fulgida* var. *mamillata* using Dactylopius tomentosa in South Africa. - Travor Xivuri |

Mid-morning refreshments

# Tuesday

| | Naupaka IV | Naupaka I | Naupaka II | Naupaka V |
|---|---|---|---|---|
| 11:30 AM | Crowdsourcing Invasive Weed Identification in Kauaʻi's Native Forests - Evelyn Wight | Weed biocontrol for Hawaii – tackling two of the toughest - Corin Pratt | Researching the Use of Unmanned Aerial Vehicles to Assist Ground-Detection Efforts for Invasive Plant Targets - Timothy Sullivan | Biological Control of the Argentine Cactus Moth *Cactobalstis cactorum*:  What Goes Around, Comes Around. - Kenneth Bloem |
| 11:50 AM | Air Potato Biological Control Extension Needs Assessment - Kenneth Gioeli | Biological control of weeds in Pacific island forests - M. Tracy Johnson | Using Unmanned Aerial Vehicles sensors to detect flowering of an invasive plant as a proxy to assess the control efficiency of a biocontrol agent - Hélia Marchante | Strategic management of cactus invasions in South Africa - Haylee Kaplan |
| **Lunch**  12:10 PM | | | | |
| 01:25 PM | **Plenary 6: Making an impact: What do we really know about the ecological consequences of alien plant invasions - Philip Hulme** | | | |
| | Symposium:  How do invader impacts change over time? - Carla D'Antonio, Paul Downey, Luke Flory | Global change and plant invasions – Moderated by Christine Sheppard | Biosecurity and risk assessment – Moderated by | Invader traits and resident communities – Moderated by Mark van Kleunen |
| 02:20 PM | Long-term dynamics and impacts: when might invader impacts change over time?  - Carla D'Antonio | Predicting plant invasions under climate change: combining models and experiments to assess the potential risk of alien plants in New Zealand - Christine Sheppard | Use of Weed Risk Assessment in Forestry Projects in Hawaii and the Pacific - J. B. Friday | [CANCELED] Revisiting Darwin's naturalization conundrum: explaining invasion success of non-native trees and shrubs in southern Africa - Simeon Bezeng |
| 02:40 PM | Long term invasion patterns: do different invasion starting points lead to the same invasion outcome? - Paul Downey | Space to invade? Comparative range infilling and potential range of invasive and native plants - Bethany Bradley | Challenges and Opportunities in a Federal Weed Risk Assessment Program - Barney Caton | Trait-based design of communities resistant to invasive alien plants: The role of limiting similarity in ecological restoration - Florencia Yannelli |
| 03:00 PM | Long-Term dynamics and impacts of a widespread invasive grass in eastern US forests - Luke Flory | Out of the weeds?  Reduced plant invasion risk with climate change - Jenica Allen | The potential for compliance-based inspection protocols in Australia's biosecurity system - Susie Hester | Resilience of plant communities after disturbance in native European and invaded North-American range: species richness, composition and traits - Kateřina Štajerová |

# Tuesday

| | Naupaka IV | Naupaka I | Naupaka II | Naupaka V |
|---|---|---|---|---|
| 03:20 PM | Changes in impacts of Heracleum over time due to negative plant-soil feedback - Jana Mullerova | Alien ornamentals and climate change: an inventory of European garden flora and the impending invasion debt - Emily Haeuser | The challenges of applying WRA systems to screen out invasive alien plants in countries with open and porous borders: Bhutan a case study - Dorjee Dorjee | Species richness, propagule pressure and the invasibility of plant communities - Richard Duncan |
| 03:40 PM | | | | |
| 04:00 PM | Positive invader/soil feedbacks versus community change: insights from California and Hawaii - Stephanie Yelenik | Will alien plants be advantaged in a high CO2 world? - Michelle Leishman | Clothing as a vector for the dispersal of weed seed - Michael Ansong | Once upon a time: long-term survival of alien plants in sites of abandoned former villages - Jan Pergl |
| 04:20 PM | Abiotic and biotic legacies of *Cytissus scoparius* impact reforestation - Sara Grove | Snowpack, fire, and forest disturbance: interactions affect montane invasions by non-native plants - Jens Stevens | Risk Analysis of Grain as a Pathway for Weed Seeds - Claire Wilson | Effects of soil nutrient availability on competitive dynamics between non-native invasive and native species in Hawaiian dry forests - Amanda Knauf |
| 04:40 PM | Invasive *Bromus tectorum* alters natural selection in arid systems, natives respond - Elizabeth Leger | A global assessment of functional changes in urban plants communities - Estibaliz Palma | The risk of alien grass invasion across the Antarctic Peninsula: thermal niche potential and human pressures - Miguel Olalla-Tárraga | Soil disturbance rather than plant community composition triggers invasion of *Bromus tectorum* in sagebrush rangelands - A. Joshua Leffler |
| 05:00 PM | How do invader impacts change over time? Discussion and synthesis - Carla D'Antonio, Paul Downey, Luke Flory | | Potential distribution and habitat suitability of the new emerging alien species in South Africa. - Jorge Renteria Bustamante | Fire does not promote cheatgrass invasion in the northern sagebrush steppe of Montana, USA. - Erik Lehnhoff |

**Afternoon refreshments** (03:40 PM)

| 5:20 PM – 7:20PM | **Poster Reception** – Even-numbered posters attended by presenters – Naupaka VI & VII | Working group discussion – **Cactaceae as invaders** (Room: Paniolo I) |
|---|---|---|
| 06:00 PM | Working group discussion – **Cross-latitude studies of invaders** (Room: Paniolo I) | |

# WEDNESDAY 23 SEPTEMBER

8:00 AM – 5:15 PM

<div style="background-color: #b6f0a0;">FIELD TRIP 1. Hawai'i Volcanoes National Park: nvasive plant strategies and biocontrol facility</div>

8:00 AM – 5:00 PM

<div style="background-color: #b6f0a0;">FIELD TRIP 2. Hakalau National Wildlife Refuge: Invasive plant control, native restoration, and native birds</div>

8:00 AM – 5:15 PM

<div style="background-color: #b6f0a0;">FIELD TRIP 3. Hawai'i Island Invasive Plants: From rainforests to tropical drylands</div>

5:00 PM – 8:30 PM

<div style="background-color: #a0c4f0;">LUAU: Dinner and Polynesian performance</div>



*Sida fallax* (native)

**EMAPi 2015**

THURSDAY 24 SEPTEMBER

| | Naupaka IV | Naupaka I | Naupaka II | Naupaka V |
|---|---|---|---|---|
| 08:00 AM | **Plenary 7: Plant naturalization: from global patterns to regional and local drivers - Mark van Kleunen** | | | |
| 08:50 AM | **Plenary 8: Biological control of invasive alien plants: any delay is opportunity lost - John Hoffmann** | | | |
| 09:40 AM | | | | |
| | Symposium: Biocontrol in Restoration – Moderated by Tom Dudley | Symposium: Plant traits, invasion, and rest-oration - Moderated by Stephanie Yelenik | Biogeography and macroecology of plant invasions – Moderated by Jan Pergl | Impacts of plant invasions – community structure – Moderated by David Clements |
| 10:10 AM | Biological control of arundo for habitat restoration and water conservation in the Rio Grande Basin and elsewhere in arid western North America - Patrick Moran | How has theory influenced community restoration? A review of the experimental restoration ecology literature - Claire Wainwright | The rise and fall of exotic species: why time dynamics of species introductions should be included in predictions of invasiveness - Alejandro Ordonez | Quantifying pine invasions impacts and legacies using observations and experiments: *Pinus contorta* in Chile. - Anibal Pauchard |
| 10:30 AM | *Melaleuca quinquenervia* in Florida: the end of an error - Paul Pratt | Plant invasions in resource-limited environments - Rebecca Drenovsky | Biodiversity, biomass and resistance to plant invasion across eastern U.S. forests - Kevin Potter | Do invasive pines affect the soil microbial community in the Cerrado? - John Hay |
| 10:50 AM | Status of aquatic weeds associated with biological control agents in the southern Mozambique Rivers - Silvia Langa | Similarities and differences between native and invasive plant functional traits across environmental gradients in Hawai'i Volcanoes National Park - Jonathan Henn | Intercontinental exchanges of weeds determined by habitat residence time and native richness - Makihiko Ikegami | Aliens spread germs: Frequency and risk factors of pathogen spillover between alien and native plants. - Jennifer Bufford |
| 11:10 AM | Introduction and Establishment of Diorhabda Beetles in Oklahoma as a Biological Control Agent of Tamarix: A Saltatory Process - Tom Royer | Can restoration using a functional trait based approach provide invasion resistance? An example in novel ecosystems of Hawaii - Rebecca Ostertag | Host-promiscuity but not provenance of rhizobial symbionts influences legume invasiveness in novel ranges - Metha Klock | The legacy of plant invasions: changes in the soil seed bank of invaded plant communities - Margherita Gioria |
| 11:30 AM | Tamarix Biocontrol for Riparian Restoration - Tom Dudley | Testing the trait-based community framework: can limiting similarity increase invasion resistance in restored grassland? - Jennifer Funk | Not all Invasives are Created Equal: Cogongrass (*Imperata* spp.) Invasion in the southern US and around the World - Rima Lucardi | Direct and indirect effects of invasive non-native plants and flood disturbance, on the dynamics of riparian zone vegetation - Zarah Pattison |

Morning refreshments

# Thursday

| | Naupaka IV | Naupaka I | Naupaka II | Naupaka V |
|---|---|---|---|---|
| 11:50 AM | The 5th Edition of "Biological Control of Weeds – A World Catalogue of Agents and Their Target Weeds: Use and Analysis - Mark Schwarzlaender | | Phenotypic plasticity of invasive *Spartina densiflora* (Poaceae) along a broad latitudinal gradient on the Pacific Coast of North America - Brenda Grewell | Direct and indirect effects of *Hedychium coronarium* J. König (Zingiberaceae) invasions. - Dalva Silva Matos |
| 12:10 PM | | | | |
| | Biocontrol Status and updates – Moderated by Adam Lambert | Connecting science to management- perspectives on restoration – Moderated by John Wilson | Inventories, floras and databases | Impacts of plant invasions – broad-scale pattern and assessment – Moderated by David Clements |
| 01:30 PM | The future of *Solanum elaeagnifolium* Cav. (silverleaf nightshade), one of the worst alien invasive plants in the Mediterranean basin - Javid Kashefi | What happens after the animals are gone? Investigating ecosystem function post the removal of non-native ungulates. - Jed Sparks | Naturalized flora of the world: geographic distribution of species richness, global flows, taxonomic and phylogenetic structure, widespread invaders - Petr Pysek | Alien species classification according to impact magnitude: filling the gaps - Sabrina Kumschick |
| 01:50 PM | Host range of endophagous insects associated with fireweed in its native range in South Africa – prospects for biological control - Daniella Egli | Return of the birds: Fynbos birds as an indicator of ecosystem recovery after alien invasive plant clearing in a riparian habitat of South Africa. - Joy Mangachena | A macrosystem study of invasion patterns and processes across continental USA - Songlin Fei | Dominance has a biogeographical component: plants exert stronger impacts in their invaded rather than native ranges - Martin Hejda |
| 02:10 PM | Multi-generational impacts of the psyllid *Arytinnis hakani* on the invasive weed French broom, *Genista monspessulana* - Brian Hogg | Competition between *Fallopia japonica* and *Salix viminalis*: a step toward the restoration of plant communities to control Asian knotweeds - Fanny Dommanget | Tracking Invasive Species across North America: EDDMapS & EDDMapS Smartphone Apps - Charles Bargeron | |
| 02:30 PM | Indirect interactions among environmental and agricultural weeds: shared herbivores complicate pest management and development of biological control - Adam Lambert | | INaturalist and the Mexican Degradation Monitoring Systems: new potential sources of data for the National Invasive Species Information System (NISIS) - Georgia Born-Schmidt | Designing and evaluating weed management strategies: a generalized modelling approach - Vanessa Adams |
| 02:50 PM | Close / Announcing EMAPi 2017 | | | |

Lunch

# Posters

| Presenter | Poster number | Theme | Title |
|---|---|---|---|
| Gina Skurka Darin | 1 | Biosecurity and risk assessment | Technology for the Prioritization of Weed Populations for Eradication: Desktop and Online WHIPPET |
| Dana Morawitz | 2 | Biosecurity and risk assessment | Controlling invasive plants in an era of climate change: New decision-support tools help set EDRR focused landscape-level strategies in California |
| Jana Pěknicová | 3 | Connecting science to management | Modelling of IAS spread as a management tool in protected areas |
| Jenica Allen | 4 | Connecting science to management | Socio-ecology of invasive plants in the northeastern US |
| Becky Kerns | 5 | Connecting science to management | Cheatgrass dynamics in ponderosa pine forests: insights into invasion theory from long-term data |
| Alexandre Sampaio | 6 | Connecting science to management | Removal of invasive grasses and direct seeding of native trees, shrubs and grasses to restore invaded Brazilian savannas (Cerrado). |
| Isabel Schmidt | 7 | Connecting science to management | Native allelopathy against alien invaders: a possible ally on the Neotropical savanna restoration |
| Patrick Moran | 8 | Connecting science to management | The USDA-ARS Areawide Pest Management Project for integrated control of aquatic weeds in the Sacramento-San Joaquin Delta |
| Samantha Setterfield | 9 | Connecting science to management | Managing alien invasive grasses in Australia's Kakadu National Park: determining control costs to underpin strategic management planning |
| Dan'sile Cindi | 10 | Connecting science to management | The feasibility of eradicating *Opuntia pubescens* (velvet bur cactus) in the Pretoria National Botanical Garden |
| Anthony Koop | 11 | Biosecurity and risk assessment | Some Recent Weed Risk Assessments Completed by Plant Protection and Quarantine |
| Shahin Ansari | 12 | Biosecurity and risk assessment | Developing a List of Known Invasive Plants to be Restricted from Introduction, Propagation, Distribution and Sale in Hawaii |
| Rima Lucardi | 13 | Biosecurity and risk assessment | Technology development to increase the efficacy of invasive propagule interceptions in the face of increasing trade volume |
| Julia Lee | 14 | Detection and rapid response | Look and you will Find: Targeted Surveys Provide Opportunities to Assess Threats to Managed Areas |
| Taylor Marsh | 15 | Detection and rapid response | No Need for Devil Weed: Eradication Efforts of *Chromolaena odorata* on the Island of Oahu |
| Taylor Marsh | 16 | Detection and rapid response | Eradicability of *Cenchrus setaceus* infestations on Oahu Army lands |
| Jana Mullerova | 17 | Detection and rapid response | Detection, monitoring and control of alien plant species: an unmanned aircraft mission |
| Natalie Rossiter-Rachor | 18 | Detection and rapid response | Monitoring the distribution and dynamics of an invasive grass in tropical savanna using airborne LiDAR. |

| | | | |
|---|---|---|---|
| Sandra Skowronek | 19 | Detection and rapid response | Mapping of two invasive plant species on the island of Sylt in Northern Germany using airborne hyperspectral and LIDAR data |
| James Parker | 20 | Detection and rapid response | *Pereskia aculeata*: early detection and rapid response of an incipient weed by the Big Island Invasive Species Committee |
| Neil Gallagher | 21 | Engaging the public | A Community Based Weed Programme with a focus on Wild Ginger (*Hedychium gardnerianum*) |
| Titiek Setyawati Setyawati | 22 | Engaging the public | Save Our Forest From Invasive Alien Plant Species |
| Elizabete Marchante | 23 | Engaging the public | Using a WebMapping platform to engage volunteers to collect data on invasive plants distribution |
| Teya Penniman | 24 | Engaging the public | Planting the Seed: A Place-based Curriculum on Maui Raises Awareness about Invasive Plants |
| Xiaozhi Gu | 25 | Global change and plant invasions | Influence of warming water on expansion of a *Nymphoides peltata* population in Taihu Lake, China |
| Weiguo Sang | 26 | Global change and plant invasions | Nitrogen depositions strongly increase the competitive advantage of invasive ragweed |
| Erin Questad | 27 | Global change and plant invasions | Invasive plant species and drought: challenges and opportunities for the restoration of native plant communities |
| Dávid Nagy | 28 | Genetics and evolution of invasive plants | Genetic segregation of native and non-native ecotypes of Solidago gigantea |
| Yoshiko Shimono | 29 | Genetics and evolution of invasive plants | Fine-scale genetic structure within a continuous population of Lolium species caused by human-mediated dispersal |
| Yumiko Higuchi | 30 | Genetics and evolution of invasive plants | The expansion route of alien Lolium species into sandy coasts in Japan |
| Tiantian Lin | 31 | Genetics and evolution of invasive plants | Parallel evolution in an invasive plant: Shifting from tolerance to growth and chemical defense in invasive *Jacobaea vulgaris* |
| Camila Sanfuentes | 32 | Genetics and evolution of invasive plants | Tolerance of an invasive plant in a copper saturated environment: Local adaptation as an evolutionary response? |
| Giuseppe Brundu | 33 | Inventories, floras and databases | Inventory of the aquatic alien plants of South America |
| Jean-Marc Dufour-Dror | 34 | Inventories, floras and databases | Highly invasive plants (still) restricted to a small specific region: Potential invaders for other countries – Examples from the eastern Mediterranean |
| Titiek Setyawati | 35 | Inventories, floras and databases | Threats of Invasive Alien Plant Species in Indonesia |
| A. Erhenhi | 36 | Inventories, floras and databases | Four most Dominant Aggressive Alien Species in Farmlands and Water Bodies of Edo and Delta State, Nigeria |
| Traian Manole | 37 | Inventories, floras and databases | Alien invasive plants species in Romania – an exhaustive review of taxonomical and ecological data |
| Cang Hui | 38 | Invader traits and resident communities | Defining invasiveness and invasibility in ecological networks with trait-mediated interactions |
| Elise Gornish | 39 | Invader traits and resident communities | Considerations of demography and habitat type on Medusahead (*Taeniatherum caput-medusae)* control |
| Carolina Musso | 40 | Invader traits and resident communities | Fire effects on leaf components: a case study comparing cerrado native and invasive grasses |

| | | | |
|---|---|---|---|
| Kateřina Štajerová | 41 | Invader traits and resident communities | The relative impacts of generalist versus specialist herbivores: comparison between native and invasive dominants |
| Ming-Yu Stephens | 42 | Invader traits and resident communities | Phenotypic Plasticity in invasive *Bromus inermis* and native *Elymus canadensis* in response to moisture variation |
| Javid Kashefi | 43 | Biocontrol of invasive plants | Current Research at the European Biological Control Laboratory |
| Nancy Chaney | 44 | Biocontrol of invasive plants | Update on progress of biocontrol of strawberry guava in Hawaiian forests |
| Corin Pratt | 45 | Biocontrol of invasive plants | Weed biocontrol for Europe – research, releases and future prospects |
| Stefan Gous | 48 | Mechanical and chemical control | Novel methods to optimise spray deposition for invasive weed control. |
| James Griffiths | 49 | Mechanical and chemical control | Aerial application of herbicides for large scale *Salix cinerea* control and restoration of wetland plant communities. |
| Laura Williams | 50 | Mechanical and chemical control | Quantifying mechanical and chemical control methods for non-native *Poa annua* on a sub-Antarctic World Heritage island |
| Travis Bean | 51 | Mechanical and chemical control | Phenological limitations to control of an invasive perennial grass, research solutions and translation to management |
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# Abstracts

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**Designing and evaluating weed management strategies: a generalized modelling approach**

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Invasive weeds are a major cause of biodiversity loss and economic damage worldwide. There is often a limited understanding of the biology of emerging invasive species, but delay in action may result in escalating costs of control, reduced economic returns from management actions and decreased feasibility of management. Therefore, models that inform and facilitate effective management strategies that account for multiple objectives (such as maintenance of environmental and cultural values) are urgently needed. We present our generalized software that can accommodate multiple species to test different management strategies including containment and eradication at local and regional scales. The software is based on a dynamic simulation method which integrates the current distribution and predicted future distribution of invasive weeds and a management model to evaluate the effectiveness of different management strategies. We present two case studies to demonstrate the adaptability of the software for informing management decisions in different contexts. We apply the model to two case studies, gamba grass in Litchfield National Park and para grass and olive hymenachne in Kakadu National Park, to provide management advice on emerging weed priorities in northern Australia. For both species we find that the current extent of invasion in our study regions is expected to double in the next ten years in the absence of management actions and identify feasible management strategies.


**Assessing the most effective weed control re-treatment interval for *Clidemia hirta* dominated areas at Opaeula Lower Management Unit, Oahu.**

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One of the primary threats to plant community health is the introduction and geographical expansion of non-native vegetation. Non-native weed control is an integral component of the Oahu Army Natural Resource Program (OANRP) management strategy in association with rare species restoration and stabilization efforts on Oahu. A trial was conducted by OANRP at Opaeula Lower Management Unit to identify the most effective re-treatment weeding interval for areas with dense Clidema hirta in the understory. Over an 18 month period in 2013 and 2014, percent cover of native and non-native vegetation was documented in macroplots weeded at 0 months, 0 and 6 months, 0 and 12 months, and in a control plot (not weeded). Weeding reduced *C. hirta* cover (from 85% to 9-30%) paired with an increase in native cover (from 19-23% to 42-47%) if initial weeding was followed by re-treatment 6 or 12 months later. However, substantial increased cover of non-native weeds other than *C. hirta* occurred, particularly grasses. The plot weeded only once had no change in native cover, and a resurgence of non-native cover near to previous levels. Little change in cover occurred in the control plot, suggesting that the rate of degradation in untreated areas is relatively slow. Trial results suggest that weed control re-treatment at Opaeula Lower Management Unit should occur within one year, in order to allow native cover to expand, and prevent non-native cover from returning to near prior levels. Weeding should be paired with grass control, to prevent expansion of non-native grasses. Because *C. hirta* dominated areas are partially replaced by other non-native taxa following weeding, care should be taken to ensure that more problematic weeds do not become established. Ongoing re-treatment has the potential for even greater beneficial results.

**Out of the weeds?  Reduced plant invasion risk with climate change**

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Invasive alien plants can alter population dynamics, community composition, and ecosystem function.  Identifying areas with the high and low potential invasive plant richness may help in effective allocation of limited conservation resources.  We developed an occurrence database of 900 terrestrial invasive plant species listed as invasive or noxious to determine the intensity of invasive plant risk across the contiguous United States.  We identified hotspots of current invasion debt (1-observed/potential invasive species richness) based on an ensemble of individual species distribution models created using MaxEnt under current climate.  We projected future changes in invasion risk based on an ensemble of 13 climate models.

Eastern temperate forests, which constitute about 20% of the contiguous US land area, were most at risk under current climate, with a projected 481 terrestrial invasive plant species capable of invading and an invasion debt of 0.84.  Mediterranean California and marine west coast forests, both small ecoregions, contained suitable areas for many species (374 and 414 species, respectively), but had the lowest invasion debts (0.39 and 0.49, respectively).  A striking pattern emerged for future projections, with lower projected invasive species richness (up to 250 species less in some areas) compared to current across a majority of the country.  Northern latitude and high elevation locations constituted the subset of places projected to have increased invasion risk.  Uncertainty in future invasive richness projections ranged from 1-43 species and was highest in areas with uncertainty in the climate model ensemble.  Measures to prevent introduction of new invasive plants, particularly tropical and subtropical species, may allow us to capitalize on plant responses to climate change without direct management in a large portion of the country.  However, management to curb the spread of species projected to shift their ranges may still be beneficial to prevent movement of species into new areas and ecoregions.


**Socio-ecology of invasive plants in the northeastern US**

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Invasive species impacts can include ecological and economic costs to property, human health, and ecosystem services. The magnitude of effect depends on the characteristics of the species in question, the characteristics of the ecosystem the species invades, and human prevention and management activities.  However, control of invasive species poses unique challenges. Invasions not only generate losses in the location where they are introduced, but also spread to other locations. These spillover effects create challenges for control since the associated costs and benefits are not localized.  In addition, many of the benefits of control (such as protection of ecosystem services) are a "public good" rather than a "private good" and hence are not generally considered in private decisions that can lead to invasions. Our multi-disciplinary approach provides critical understanding of these issues and the interactions of public policy, land use change, and invasive plant distributions.

We are developing a dynamic integrated model system approach with three main components: 1) a new set of spatially-explicit land use and invasive species regulation and management policy scenarios, 2) a new Markov chain land use change model, which will generate quantitative forecasts of future and historical land use changes, and 3) a suite of species distribution models (MaxEnt, Hierarchical Bayes, Cellular Automata, and Demography-Driven) to project invasive plant distributions, plus 4) a model simulation to compare spatially-explicit management strategies for invasive species. We are developing the modeling framework for the Long Island Sound watersheds in the northeastern US, with primary focus on five regionally important invasive plant species (*Alliaria petiolata, Berberis thunbergii, Celastrus orbiculatus, Euonymus alatus,* and *Phyllostachys aureosulcata*).  Our results will be relevant for land use planning, assessments of ecological capital, and invasive species policy and management and our framework will be scalable to other systems and species.

**Developing a List of Known Invasive Plants to be Restricted from Introduction, Propagation, Distribution and Sale in Hawaii**

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Historically, Hawaii's geographic isolation limited the number of plants that were able to arrive and establish. Since Western contact 237 years ago, more than 8,000 species of plants have been introduced to the islands. Of those plants that became invasive in Hawaii's natural areas, the majority (>80%) were intentionally introduced. Federal and State noxious seed and weed rules regulate about 200 species of plants, half of which are already present in Hawaii. In 2008, the Hawaii Department of Agriculture gained the statutory authority to restrict the importation and sale of invasive plants, yet rules for how invasive plants are added to a restricted plant list have yet to be developed. Therefore, deliberate introductions of ornamental, agricultural, forestry or biofuel plants continue to pose a high risk to Hawaii's environment. The Coordinating Group on Alien Pest Species is working collaboratively with plant industry stakeholders to develop a science-based approach to identify and document invasive plants not yet widespread in Hawaii, and use the information to manage the pathway of intentional invasive plant introductions into and around the State. To start, noxious weed and invasive plant lists collected from each U.S. state and various countries formed a starting list of 1035 documented invasive plant species. Based on online horticultural resources, 419 (41%) were found to be in the trade and have the potential to be deliberately distributed through commercial or private avenues. Some of these species are regulated or documented as widespread in Hawaii leaving 275 (27%) "offshore" or "incipient" plant species which are being screened using the Hawaii Pacific Weed Risk Assessment to determine their potential to be invasive in Hawaii. Once screening is complete, the resulting list and its supporting documentation will be shared with plant industry stakeholders to form a final list for proposed restriction.

**Clothing as a vector for the dispersal of weed seed**

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With more people traveling including to remote locations, humans can unintentionally transport seeds over long distances. This can facilitate biological invasions in urban, rural and remote natural areas when it involves the dispersal of weed seed. Recent reviews found that seed from a diversity of invasive species can be dispersed by cars, horses and clothing. For example, of the 626 species already found to have seed dispersed via cars, 599 are weeds, of the 249 species with seed know to germinate from horse dung, 99% are weeds and of the 449 species with seed found attached to clothing, 391 are weeds. A range of factors affect the amount and type of seed dispersed from clothing and the distance that it's dispersed. This includes seed traits, what people wear and their behaviour. For instance, experimental research found that although most seeds fall of clothing soon after attachment, some seeds become tightly attached and may be carried long distances. The rate at which seed detaches varies among species, with seeds with attachment structures such as hooks, burs and awns tending to remain attached for longer than those without these structures. Seed weight and size also affect how long seed remain attached but this depends on the type of clothing. Seeds tend to become more tightly attach to clothing made of "woolly" or "fleecy" fabrics than those with smother surfaces such as drill cotton. Visitors to a national park in Australia were concerned about weeds, and most had found seed attached to their clothing when entering or leaving parks. Unfortunately over a third of them then disposed of the seeds in ways that could facilitate the spread of weeds. These results highlight the importance of clothing as a dispersal vector, and the need to reduce the risk of this type of seed dispersal.

**Tracking Invasive Species across North America: EDDMapS & EDDMapS Smartphone Apps**

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EDDMapS' primary goal is to discover the existing range and leading edge of invasive species while documenting vital information about the species and habitat using standardized data collection protocols. EDDMapS allows for data from many organizations and groups to be combined into one database to show a better map of the range of an invasive species. Goals of the current project include: integration of existing regional datasets, increase search options on EDDMapS website, update NAISMA Invasive Plant Mapping Standards, and coordinate with local, state and regional organizations to develop early detection networks. After nine years of development of EDDMapS, it has become clear that these local organizations are key to developing a successful early detection and rapid response network. The University of Georgia Center for Invasive Species and Ecosystem Health has released 15 smartphone apps to support data entry into EDDMapS. EDDMapS has been implemented in 40 states and 4 provinces.

**Improving Control of Tropical Invasive Trees Via Undiluted Herbicide Injections**

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Hawaii hosts a wide array of non-native, woody trees, many of which are considered to be invasive pests which threaten the integrity of delicate native ecosystems and adversely impact watershed health. The Oahu Army Natural Resource Program (OANRP) is tasked with conducting habitat restoration to support endangered species protection, and to this end conducts hundreds of hours of weed removal annually. OANRP's default control method uses a 20% dilution of a triclopyr product in biodiesel, applied with or without cuts to the basal area of woody weeds. Anecdotally, this technique is mostly successful, but applications are uncalibrated; high doses may mask mediocre results. To identify more efficient and effective control techniques for invasive trees, in 2010 OANRP began collaborations with the College of Tropical Agriculture and Human Resources (CTAHR) at the University of Hawaii. Field efficacy trials were installed on 23 species to examine the potential efficacy of low doses of several active ingredients (imazapyr, aminopyralid, glyphosate, triclopyr). The treatment technique, dubbed Incision Point Application, involves making discrete, regularly spaced cuts around the trunk of a tree, and applying measured amounts of undiluted herbicide to each cut. Treated trees were monitored for up to two years. Performance was measured by recording defoliation and cambium health over time. Surprisingly, triclopyr was the least effective product tested. Imazapyr exhibited the greatest success, providing the most effective control across the greatest number of species. Using the results of these trials, OANRP has begun controlling canopy pests across large acreages at a cost of pennies per tree.

**Restoring *Psidium cattleianum* dominated forest in the Waianae Mountains, Hawaii**

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Diverse mesic forests in the northern Waianae Mountains of Oahu support a vibrant mix of endangered species. Unfortunately, much of this forest is heavily invaded by *Psidium cattleianum*, an exotic tropical tree hailing from South America.  The invasive characteristics of *P. cattleianum* are well documented, as is the threat it poses to native taxa.  The Oahu Army Natural Resource Program (OANRP) conducted an informal trial investigating strategies for removal of *P. cattleianum* monocultures (100m2) which suggested clear-cutting and chipping slash efficiently controlled the invasive tree while allowing re-colonization by native plants.  Based on this, in 2010 and 2012 OANRP removed 0.9 ha of dense *P. cattleianum* from Kahanahaiki Gulch with the goal of reducing alien vegetation cover, increasing native vegetation cover and diversity, and connecting surrounding native forest patches.  This project included flying a chipper into the site to grind up large slash piles.  Clearing work was done by full-time staff in 2010, and by a combination of full-time and temporary staff in 2012.  As feasible, initial clearing was timed to coincide with the senescence of the *P. cattleianum* seed bank, 3-6 months post fruiting, to minimize seedling germination.  Volunteers conducted much of the follow-up weed control.  Encouragingly, the native tree Acacia koa recruited heavily into the site.  No restoration outplanting was conducted, although extensive hand-broadcast of a fast growing native herb, *Bidens torta*, was performed. Photopoints were used to document the dramatic changes at the site.  Plots comparing the areas cleared in 2010 and 2012 indicate that while both native vegetation cover and species richness dropped one month after clearing, after two years, both recovered and greatly exceeded pre-clearing levels, while *P. cattleianum* cover remained low.  While this aggressive strategy had high initial costs, with a moderate level of follow-up, native forest reclaimed the area.

**Phenological limitations to control of an invasive perennial grass, research solutions and translation to management**

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Buffelgrass (*Cenchrus ciliaris*) is a C4 perennial bunchgrass that is invasive in subtropical regions worldwide, threatening biodiversity and creating fire-prone monocultures in previously fire resistant landscapes. In parts of the Sonoran Desert, buffelgrass populations are expanding exponentially and at approximately 200 person-hours acre-1, manual removal efforts cannot keep pace with spread rates. Chemical control spray crews typically utilize uncalibrated hand-pump backpack sprayers and spray-to-wet with %v/v solutions of glyphosate. Crews can treat 1 acre of buffelgrass in 6-8 person-hours. However, green-up is highly erratic and only occurs for 2-6 weeks year-1, usually in nonconsecutive periods of time. Because glyphosate has no soil residual and requires active growth for translocation, this chemical control approach is also not keeping pace with buffelgrass spread. To address this limitation, we evaluated imazapyr efficacy on buffelgrass in the field at multiple rates using a calibrated $CO_2$ pressurized backpack sprayer at two times of year on dormant plants (winter) or on green and actively growing plants (summer). Our results suggest that dormant buffelgrass could be controlled with imazapyr at 0.5-1.0 lb ae ac-1. This research finding could dramatically increase the treatment window for buffelgrass and may help slow or halt rates of spread. However, because of the potentially long soil residual, mobility in soil, and susceptibility of native vegetation, several modifications to the current equipment and treatment approach of spray crews are needed before imazapyr can be safely utilized in actual buffelgrass control efforts. Here we present suggestions for translating this research result so that it may be safely reproduced to manage buffelgrass.

**Low abundance effects of alien plants on native plant richness**

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How abundant does an invasive plant need to be to have an impact on the local plant community? Observational studies often focus on heavily invaded areas to detect the impact of alien plants, but even at low abundances some alien plants may have an effect on local plant diversity. However, the frequency with which low abundance effects occur remains unclear. We examine the minimum abundances at which alien species are associated with a decline in species richness across a widely invaded landscape.

We examined the abundance of 55 widespread alien plant species and their association with plant species richness across 752 grassland plots over Banks Peninsula, New Zealand. For each focal alien species, we tested for declines in resident species richness with increasing abundance of the focal species using bootstrapped generalised linear models. When a decreasing pattern could be detected, we defined the critical abundance as the lowest abundance class at which the decreasing trend started. We repeated these analyses separately for the native and alien richness components of the resident plant community, and interpreted the results in terms of potential impact extrapolated at the landscape scale.

Out of 55 species, 11 (20 %) presented a critical abundance associated with a decline in native species richness, and 7 (12%) with alien richness. For native richness, critical abundances were distributed across a wide range of alien plant abundances, with some species, such as *Achillea millefolium*, associated with significant declines in species richness even when only occasional in plots. In contrast, other species such as *Dactylis glomerata* only had significant effects when they were dominant in these plots. Taking into account these potential impacts at low species abundance may modify our perception and ranking of species impact at the landscape scale, and help improve risk assessment and invasion management.

**Holding the line: a quarter-century of ginger abatement what IPM has to offer conservation in Hawai`i**

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Himalayan ginger (*Hedychium gardnerianum* Ker-Gawl./ kahili ginger) is a global environmental pest plant in at least 12 island-nations in the Atlantic, Indian, Pacific oceans as well as two continents. This weed's expanding range in the high Hawaiian Islands threatens to displace native montane mesic/wet forests and infest the upper reaches of watersheds. Its' trend toward forming nearly-monotypic stands, ability to spread and thrive in undisturbed montane forests, along with its tendency to 'hog' surface water make it a severe risk to the integrity of Hawaii's montane biological diversity and potential water quantity harvest. Using 25 years of information from a specific project site in The Nature Conservancy's Waikamoi Preserve on East Maui, a synopsis will be provided to show the Integrated Pest Management (IPM) aspired to contain this serious pest and progress in halting its habitat alteration. This information encompasses decades of consistent manual control; various chemical controls; enhanced cultural control by eliminating ungulates; and biological control exploratory research in its native range of the Himalaya. These IPM strategies are regularly communicated to volunteers, hikers, and through outreach with local academia and community groups. It is hoped to result in supporting the need for ginger control, and influence a favorable view towards biological control and safe chemical control in natural areas.

**Biological Control of the Argentine Cactus Moth *Cactobalstis cactorum*: What Goes Around, Comes Around.**

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The Argentine cactus moth, *Cactoblastis cactorum*, is an invasive insect from South America that poses a serious threat to Opuntia-rich areas in the southwestern USA and Mexico. It was first detected attacking rare and endangered Opuntia cacti in the Florida Keys in 1989 and has since spread along the Gulf and Atlantic Coasts and now occurs as far west as Louisiana. A combination of tactics such as the sterile insect technique (SIT) and host plant removal were successful at slowing the spread of this insect and eradicating outbreak populations on small islands in Alabama, Mississippi, and Mexico. However, the cactus moth continued to slowly spread westward, and funding levels were insufficient to carry out such a program indefinitely. As a result, in 2012 the program refocused on the potential use biological control and disruption of the moth's pheromone communication systems as long term management strategies.

USDA-ARS cooperators working alongside scientists in Argentina have identified a new biological control agent, the parasitoid, *Apanteles opuntiarum*, which appears to be host specific to *C. cactorum.* Host range testing is still on-going inside a quarantine facility in Florida; however, if all the results confirm the specificity of the parasitoid, a request for field release could be made in 2016 and field releases initiated as early as 2017. One question that scientists are now struggling with is "what are the risks and implications of the parasitoid spreading to the Caribbean islands and/or other areas where control of weedy cacti by *C. cactorum* was intentionally undertaken and are considered successful biological control programs?"

**INaturalist and the Mexican Degradation Monitoring Systems: new potential sources of data for the National Invasive Species Information System (NISIS)**

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The National Invasive Species Information System (NISIS) for Mexico formally began in 2007 and has been growing ever since. At this time NISIS features 1969 species (including exotic and translocated natives) of which 439 have been identified as invasive for Mexico, and has over 206,000 records of occurrence across the country. Among the invasive species there are 155 terrestrial or aquatic plants. Obtaining data, with the aim of establishing an early detection and rapid response system has been particularly difficult, which is why CONABIO is exploring new potential sources of information by siding with other initiatives in collaboration with partner institutions. One of these efforts was the launch of an invasive species section in the citizen science platform INATURALIST, in order to engage with citizen scientists and at the same time offer a portal for the National Commission of Natural Protected Areas (CONANP) to report their sightings of native as well as invasive species. The other attempt is to include certain invasive species within two systems for monitoring degradation established in 2015 in Mexico. These two systems, the High Resolution Degradation Monitoring System (SAR-MOD, letters in Spanish) and the Large Coverage Degradation Monitoring System (SAC-MOD) are both based on the National Forest Inventories (INFyS) and aim to provide additional information on native fauna and its ecological functions. This is done by collecting sound recordings, photo, video material and sightings of birds, foot prints and exotic invasive species. CONABIO developed a pilot list of 23 invasive animals and plants based on level of impact and ease of identification, which are sampled along transects across the country.

**Space to invade? Comparative range infilling and potential range of invasive and native plants**

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Mitigating the threats from non-native, invasive species requires information about the locations these species are likely to invade. Our understanding of potential ranges for native and non-native species is often based on their current geographic distributions. But, because invasive species have had less time to expand their ranges following introduction (i.e. these species are still spreading and not at equilibrium), it is often assumed that models will underestimate suitable environmental conditions. If this assumption is correct, species distribution models should predict disproportionately smaller potential ranges for non-natives than natives. We compared the geographic ranges of 13,575 plant species, (9402 native, 2397 endemic, 1201 alien, and 755 invasive) within the continental US. We calculated US longitudinal and latitudinal range extents as potential indicators of range limiting factors, modeled potential range based on climate using principle components analysis, and calculated occupancy of potential ranges (range infilling). Contrary to expectations, modeled potential ranges were significantly larger for non-natives than natives, even for species with few occurrences. Distributions of native species, not invasive species, appeared strongly limited longitudinally. However, invasive plants occupied substantially less area within their climatically suitable ranges than native plants (lower range infilling). Invasive plant distributions were consistently broader both climatically and geographically than comparable native species. This suggests that invasive plant distribution models at regional scales are not underpredicting potential ranges relative to models for native species. In contrast, the comparatively limited longitudinal ranges of native species suggest a high degree of non-climatic limitation, which likely causes distribution models to underpredict the potential ranges of native species. Invasive plants have not achieved the degree of range infilling expected relative to natives. Thus, plants introduced to the US still have plenty of space to invade.

**Empowering communities to address invasive species: working at the neighborhood level for action on albizia trees in Hawaii.**

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One of Hawaii's most notorious invasive species, *Falcataria moluccana*, made the national spotlight when hundreds of downed trees crushed houses, blocked road access, and knocked out power to residents after Tropical Storm Iselle. While multiple agencies and land managers agree that albizia poses a significant threat to human populations as well as the natural ecosystem, the sheer magnitude of the infestation has proven beyond the scope of any single agency to manage. Large-scale legislative action has been slow to manifest; however, local leaders encouraged a grass-roots effort to empower communities to take hatchet and squirt bottle into their own hands. The local invasive species committee, BIISC, has developed a program to educate and train volunteer community members to control early invasions in their own neighborhoods as well as use targeted methods to report hazardous trees to property owners and agencies to demand action. In this session, we will share what works, what doesn't work, and the overall effectiveness of enlisting community volunteers in holding the line against one of Hawaii's most notorious invasive trees.

**Ecology and management of two invasive trees in Arizona riparian habitats.**

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Saltcedar (*Tamarix ramosissima* Ledeb.) and Russian olive (*Elaeagnus angustifolia* L.) are alien invasive woody plants that occupy many streams and wetlands in Arizona. Saltcedar is present in over most of the state and Russian olive is found in the northern part of the state on the Colorado Plateau. Both species were introduced as ornamentals, and/or for stream bank stabilization. Past cultural management aided their spread and establishment. Both species are considered to be phraetophytes and provide inferior habitat quality compared to native vegetation. Further they transform the riparian area to poor watershed quality. The ecology of both species will be presented in a compare and contrast fashion. Impacts of these species to the invaded landscapes will be discussed. Management for these species can be placed in an integrated pest management (IPM) program. Current vegetation management techniques, such as changes in cultural practices, mechanical, chemical, fire and biological treatments will be discussed. Mechanical treatments can promote vegetative regeneration as does prescribed or wild fires. Chemical treatments can be applied as cut-stump, basal bark, or foliage sprays. Best management practices for each treatment will be presented. Recently, biological control with the release of a beetle targeting saltcedar has been showing promise as part of an IPM approach for its control. Restoring properly functioning riparian habitats is a worthy goal and vegetation management of these species can provide better water yield from treated sites.

**Towards eradication of *Miconia calvescens* from the Hawaiian Island of Kauai: a history of detection and control efforts from the past 14 years.**

Kelsey Brock

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*Miconia calvescens* is a tropical tree native to South and Central America and is recognized as a priority weed target in Hawaii due to its known ability to form monotypic stands on Pacific islands. Significant resources are required to contain or eradicate this plant owing to its quick growth and prolific seed production. *M. calvescens* occurs on 4 of the main Hawaiian Islands, with large populations occurring on Maui and Hawaii for which management focuses on containment rather than eradication. As a result of relatively early detection, promising efforts are underway by the Kauai Invasive Species Committee (KISC) to eradicate *M. calvescens* from the island using both ground and helicopter detection and treatment. Number of mature and immature *M. calvescens* detected was assessed over the past 14 years since control commencement, revealing the history of *M. calvescens* detection by ground and helicopter in Kauai. These data show an increase in detection and treatment upon implementing helicopter operations, emphasizing the value of *M. calvescens* detection from the air. Furthermore, the fluctuating proportion of immature plants to mature plants likely reflects the persistence of undetected mature plants and new individuals arising from remnant propagules in the seed bank. This stresses the need to perform ground reconnaissance after helicopter operations to effectively remove young plants that may escape helicopter detection before maturation.

**Does flow regime predict alien plant invasion in a gravel floodplain ecosystem?**

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Braided river floodplains in the Canterbury Plains of New Zealand are classified as threatened ecosystems currently undergoing dramatic changes, including adjacent land-use intensification and increased water abstraction. In addition, both the regional environmental management authority and conservation NGOs are concerned by the invasion of these ecosystems by alien plants that reduce biodiversity and alter ecosystem processes. However, whether these plant invasions are consequences of the changes in flow regime and land-use has not yet been elucidated. We investigated the relative importance of flow regime, adjacent land-use, climate, and local riverbed variables in predicting the richness and abundance of alien plant species in braided river floodplains. We measured the percent cover of all plant species in a regional, plot-based survey that spanned multiple rivers encompassing gradients of hydrology, climate and land-use. Data on floodplain topography and substrate texture enabled us to determine the relative importance of both regional and local factors in shaping alien cover and richness. At a local scale, total alien species cover and richness were predicted primarily by substrate texture and floodplain topography. Significant regional predictors included maximum annual flow and variability of winter flow, for cover and richness respectively. When alien cover was split into life-forms (e.g. shrubs, herbs, grasses), floodplain substrate and topography were most explanatory. Significant regional predictors for different life-forms varied, with annual grasses and annual/perennial herbs related to flow regime while shrubs were associated with land-use. These results suggest that invasibility of river floodplains is mediated primarily by local factors and, subordinately, by regional differences in flow regime and land-use. The responses of alien species abundance to altered flow regimes will have direct implications for predicting the ecological impacts of water abstraction, land-use and climate change, and will provide the evidence base for setting environmental flows in these threatened ecosystems.

**A code of conduct on plantation forestry and invasive alien trees**

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Afforestation has a long history but the widespread availability of thousands of species of non-native trees in the last century has revolutionized commercial forestry, agroforestry and arboriculture in general. Alien trees planted for production purposes have strong direct positive economic impacts on the local and national economies of many countries, but often lead to sharp conflicts of interest when the species become invasive, and to negative impacts on the ecosystems. In many parts of the world, trees now feature prominently on the lists of invasive alien plants, and in some areas, non-native woody species are now among the most conspicuous, damaging and, in some cases, best-studied invasive species.
This Code of Conduct is addressed to all relevant stakeholders and decision makers in the 47 Member States of the Council of Europe. It aims to enlist the co-operation of the Forest sector (trade and industry, national forest Authorities, certification bodies and environmental organizations) and associated professionals in preventing, reducing and controlling possible introductions of invasive alien tree species in Plantation Forestry.
This Code is voluntary and does not replace any statutory requirements under international or national legislation but should be seen as complementary to them. It also complements the Code of Conduct on Horticulture and Invasive Alien Plants published by the Council of Europe and the European Code of Conduct for Botanic Gardens on Invasive Alien Species. Although prepared specifically for forest plantations of alien trees in Europe and in the Mediterranean, many examples and many if not most of the recommendations for action contained in this Code could be of relevance to forest plantations in other countries and regions, as a small number of tree species now form the foundation of commercial forestry enterprises in many parts of the world.

**Inventory of the aquatic alien plants of South America**

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Alien plant invasions in inland freshwaters can alter community structure, ecosystem functions and services with significant negative impacts on biodiversity and human activities. National inventories of aquatic alien plants are a fundamental basis for prioritization, risk analysis and management and provide substantial insights to our understanding of general patterns of plant invasions in inland waters. We present the first comprehensive database of the South American aquatic alien flora (floating and rooting hydrophytes, helophytes and amphibious alien species) considering both species that are alien in and to South America. The database is a critical collection of existing inventories and researches already available for this macro-region, where the knowledge of the diversity of the aquatic alien flora is still limited indeed. The project started in 2014 on a voluntary basis and we present herewith the analysis of the preliminary results on set of 142 alien species, belonging to 40 families, with 32 species ranked as invasive in at least one South American country. Alismataceae, Araceae, Hydrocharitaceae, Nymphaeaceae, Plantaginaceae and Poaceae are the families with the highest number of alien species. The majority of them are of South American origin (alien in South America), followed by those of African and Asian origin (alien to South America). The database collects also all the available information on date of first introduction, introduction pathways, main traits and life form. The project is ongoing and open to further collaboration with other scientists working in this field.

**Aliens spread germs: Frequency and risk factors of pathogen spillover between alien and native plants.**

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Population dynamics and competitive interactions within plant communities, including invasions, can be profoundly influenced by plant pathogens.  Pathogens shared between alien and native plant species can promote invasion through spillover, where alien pathogens move from alien plants to native plants, or through apparent competition, where alien plants host alien or native pathogens with a disproportionate impact on native plants.  Conversely, native pathogens may provide biotic resistance, if they heavily impact alien plants.  Understanding the frequency and patterns of pathogen sharing between alien and native plant species is important to understand the relative frequency and importance of these indirect effects.  Phylogenetic similarity and the extent of contact between native and alien plants should influence the likelihood of pathogen sharing.  To examine the frequency with which alien and native plants are colonized by biogeographically novel pathogens and test the importance of phylogeny and contact, we assembled a large database of interactions between plants and pathogens in New Zealand.  The database included 15000 records of fungal, oomycete, and plasmodiophorid pathogens recorded on native or alien plants over the last 150 years.  Pathogen origin was assigned by expert opinion using known distributions and historical records.  Pathogen spillover in New Zealand is asymmetric; 29% of alien plants have at least one native pathogen, while 52% of native plants have at least one alien pathogen.  Frequent pathogen spillover indicates plant introductions pose a serious risk of pathogen-mediated negative impacts, but measures of phylogenic relatedness and contact were not effective predictors of the proportion of alien pathogens on native hosts.  For alien plants, the proportion of native pathogens increased for widespread and woody species and for plants which have native congeners.  The high frequency of pathogen sharing emphasizes the potential importance of pathogen-mediated indirect impacts of alien plant invasions, especially between closely-related species.

**The status of weed biocontrol in Vanuatu**

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Biological control of weeds in Vanuatu began in 1935, with the introduction of the tingid *Teleonemia scrupulosa* to control *Lantana camara*.  To date nine biocontrol agents have been introduced to control eight weed species.  Eight of these agents have established on their respective hosts while a ninth, *Zygogramma bicolor,* an agent for *Parthenium hysterophorus* has only recently been released and establishment is yet to be confirmed.  Another agent, Epiblema strenuana was first detected in 2014 on parthenium plants on Efate but it is not known how it arrived in the country.  Control of the weed species range from being very good to inadequate.  By far the most successful agent has been *Calligrapha pantherina* which was introduced to control *Sida acuta* and *S. rhombifolia*.  The insect was released on seven islands and managed to spread to at least another 10 islands where it has effective controlled both Sida spp.  Control of the two water weeds *Eichhornia crassipes* by *Neochetina bruchi* and *N. eichhorniae* and *Pistia stratiotes* by *Neohydronomus affinis* has also been fairly good in most areas.  Two agents *T. scrupulosa* and *Uroplata girardi* were released on *L. camara* and four other agents have been found on the weed but L. camara is still not under adequate control.  The rust *Puccinia spegazzinii* was released on *Mikania micrantha* in 2012 and successfully established.  Anecdotal evidence suggests that it is having an impact on *M micrantha* but detailed monitoring is required to determine the overall impact.  This paper discusses the status of biocontrol of weeds in Vanuatu and future prospects.

**Tuber development and growth rates of two varieties of an invasive liana, *Dolichandra unguis-cati* in Australia**

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Cat's claw creeper (*Dolichandra unguis-cati* (L.) Lohmann (syn. *Macfadyena unguis-cati* (L.) Gentry), a Weed of National Significance has two forms, a long-pod (LP) form and a short-pod (SP) from. The LP form occurs in only a few localities in southeast Queensland while the SP form is widely distributed in Queensland and New South Wales. The aims of this investigation were: to evaluate whether there are significant differences in tuber development and root/shoot resource allocation between the two forms of cat's claw creeper; and if there are any significant differences, to find out whether the differences in resource allocation can be related to prevalence and invasiveness levels for the two forms. Long pod and short pod seeds collected in 2013 from various localities in Qld were germinated in growth chambers. Seedlings were then grown in a greenhouse for 18 months with regular watering but no additional nutrients. Harvesting of plants was done at 5 months, 10 months and 18 months respectively. Specific leaf area, leaf dry matter content, number of tubers, tuber size, root and shoot dry weight and branching architecture were measured for both forms of cat's claw creeper. SP exhibited significantly higher total number of tubers per plant and tuber size than LP at 18 months. Root/shoot ratio was also significantly different between the two forms and the SP exhibited a high level of branching than LP. Assuming that the two forms were introduced in Australia at around the same period, these results could explain why SP is widely distributed (and therefore more invasive) in Qld and NSW while LP is only confined to a few localities in south-east Queensland. These results infer that different management strategies should be adopted in controlling the two forms in Australia.

**Incorporating passive surveillance into management of pests and weeds**

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Information on the location of pests and diseases often comes from members of the public, industry groups, plant or animal health professionals and their networks, all of whom report suspected detections at their discretion. Surveillance that leads to these 'passive detections' is activated and maintained through public- or industry-funded awareness campaigns. While several recent studies have demonstrated the benefits of passive surveillance across a range of pests and diseases, and while public awareness campaigns have become an integral part of invasion management programs, there is still much to learn about this type of surveillance. These include the 'return on investment' in the activities that lead to passive surveillance, the size and types of investment required to achieve the desired level of reporting from the public, which parts of the community are more likely to report and whether these reports are reliable. This paper discusses recent findings on passive surveillance and puts forward a general framework for assessing the cost-effectiveness of passive surveillance.

**Environmental conflict and its resolution: The case of invasive alien species management in Cape Town, South Africa.**

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In a country as biologically diverse as South Africa, it is of critical importance to ensure that effective invasive alien species (IAS) management strategies are in place. The underlying though crucial role of public support in successful IAS management is not always recognised, and only comes to the fore when public opposition to IAS management strategies emerges as a barrier to successful IAS management, as has recently been the case with the removal of pine trees and mallard ducks in Cape Town. Studies have shown that public engagement in IAS decision making is vital in reducing impediments to consensus. In this regard, the use of collaboration and consensus-based approaches are well-established. We investigated whether the decision-making processes used in Cape Town are congruent with these approaches, through the use of qualitative, in-depth interviews with both IAS managers and affected and/or interested members of the public. Results revealed an inconsistency between the actual methods used, and collaboration and consensus-based approaches. We then proceeded to identify several types of conflict between stakeholders, as well as the main challenges to effective public engagement in decision-making processes involved in IAS management. Lack of communication at all levels, and among various actors, emerged as the most significant contributor to conflict. Our findings suggest that IAS managers' attempts at communicating IAS-related issues to the public are insufficient and are not as far-reaching and well received as those managers commonly perceive them to be. This study also highlights that taking into consideration the values and attitudes of the public will greatly aid in understanding their actions, and will facilitate the development of sound methods of communication. This, ultimately, has the potential to reduce conflict over the management of IAS in Cape Town.

**Challenges and Opportunities in a Federal Weed Risk Assessment Program**

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Adding species to the Federal Noxious Weeds (FNW) list based on weed risk assessments (WRAs) is the visible culmination of assessment, management, and rulemaking activities. However, the Weed Team in the Plant Epidemiology and Risk Analysis Laboratory (PERAL) deals with other issues and does even more work behind the scenes, including: species screening and prioritization, guidelines and manuals development, quality management , creating and reviewing datasheets for species for the NAPPRA (Not Allowed Pending Pest Risk Analysis) list, consultations with other agencies (at all levels), training, and weed analyses for commodity import pest risk assessments. Screening and prioritization is particularly important because we have limited resources, a long list of potential threats to assess, and also have to respond to increasing numbers of priority requests. We have screened 1,040 species with a quick prioritization tool that combines a threat assessment with an evaluation of whether or not federal action is likely. Consultations are very important and usually represent our greatest challenges and opportunities. Besides completed WRAs that stakeholders might have questions about, we consult on a range of topics including risk assessment for genetically engineered (GE) plant (crop) species, hybrids, and possible biofuel species. Biofuel species assessments are challenging because they involve risk management and stakeholders with diverse agendas. Training on our WRA tool is a highly requested activity, especially as the tool is adopted by different agencies and groups. Finally, weed analyses for commodity imports have greatly increased this year, mostly due to seed import requests. Rulemaking for these is very complicated, but other interesting issues have arisen as well, such as possible regulation of herbicide resistant biotypes of non-actionable species.

**Update on progress of biocontrol of strawberry guava in Hawaiian forests**

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*Tectococcus ovatus*, a biocontrol agent for the invasive plant strawberry guava, was released and established at two demonstration sites on Hawai'i Island in 2012-2013. Over the past two years the biocontrol has gradually spread within and between trees at these sites, but has not yet had a major impact on growth and reproduction. During 2014 the biocontrol was released at forest sites on Hawai'i, Oahu, Maui and Lana'i. Populations have established and have begun to spread at all release sites attempted to date. Initial rates of spread observed so far have been roughly 3-15 m per year. Strawberry guava tree growth and fruit production are being monitored at several sites to document the eventual impacts of biocontrol. Further releases are planned at additional sites, including forest plots where demographic analysis of strawberry guava populations has been conducted for the past ten years. These plots will provide a detailed evaluation of the impacts of biocontrol on all stages of the plant's life cycle: fruiting, seedlings, vegetative sprouts, saplings, and young and mature trees.

**Allelopathy by exotic invasive plants can alter nitrogen cycling through effects on soil ammonia-oxidizing archaea (AOA) and ammonia-oxidizing bacteria (AOB)**

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Plant invasions can have dramatic impacts on nitrogen (N) cycling and associated soil microbes through allelopathy. No study has linked changes in N cycling to changes in soil ammonia-oxidizing archaea (AOA) and ammonia-oxidizing bacteria (AOB) communities due to allelopathy of invasive or native plants. To examine the role of AOA and AOB in N cycling following plant invasion, we incubated soil with 2 concentrations of aqueous extracts from 3 invasive and 2 native plants. The results showed that both invasive and native plants influenced soil N transformation and the abundance of soil AOA and AOB through allelopathy. AOB predominates in soil potential nitrification, and AOA may predominate in soil net nitrification. Interestingly, invasive plants maintained the role of AOB in potential nitrification, whereas native plants did not. The altered soil ammonia-oxidizer communities and modified N processing rates induced by invasive plants provide a mechanism for understanding effects of invasion on N cycling through allelopathy.

**The contribution of seeds to the recruitment of a *Nymphoides peltata* population**

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The *Nymphoides peltata* population expands quickly in Lake Taihu, China. One question addressed in this study is whether the seeds of *N. peltata* contribute to this expansion. The buoyancy and germination of *N. peltata* seeds and the development of *N. peltata* seedlings were studied from Lake Taihu. The results indicated that a low wind velocity of 2.4–3.0ms−1 had a slightly negative effect on seed buoyancy. After 19 and 67 h of gentle stirring, 50% and 90%, respectively, of the *N. peltata* seeds had sunk. Few seeds floated again after sinking, but these refloating seeds sank soon with the disturbance. The N. peltata seeds did not germinate without stratification, but the stratification of seeds for a two-week period resulted in a high germination rate (63.3%) at a light intensity of 20 mol photonsm−2 s−1. Both the light and stratification treatments stimulated the seeds germination. A high germination rate (74%) was observed for the seeds that laid on the water-sediment interface; however, nearly all of the germinated seeds floated on the water surface after germination. Only a small fraction (14%) of the buoyant seedlings could re-establish in shallow water (less than 3 cm). In the eighth week of the experiments, the buoyant seedlings that failed to re-establish rotted. Sufficient light was important for both seed germination and seedling development. It was found that sexual reproduction is likely to have little direct contribution to the rapid expansion of *N. peltata* towards the centre of this large shallow lake.

**Dogs and Drones: Improving surveillance options to delimit plant invasions for eradication**

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Accurate and cost-effective surveillance and detection to ensure complete delimitation of an invasion is critical to the success of eradication attempts.  Eradication of invasive alien plants that occur over a large search area is not often attempted due in part to the lack of accurate and affordable surveillance options. An eradication attempt for hawkweeds (*Hieracium* spp.) is underway in Australia. Due to the size (greater than 10,000 ha) and nature of the search area, much of which is in remote, alpine wilderness, a novel combination of surveillance techniques is being trialled. Dogs have long been used for detecting illicit substances and, more recently, are being used in conservation to find endangered or pest animals. Partners in the hawkweed eradication program are trialling the use of specially trained dogs to assist with detecting hawkweed plants, which are cryptic and difficult to detect by humans when not in flower. Three spaniels, of varied age and experience, were trained to distinguish hawkweed from other plant species and detect hawkweed in field situations. Subsequent field trials monitored the dog's detection capabilities under different environmental conditions, and evaluated how dog detection abilities compared to those of humans in a field situation. While dogs are being used to improve localised detection, widespread surveillance is being augmented with the use of drones (unmanned aerial vehicles, UAVs) and image analysis algorithms. We are testing the ability and cost-effectiveness of using drones to collect aerial image data over large areas and in remote or difficult-to-access terrain.  Machine learning algorithms were developed to analyse image data and identify potential outlier hawkweed infestations that can be followed up by ground surveillance. This study aims to determine the optimal use of detection dogs and drones to provide more cost-effective options for invasive plant delimitation and eradication, especially for remote or rugged landscapes.

**The feasibility of eradicating *Opuntia pubescens* (velvet bur cactus) in the Pretoria National Botanical Garden**

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Many cacti in the genus Opuntia are notorious invasive species, and *Opuntia pubescens* (velvet bur cactus) is no exception. It started to spread inside the Pretoria National Botanical Garden (PNBG) and is now targeted for eradication.  The purpose of this study is to assess the feasibility of eradication of *Opuntia pubescens* in the PNBG as this is the only known population in South Africa. It is also aimed at finding new localities of this cactus species in areas where it might have been misidentified or overlooked, and also assessing the efficiency of the control operations.  *Opuntia pubescens* is an alien succulent armed with thin barbed thorns and has lemon-yellow flowers. The plant is relatively small and grows on average to approximately 40cm high. It is much branched with cladodes (joints) that are easily detached, 3 – 7cm long. The cladode surface is nearly smooth but mostly velvety or pubescent. The detached cladodes easily attach themselves to passing animals which carry them over distances resulting in the rapid spread of the species. The sterile fruit is small (about 2-2,5cm), green to red, and slightly spiny with a depressed umbilicus. All detached cladodes and fruit when falling to the ground can root and grow to form new plants. *Opuntia pubescens* can be confused with the jointed cactus (*Opuntia aurantiaca*) and the  bur cactus (*Opuntia salmiana*).The impacts of *Opuntia pubescens* are not yet known but it is suspected that they will be similar to the notorious jointed cactus (*Opuntia aurantiaca*) which entails  decrease in grazing area for livestock; injuries to humans and livestock; loss of vegetation; lowered value of pasture; displacement of indigenous plants and curtailed movement of animals and people in the infested area.

**Recent advances in genetic characterization of plant invasions: case studies from Cucurbitaceae and Boraginaceae**

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Tools available to invasion biologists seeking to reconstruct the history of specific plant invasions were formerly limited to historic reports and herbarium records, and these often provided only a sparse outline of the history of an invasion. Furthermore, post-invasion evolutionary processes are often suspected of creating new niche dynamics for invaders, resulting in enhanced spread and evolutionary adaptation. It is postulated that post-invasion adaptations may occur in as little as 20 generations following introduction in some plant species. This phenomenon calls for more population genetics research on invasive species. It is also critical to consider the impact of rapid environmental changes occurring at present, including climate change. Alien species may outperform native species through enhanced genetic diversity or beneficial mutations, both of which can now be assessed by global studies of population genetics in individual or related species. Recent advances include the ability to identify specific gene regions appropriate for large-scale comparisons through DNA barcoding, and characterization of sequence differences through statistical analysis and bioinformatics. Although DNA barcoding is particularly useful for differentiation at the species and subspecies level, it is also potentially useful for study of intraspecies population diversity in some cases. Recent advancements in next generation sequencing (NGS) coupled with reduced sequencing costs for analysis of large scale genomic data sets and advancements in bioinformatics software have also impacted our approaches to the study of plant invasion. Here we focus on selected examples of invasive Cucurbitaceae (*Citrullus lanatus* var. *citroides* and *Cucumis myriocarpus*) and Boraginaceae (*Echium plantagineum* and *Echium vulgare*) in which we have successfully employed DNA barcoding to study genetic diversity and phylogeography.

**Of rivers and disturbances: what drives the spread of *Impatiens glandulifera* populations from river corridors?**

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Riparian habitats are among the most invaded ecosystems worldwide. The great abundance of invasive species in river corridors is attributed to efficient transport of alien species' propagules, reduced competition from native plants due to regular disturbances, and a strong human impact in the river vicinity. River corridors thus also act as stepping stones for spread to other habitats. Our study species, *Impatiens glandulifera* Royle, is an annual from the Himalayas, which invades massively along rivers in the temperate regions, but occurs in a broad range of other than riparian habitats. We mapped its distribution and recorded its abundance in over 1700 plots along four rivers in central Europe, covering the total of 158 km of watercourse. The rivers differed in the time of the balsam's introduction and beginning of spread, and plots were characterized by shading level, degree of soil disturbance and flooding regime. We found a strong effect of the residence time at the site, with river invaded 10 years ago being significantly less infested than those invaded earlier. The rivers differed in the distance from the river bank to which the populations colonized the surrounding habitats, but this distance did not depend on the residence time. The more distant populations occurred predominantly in highly disturbed sites, such as road margins or ruderal habitats, and on tributaries. The largest populations were located relatively close to the rivers, especially in the areas frequently flooded, and the mean population size decreased with distance from the river bank. A high number of small populations found rather far from the river banks indicates a good dispersal ability of *I. glandulifera* and the key role played by stochastic dispersal events. We suggest that number of non-riparian *I. glandulifera* populations is likely to increase in the future, but the spread will be less extensive than along rivers and will remain confined to disturbed sites.

**Is coexistence between invasive *Microstegium vimineum* and native plants dependent on invasion history of the soil?**

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Coexistence of species with differences in average fitness is a result of stabilizing niche differences. Stabilizing niche differences are characterized by negative frequency dependence, decreasing per capita growth rate with increasing frequency of conspecifics, which can buffer species from extinction and prevent competitive exclusion of heterospecifics. Invasive species often competitively exclude native species in local areas, a result of higher average fitness and/or possibly weak negative frequency dependence. Invasive plants may have these traits because they lack coevolution with species in the invaded range; for instance, they may lack co-evolved specialist enemies. However, enemies may accumulate through time, which could reduce average fitness and increase negative frequency dependence for the invader. If this occurs then competitive outcomes between invasive and native species may shift from dominance by the invader to coexistence between the species. We performed an observational study, field experiment, and currently, a greenhouse experiment to investigate whether stabilizing niche differences are increasing and fitness is decreasing for invasive *Microstegium vimineum* across invasion time and whether this can be related to changes in the soil microbial community, specifically an accumulation of soil pathogens.

Through the field experiment, we found evidence that suggests an increase in stabilizing niche differences and a decrease in average fitness differences between native species and *M. vimineum* through invasion time. In the observational study we found changes in the general fungal community on *M. vimineum* roots and soil across invasion time and with survivorship of *M. vimineum* individuals, suggesting that soil microbes could be driving these changes through time. With the final greenhouse experiment we will directly estimate the two components of coexistence, stabilizing niche differences and relative fitness differences, for *M. vimineum* and native *Pilea pumila* and how they change based on the invasion history of the soil microbial community.

**Conditions under which invader impacts change over time**

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Many sites dominated by alien plant species are considered to be stuck in an arrested state of succession or alternative stable state and the observed persistence of relatively unchanging invader-dominated states supports this view. Yet there have been no systematic efforts to outline the conditions under which invaders maintain mono-dominance versus when they begin to share dominance with other species. Using examples from California and Hawaii, I argue that climate fluctuations particularly towards harsher environmental conditions (drought, higher temperatures) should generally weaken invader dominance and promote greater coexistence of the invader with natives or other species particularly when invaders rose to dominance as a result of disturbance. Some invaders create strong positive feedbacks and these may be resistant to climate fluctuations although the prevalence of such strong feedbacks is unknown. In California grassland invaded by the non-native annual grass *Bromus diandrus*, we document very strong litter feedbacks that seem to make patches of this grass resistant to climatic fluctuations and as its dominance persists, so does suppression of native species. By contrast dominance with weaker feedbacks and priority effects that were susceptible to climate drying in an invaded Hawaiian woodland resulted in community change over time. In this talk I present an overarching framework for evaluating when invader dominance and resulting impacts should persist over time, versus when they may decline and more species rich assemblages occur.

**Biological control of weeds in the Pacific: current status and future prospects**

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Biological control of weeds began in the Pacific islands Countries and Territories (PICTS) in 1911, with the lantana fly introduced into Fiji and New Caledonia from Hawaii. To date, a total of 61 agents have been deliberately introduced into the Pacific region to control 20 weed species in 17 countries. A further two agents, the rubber vine rust and the chromolaena leaf mite spread naturally into the region. Of the agents introduced, 36 agents have established and their general impact ranges from none to complete control of the respective target weed. Fiji has been most active in weed biocontrol, releasing 30 agents against 11 weed species. Papua New Guinea (19 agents to control 12 weeds species), Guam (16 to control 4) and Federated States of Micronesia (13 to control 3) have also been actively involved in weed biocontrol. For some weeds, e.g. *Lantana camara*, agents have been released widely, being found in 15 countries of the 21 countries in which the weed occurs. However, for other commonly found weeds, agents have had limited release, e.g. *Sida acuta*, whose agents are found in only four countries in which the weed is present. In cases where weed species have been targeted for biocontrol elsewhere in the Pacific, safe and effective biocontrol agents can be moved from one country to another. However, for some weed species, e.g. *Arundo donax*, agents which have been released elsewhere in the world could be introduced, following additional host specificity testing. This paper reports on the status of weed biocontrol in the PICTS and provides biocontrol options for weeds and countries where relevant.

**Competition between *Fallopia japonica* and *Salix viminalis*: a step toward the restoration of plant communities to control Asian knotweeds**

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Competitive interactions seem to play a major role in plant invasive success. However they have mostly been addressed through the invader impacts on other species of the plant community and rarely through the way plant communities could contain alien species. Understanding such mechanisms would help in designing restoration projects using plant community competitive properties to control invasive populations. In this study, we looked at the role of competitive interactions in the success of *Fallopia japonica* (Houtt.) Ronse Decraene using a willow frequently used in bioengineering techniques: *Salix viminalis* L.. *S. viminalis* has a high growth rate and is, as such, a potential candidate to compete with *F. japonica* in restoration projects of invaded areas.  Both species were grown in semi-controlled conditions in mesocosms (truck dumpsters), alone or in competition. We conducted measures of morphological traits (vegetative height, specific leaf area) as well as biomass measurements (aboveground and underground) on each species after two growing seasons.
Even under a dense canopy of *S. viminalis*, *F. japonica* was able to survive and grow. However, its performance was significantly reduced compared to monocultures and its spatial colonization was less extended. If *S. viminalis* was affected by *F. japonica* particularly through underground interactions, *F. japonica* expressed a competitive stress through a modification of its aerial structures.  We conclude that competition for light plays a major role in *F. japonica* invasion and that bioengineering techniques aiming at restoring a competitive neighborhood offer an interesting potential to control *F. japonica*.

**The challenges of applying WRA systems to screen out invasive alien plants in countries with open and porous borders: Bhutan a case study**

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Invasion by alien plants is a growing problem worldwide, causing significant impacts to production systems (i.e. agriculture), the environment and human health. Since intentional introductions of alien plants through the expansion of global trade and increased movement of people worldwide has contributed to the problem, Weed Risk Assessment (WRA) system have been developed to  screen out those alien plants that are likely to become invasive. WRA systems have been effective in developed countries at preventing new incursions, but are yet to be tested and adopted in developing countries, especially those that have open porous borders. Here we outline the challenges and implications associated with applying a pre-border WRA system in the developing world, and in such countries with open and porous borders. Many of these border entry and exit points are unregulated and a significant amount of goods are traded along them both formally and informally. Moreover, the current list of invasive alien plants in the region is underestimated and as such the risk of other invasive alien plants (i.e. those not listed) gaining entry into the country is relatively high. To illustrate these challenges and implications we present a case study from South Asia involving three countries that share common borders and are historical trading partners (Bhutan, Nepal and India), in which WRA is needed, but not presently implemented.  In addition, we reviewed the existing WRA systems to identify the practicalities of adopting and implementing such systems within our case study context (i.e. some questions are not relevant) and what additional challenges and implications arise, along with the strengths. Lastly we propose a series of recommendations as a way of stimulating debate as to how best manage the risk associated with alien plants in developing countries with open and porous borders, given the outcomes are important for global biosecurity.

**The invasion of Kakadu National Park's wetlands: threat and response**

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Australia's Kakadu National Park is one of the few World Heritage areas listed for both its natural and cultural values. Kakadu's seasonally inundated wetlands support an outstanding abundance of biodiversity, provide critical resources for Indigenous landowners and are a major tourist attraction. Unfortunately, these wetlands are under threat from a range of high-impact exotic plants. The response of managers to these weeds has varied substantially. For example, the response to the threat from the shrub *Mimosa pigra* (mimosa) was rapid and well-resourced and considered a case study of best practice weed management. In contrast, there has been limited response to two aquatic grass weeds, *Hymenachne acutigluma* and *Urochloa mutica*. Subsequently, whereas mimosa remains under control with a limited number of small infestations, the exotic grasses have spread extensively in recent years. We document the history, invasion and management response in Kakadu, explore reasons for the different management responses and suggest actions that should commence immediately to avoid a squandering of the efforts made to save Kakadu's wetlands from mimosa by converting them to a grassland dominated by invasive grasses.

**Long term invasion patterns: do different invasion starting points lead to the same invasion outcome?**

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Studies on the invasion patterns of alien plants have historically been short-term in nature (i.e. <5 years in duration). Most studies have been initiated well after the initial invasion has occurred and contain little reference to the invasion starting point; therefore, it is difficult to determine where they fit into the invasion timeline. As a result, our understanding of the initial invasion stages is extremely limited. Here I present data on the invasion patterns of Scotch broom (*Cytisus scoparius*) collated over a 26 year period in which plants were tagged and annually followed from two different invasion starting points (i) the edge of an invading front, and (ii) an isolated bush ahead of an invading front. The invading front was highly dynamic with a rapid population growth rate, which was followed by an equally rapid decline after about 4 years, which was subsequently followed by a gradual decline over the next 12+ years. In contrast invasion from an isolated bush ahead of an invading front was very gradual over a prolonged period, with the maximum density reached after about 12 years, being less than half that of the invading front. However, after 26 years the density of Scotch broom in both invaded sites was virtually identical, as was the number of native plant species present, illustrating that despite large initial differences in the invasion patterns associated with different invasion starting points the long-term invasion pattern was very similar. These results suggest that invasions transition into a stable state over the long term in the absence of disturbance and independent of the initial colonization process.

**Plant invasions in resource-limited environments**

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Historically, invasion biology focused on ruderal species dominating high disturbance environments. Plant traits, such as rapid growth rates, high seed production, and early reproduction, were identified as key factors promoting invasiveness. These traits can be resource-intensive, and so invasiveness of species and invasibility of communities became associated with high resource environments. As a consequence, resource reduction was often promoted as a method to minimize invasive species spread. However, we now recognize that resource-limited systems are also invasible, with non-native species finding success in environments limited by factors such as nutrients, water and light. Our work in systems as divergent as sagebrush steppe and eastern deciduous forests suggest traits related to resource use efficiency and plant architecture (both above and belowground) may promote invasive species success in resource-limited habitats. Additionally, differences in resource use and storage among native and non-native plants may influence community recovery during the restoration process. Surprisingly, although we have detected strong differences in trait values among species, evidence for trait plasticity has been weak, suggesting the potential importance of exaptation in these resource-limited systems. Determining the functional and performance traits associated with invasive species success in resource-limited systems is critical to identifying those species most likely to be problematic and to developing trait-based management plans that include native species with the greatest probability of success.

**Tamarix Biocontrol for Riparian Restoration**

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The release of the cyrsomelid beetle, *Diorhabda* spp., for biocontrol of tamarisk (*Tamarix* spp.) has, in some ecosystems, led to major reduction in Tamarix cover and low to high rates of mortality, retention of groundwater otherwise lost to transpiration, modest increases in associated vegetation and increased food availability to insectivorous wildlife. The restoration trajectory, however, is complex and may involve decline in habitat quality in the early phases ecosystem restoration. Such results highlight consideration of both short- and long-term effects of the use of conservation biocontrol, and effective monitoring programs to evaluate trends in the recovery process.

**Highly invasive plants (still) restricted to a small specific region: Potential invaders for other countries – Examples from the eastern Mediterranean**

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Prevention is the most efficient control strategy against alien invasive plants (AIP). It requires that potentially invasive plant taxa, not yet introduced into regions where they could turn invasive, are identified as early as possible. Therefore, alongside the most famous and already widespread AIP it is crucial to point out highly invasive plant taxa which distribution is still confined to a small region of the globe. It becomes even more important to consider those taxa when it happens that some are recommended as ornamentals or for other purposes outside their native range. *Acacia victoriae* Benth. (Elegant wattle), *Acacia salicina* Lindl. (Willow wattle), *Atriplex holocarpa* F. Muell. (Pop saltbush) and Heterotheca subaxillaris (Lam.) Britton & Rusby (Camphorweed), were all intentionally introduced to Israel during the 20th century for forestry, sand dune stabilization and ornamental purposes. After a lag phase of at least 50 years the Elegant wattle and the Willow wattle used in forestry became invasive in natural areas in the semiarid (BSh) region of the country. The Pop saltbush introduced in the 1960s to improve forage escaped from experimental plots and spread over the arid region of the Negev desert (BWh) and reached the Dead Sea valley. The Camphorweed introduced in 1975 for sand dune stabilization has now infested all the sandy habitats along the Mediterranean coastline (Csa). These AIP ae so far reported as invasive only in Israel and their highly invasive patterns deserve special attention in order to prevent their introduction in regions experiencing Mediterranean, semiarid or arid climates outside their native range. Recently, the unintentionally introduced *Ambrosia confertiflora* DC (Burr ragweed) became a major concern to local ecosystems and agriculture in Israel. Until then it was invasive only in Australia. Due to Israel location it could now pose a serious proliferation risk to Africa, Western Asia and Europe.

**Species richness, propagule pressure and the invasibility of plant communities**

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Two factors are thought to affect the likelihood that a new species will invade a plant community: 1) the inherent vulnerability of the community to invasion. Due to differences in biotic and abiotic factors some communities are thought to be more vulnerable to invasion by new species than others; 2) the number of arriving propagules. These two factors should also interact: where communities are vulnerable to invasion, few propagules may be required for successful colonisation, but where communities are resistant to invasion it may require many propagules to overcome that resistance.

We use the results from a large seed addition experiment to explore the interaction between propagule supply and invasibility. Seeds of the alien plant *Hieracium lepidulum* were added to 265 plots above treeline in Canterbury, New Zealand at densities ranging from 25 to 15625 seeds per 30 x 30 cm plot. More *H. lepidulum* plants recruited into plots with higher rates of seed addition but the number of plants saturated at high seed addition rates, implying a limited number of sites were available for colonisation. At a fixed rate of seed addition plots with higher native species richness also had higher rates of *H. lepidulum* recruitment, implying that species rich sites were more invasible. However, propagule supply and native species richness interacted to determine the final outcome: plots with high native species richness and high propagule supply were substantially more invaded than other plots. The results suggest that the manner in which invasibility (here linked to native species richness) and propagule supply interact are critical determinants of invasion outcomes.

**Vital lessons we need to learn from invasions**

Regan Early

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The extent of biological invasions is worsening, exacerbated by environmental change and globalised markets. In highly invaded regions, even more invaders are set to arrive, and ongoing invasions will worsen considerably. However, I show that emerging invasions also threaten the last remaining biodiversity strongholds and human livelihoods in the most fragile of economies. Despite the growing global threat from invasive alien species, existing policies - particularly in the developing world - are not yet up to the challenge.

Being able to predict the extent of invasions would help us take preventative action, but I challenge the fundamental principle that climate determines species' native and naturalised ranges similarly. This also means that climate change impacts in species' native ranges are far more unpredictable than we thought. I show that comparative research on species in their native and naturalised ranges is indispensable for understanding what does determine species ranges, and is already yielding promising results. For example, biotic interactions, particularly fungal pathogens, play a major role in determining where plant species can survive.

However, it's not just climate change and invasion ecology that urgently require improved estimates of range constraints. The survival of hundreds of endangered species globally would be improved by protection in regions where they have naturalised outside their native ranges. Invasion biologists should come to terms with the conservation value of naturalisation, and make a concerted effort to assess the risks and benefits.

**Host range of endophagous insects associated with fireweed in its native range in South Africa – prospects for biological control**

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*Senecio madagascariensis* (fireweed; Asteraceae), native to southern Africa and Madagascar, has become a major weed of pastures in Australia, South America, Japan and Hawaii, resulting in decreased productivity and poisoning of livestock. Due to the plant's short life history, high reproductive output and ability to flower throughout the year, chemical and mechanical control are short-term and ineffective management solutions. Biological control efforts by Australia have recently been focused in KwaZulu-Natal province, South Africa, after genetic studies confirmed this region as the origin of the weed in Australia. Host specificity of candidate insect agents is imperative as Australia has over 80 native Senecio species, some of which co-occur with fireweed. Fireweed is also able to hybridise with the Australian native *S. pinnatifolius*. To determine the native field host range of the insects feeding on fireweed in KwaZulu-Natal, 14 Senecio species were sampled, including the closely related *S. inaequidens* (invasive in Europe), S. harveianus, and S. skirrhodon (invasive in New Zealand) which together with fireweed form the *S. inaequidens* species complex. The COI gene of endophagous insect larvae that were recovered from these plants was sequenced to differentiate between species, and identify those unique to fireweed. DNA from larvae was then matched to adults for species identification. Attention was focussed on the most damaging endophagous species, namely stem-boring Curculionidae, and stem-boring, shoot-tip, and capitulum-feeding Lepidoptera. Stem-boring Curculionidae were recovered on eight Senecio species, stem-boring Lepidoptera on five species, and capitulum-feeding Lepidoptera on 10 species. Shoot tip-feeding Lepidoptera were only present on plants in the *S. inaequidens* species complex. This information will assist in prioritising potential agents for importation and testing in Australia.

**Four most Dominant Aggressive Alien Species in Farmlands and Water Bodies of Edo and Delta State, Nigeria**

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Alien species are a major concern to governments, biologists, ecologists, agriculturists, plant conservationists and other environmental stakeholders, but little is known about the distribution of invasive alien plants in Nigeria.  In this study, eight farmlands and two water bodies were used as pilot survey of invasive alien plants in Edo and Delta State, Nigeria. Four dominant alien species viz; *Chromolaena odorata* (L.), *Eichhornia crassipes* (Mart.) Solms, *Mimosa invisa* Mart, and *Mucuna pruriens* (L.) DC were collected belonging to three families; Asteraceae, Pontederiaceae and Fabaceae. Three of these plants collected are terrestrial alien plants (*C. odorata*, *M. invisa* and *M. pruriens*) while *E. cressipes* is aquatic. Some of these alien plants also have useful benefits to the farmers and garden owners although the negative impact outweighed the positive. Many farmers and garden owners spend a lot of resources battling the menace of these invasive alien plants. Management and control of these species vary among the locals of these two states, although there were some similarities in some areas.

**Dynamic and management of exotic knotweed at landscape scale: impacts and perceptions**

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Exotic Asian knotweeds are among the worst invasive plant species in a large part of the North Hemisphere. Most studies have focused on management and control technique at the local scale. But researches at landscape scale are still very scarce, and factors governing spatial and temporal dynamic of invasive knotweeds at landscape scale are still poorly known. DYNARP project aims at evaluating the respective roles of biotic and abiotic factors, of management techniques, and of the factors linked to social perception, in the spatial and temporal dynamic of exotic Asian knotweeds at the landscape scale. These scientific results should help managers to improve knotweed control at this scale.
The method relies on complementary cross-disciplinary approaches:
•Remote sensing techniques with current and past images, from satellite and aerial photography, and monitoring over several years of knotweed patches with ultra-high resolution unmanned aerial vehicles,
•Field sampling of knotweed patch limits with accurate GPS; of abiotic factors (soil, slope, etc.); of biotic factors with functional characteristics of the local and surrounding plant communities; and of knotweed performance through biological traits,
•Questionnaires for knotweed managers, in order to describe accurately management techniques and to understand the reason of their management choices.
Investigations are done along linear transport-infrastructures, including several motorways, navigable canals, rivers and railways.
The first results of the analysis of diachronic series of aerial images and samplings on fifty invaded sites are showing two opposite trends of spatial expansion or reduction, resulting from different ecological and management processes.

**A macrosystem study of invasion patterns and processes across continental USA**

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Biological invasions are a major component of global change, demanding to be studied under a macrosystem framework. Using a sub-continental empirical dataset with over 120,000 plots, we compiled and mapped invasion richness (number of species) and invasion prevalence (percentage of plots invaded) of non-native plants across the forest ecosystems in USA. We then modeled each of these invasion measures as functions of 22 factors reflective of propagule pressure and/or habitat invasibility for eastern and western forests separately using simultaneous autoregressive spatial error models. Eastern forests had higher mean invasion richness and prevalence than western forests. Spatial patterns of invasion richness and prevalence differed, especially in the West. Propagule pressure factors were always positively associated with both invasion measures. The importance of propagule pressure in less-invaded western forests suggests that spatial variability in propagule inputs, coupled with lags between establishment and commonness, drive the spatial differences between invasion richness and prevalence during early invasion stages. Meanwhile, declining spatial disagreement between invasion measures, and the relative unimportance of propagule pressure, in heavily-invaded eastern forests suggest that species-specific variation in response to habitat invasibility drives spatial differences between invasion measures during later invasion stages. These insights further illustrate the importance of spatial heterogeneity in invasive plant management and policy at macroscales.

**Long-term dynamics and impacts of a widespread invasive grass in eastern US forests**

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Most research on the ecological effects of plant invasions has focused on relatively brief time periods, thus little is known about how the impacts of invasions might change over successional time frames. To evaluate the longer-term effects of plant invasions, we established an experiment with communities of native trees and herbaceous species and then experimentally invaded half of all plots with *Microstegium vimineum* (stiltgrass), one of the most widespread and problematic invasive plants in eastern deciduous forests. After five years, we divided the plots into quadrats and applied prescribed fire to one quadrat per plot in the spring of two subsequent years. Initially, Microstegium dominated invaded plots, constituting more than 65% of average plot biomass during the first three years of the experiment, resulting in 46-64% less native herbaceous species biomass, nearly 40% lower diversity, and significantly less natural tree recruitment in invaded than control plots. However, the invasion began to rapidly decline four years into the experiment and after eight years, Microstegium represented less than 1% of plot biomass, regardless of the fire treatment. As the invasion waned, native herbaceous species recovered such that there was no difference in native biomass during years seven and eight. Fire significantly reduced tree density and increased light availability, thereby promoting native herbaceous performance, particularly forbs. The effects of fire and invasion were synergistic and persistent in that tree density was 64% lower in invaded subplots treated with fire at the end of the experiment. The pronounced initial impacts of the invasion followed by decline of the invasion and recovery of native species demonstrate that although the effects of plant invasions can be dramatic, they may be overwhelmed by ecological succession over the long term.

**Impacts of *Opuntia stricta* on biodiversity, ecosystem function and social perceptions in Kruger National Park, South Africa**

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*Opuntia stricta* (sour prickly pear) has invaded many regions globally, including the Kruger National Park (KNP), South Africa. Introduced as an ornamental plant in the 1950s, *O. stricta* spread to cover an area of about 60,000 ha. While various mechanisms of invasion have been assessed, including invasion vectors, propagule pressure and environmental conditions, an understanding of the potential impacts is less well developed. Together with long-term information on spread dynamics, management regimes and an understanding of prominent drivers of invasion, the KNP provides a model system in which to examine impacts on biodiversity, ecosystem processes, economics and social perceptions. We assessed the effects of *O. stricta* on the carbon, nitrogen and phosphorus cycles, as essential components of ecosystem function. The functional capacity of the soil microbial community that drives these cycles varies among soils dominated by different plant species. While we examined areas invaded by *O. stricta* and adjacent non-invaded areas, we also examined whether we could detect any legacy effects. Here we examined sites that had been densely invaded for at least a decade, but through the effects of the biological control agent *Dactylopius opuntiae* have remained at a low abundance since 1998. Combining previous work of impacts on biodiversity indicators, tourist perceptions and willingness to pay for control, we provide a synthesis and general model of the potential threats posed to protected areas.

**Limiting invasive *Ruellia simplex* via breeding sterile cultivars and developing efficient control in natural areas**

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*Ruellia simplex* (Mexican petunia) is native to Mexico, the Antilles and Western South America. It has profuse flowering and low maintenance requirements, and is a popular landscape plant in Southern U.S. However, this introduced plant has escaped cultivation and become invasive in natural areas in Florida and six other Southern states, Hawaii, Puerto Rico, and the U.S. Virgin Islands. For many years, 'Purple Showers' (origin unknown) with tall habit and purple flowers was the only sterile cultivar. Our objective was to develop sterile cultivars with other flower colors and different growth habits. Breeding techniques utilized ploidy manipulations and interspecific hybridizations. This approach was coupled with efforts to control invasive populations in natural areas. Tetraploid *R. simplex* plants in three different flower colors were obtained by treating diploid plants with oryzalin. Hybridizations were performed between tetraploid and diploid individuals in both directions, as well as between different morphotypes and species of Ruellia. All seeds were sown in 2010 and progenies were grown in a greenhouse at Gainesville, Florida. Plants were selected for female sterility and lack of fruit formation, and their ploidy levels were determined by flow cytometry. In 2011, a total of 15 selected breeding lines and five commercial cultivars as controls were evaluated in replicated field trials located in northwestern, north central and southeastern Florida. Breeding lines were evaluated monthly from May to October for landscape performance, flowering and fruiting. A purple-flowered and a white-flowered breeding line were selected and evaluated for female and male fertility. It was demonstrated that both lines are sterile, and they were approved for cultivar release by the UF IFAS Cultivar Release Committee and the UF IFAS Invasive Plants Task Force. They were released as Ruellia 'Mayan Purple' and 'Mayan White', and both cultivars are now patented and commercially available. Ruellia 'Mayan Pink' was released in 2013 and will be commercially available in mid-2015. Breeding efforts are ongoing. Direct control methods to controlling *Ruellia simplex* in natural areas were also evaluated. Treatments included four levels of aquatic-labeled glyphosate herbicide application frequency (0, 1, 2 or 3 herbicide applications) and two application seasons (spring and fall). Twelve 3 m x 3m plots were used in a floodplain forest wetland natural area in central Florida. Results showed that glyphosate treatments reduced *R. simplex* by 60-70% when sprayed once either in the spring or the fall. Additionally, the plant composition of the seedbank and the potential for recolonization of the native plant community was assessed. The goals were to explore revegetation approaches for native plant establishment, and *R. simplex* invasion limitation. Results indicate that native species recovery may be a multi-year process with several revegetation efforts, and that additional chemical control incorporating a growth regulator herbicide that targets Ruellia rhizome growth may be necessary.

**Use of Weed Risk Assessment in Forestry Projects in Hawaii and the Pacific**

J.B. Friday

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The Hawaii Pacific Weed Risk Assessment (HPWRA) is a quantitative system of evaluating the risk that an introduced plant will become invasive. The HPWRA is based on systems in use in New Zealand and Australia. A web interface (www.plantpono.org) makes the system transparent and easy to use by individuals and the public. While compliance is voluntary, most landowners choose to avoid planting potentially invasive species out of a widespread understanding of the problems caused by invasive plants.  Government agencies who fund cost-share projects in forestry, agroforestry, and urban forestry also require that proposed species be screened with the HPWRA in order for grant proposals to be accepted. Although the system was designed as a voluntary and not regulatory system, the threat of losing public funding compels landowners who wish to enroll in cost-share programs to comply. As the US federal government does not fund the planting of invasive species unless they can be justified, projects and state programs receiving federal funding also use the HPWRA to make sure they are not funding invasive species. Federally funded nurseries in the American-affiliated nations of the Pacific also use the HPWRA to screen species grown in their local nurseries.

**Testing the trait-based community framework: can limiting similarity increase invasion resistance in restored grassland?**

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It has been recently proposed that a trait-based community assembly framework can guide restoration efforts to assemble plant communities that are resistant to invasion.  One specific hypothesis, based on the theory of limiting similarity, is that community resistance to invasion can be strengthened by selecting native species that are similar to invasive species in resource use, thus increasing competition.  While several studies have documented limiting similarity in invaded systems, there have been few attempts to utilize trait data from invasive and native species for the purpose of directing ecological restoration.  Following the theory of limiting similarity, we predicted that invasive species will have lower fitness when grown in the presence of native species with similar timing and pattern of resource use.  We also predicted that functional traits would be better predictors of competition than phylogenetic relatedness.

We collected functional trait data from over 50 native species in a California serpentine grassland, including timing of germination, leaf nitrogen (N) content, leaf mass per unit area, photosynthetic capacity, root depth, root to shoot biomass ratio (R:S), and specific root length (SRL).   We then used multivariate analyses to identify native species that were similar in water and nutrient use to the dominant invasive species, ryegrass (*Festuca perennis*).  Five functionally similar and five functionally distinct native species were grown in competition with ryegrass and in monoculture.  We measured total above-ground biomass of each species as an indicator of competitive ability.  Leaf N, R:S, and SRL were strongly correlated with competitive ability.  Functional similarity and phylogenetic distance were poor predictors of ryegrass and native plant performance.  While functional traits can be used to predict competitive outcomes, the success of this approach depends on the selection of appropriate traits.

**A Community Based Weed Programme with a focus on Wild Ginger (*Hedychium gardnerianum*)**

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Horizons Regional Council
New Zealand Biosecurity Institute
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The ecology of invasive pest plants is complex so strategic management of pest plants needs to acknowledge and incorporate such complexities. Horizons Regional Council, (a local government agency in New Zealand) is a community based organisation. Engaging with the public is always 'key' to successfully managing invasive pest plants. Horizons run an urban weed programme that emphasises engagement with the people who live in the community.  This community based urban weed programme involves promotional and activity phases weighted heavily on promotion i.e. live radio interviews, a weed warrior 'the ginger ninja', home visits to members of the public, use of social media, hand delivered flyers, newspaper articles, and road signage

The promotional phase is the key to success. Radio and the Ginja ninja create interest and draw in a number of important organisations and people i.e. local body politicians, local conservation staff, a recycling business, a botanist , and a garden guru have all appeared on radio talking enthusiastically about weeds. The programme has been run for 4 years. The measure of success is recorded in the number of responses created during the promotional phase. In 2013 responses to the programme increased 100% on previous years and overall enquiries, since then, from the public about weeds has also amplified as the community understand Horizons is a centre of expertise for environmental weed issues.
This New Zealand urban weed programme is a campaign that engages the public like no other; although unique to this country it could be recreated in other locations and scaled across any biosecurity portfolio.
This New Zealand urban weed programme is a campaign that engages the public like no other; although unique to this country it could be recreated in other locations and scaled across any biosecurity portfolio.

**Genetic analysis of reproductive modes of invasive yellow flag iris and Russian knapweed**

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Understanding how invasive plants reproduce can help managers plan efficient control efforts. In this study we use genetic markers to investigate reproductive mode of two invasive plants: one aquatic (yellow flag iris) and one on rangeland (Russian knapweed). Aquatic weeds typically reproduce through vegetative means. There have been contradictory reports of yellow flag iris dispersing primarily by seed vs. pieces of roots breaking off and floating to new locations. We performed AFLP analysis of 20 aquatic populations across the Pacific Northwest of USA and found only 5 genetically identical pairs of plants in 171 samples, and identical pairs were always from a single population. This evidence suggests that yellow flag iris disperses almost entirely by seed, not root fragmentation. We also genotyped six Montana patches (10-53m diameter) of Russian knapweed (n=174 plants), a self-incompatible rangeland invasive plant known to spread by seed and rhizome growth. In six patches we found only eight genotypes. No genotypes were shared between patches. This suggests that for Russian knapweed, long distance distribution is by seed, and then founding individuals most often expands patch size by underground rhizomes. The largest genet found was 53m across. These findings inform land managers of which part of the plant to target when trying to reduce local or long distance spread, and if classical biological control is proposed, which agent type would be most effective for managing further dispersal.

**Invasive plants that hybridize: Challenges in cattail identification and in estimating hybridization rates**

Pamela Geddes

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In the Midwestern US, two wetland plant species- native *Typha latifolia* and exotic *T. angustifolia*- hybridize to form T. x glauca. The native parent *T. latifolia* can co-exist with other native plant species without lowering biodiversity. However, the exotic parent *T. angustifolia* is an aggressive invader that substantially reduces plant biodiversity. The hybrids also display invasive growth characteristics, forming dense monocultures that out-compete native species and thus threaten wetland function. Due to variable morphology, Typha species are difficult to identify in the field. Therefore, landowners and conservation managers have trouble knowing which species are in their wetlands and currently respond by removing all Typha (regardless of species), which is a drain on their resources and unnecessarily affects the native cattail. On a larger scale, the extent of hybridization across the Midwest is not well documented. Our goal was to use six previously described microsatellites that discriminate between the parent taxa and hybrids to quantify hybridization rates in cattail populations across the Midwest, and to estimate the presence of advanced-generation hybrids. After sampling plants from 39 populations in 7 states, we found that approximately 20% of populations sampled contained pure *T. latifolia*, while approximately 10% contained pure *T. angustifolia*. We also found not only first-generation hybrids (i.e., *T. x glauca*) but also advanced-generation hybrids, suggesting *T. x glauca* backcrosses to either parent or with other hybrids. Similarly to another study of comparable size, we found regional differences in the relative abundances of each species. Our data suggest that hybrids are replacing both parental species within the Midwestern region. Further analyses with other molecular tools will give us a more robust understanding of regional trends, which could have implications in the management of Typha stands as well as conservation of the native parental species.

**Pollination and rhizobia mutualists limit the invasion success of one (*Spartium junceum*) but not another (*Genista monspessulana*) alien legume**

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The presence of mutualistic partners can facilitate alien plant invasions, while their absence can prevent establishment. While most studies consider only one type of mutualistic relationship, alien plant species will often interact with multiple types of mutualists.  As a case-study we explored interactions between two alien legumes (*Genista monspessulana* and *Spartium junceum*) in South Africa and their associated nitrogen-fixing bacteria and pollinators.  Both species are (or have been) limited by pollination in some parts of their introduced ranges, but both species are also widespread and damaging invaders in a number of countries. We found both species to be reliant on pollinators for seed production but both are successfully pollinated in South Africa.  However, while *G. monspessulana* is frequently visited (by honeybees in particular), *Spartium junceum* is much less frequently visited (pollinated by native carpenter bees).  But the differences in nodulation were much greater.  *Genista monspessulana* populations in South Africa are nodulated by at least four distinct lineages of Bradyrhizobium, while we found no root nodules present on *S. junceum* plants.  Therefore while *S. junceum* is currently much more widespread than *G. monspessulana*, this is likely due to introduction effort (only the former was used as an ornamental).  In fact, the inability to nodulate, and thus fix nitrogen, and relative low rates of pollination of S. *junceum*, suggest it currently poses a much lower risk than *G. monspessulana*.

**Air Potato Biological Control Extension Needs Assessment**

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A new initiative is helping connect land managers struggling with invasive air potato (*Dioscorea bulbifera*) with a new weapon in our arsenal: the air potato leaf beetle (*Lilioceris cheni*).  Host specificity testing for the air potato leaf beetle was undertaken by scientists at the USDA ARS Invasive Plant Research Laboratory in Fort Lauderdale.  Researchers successfully demonstrated that the air potato leaf beetle is a specialist and can only develop on air potato.  Larvae and adults feed predominantly on air potato leaves and occasionally on bulbils and do considerable damage to the plant.  Program partners include UF/IFAS Extension, USDA ARS, USDA APHIS and the Florida Department of Agriculture and Consumer Services.

In 2014, an Air Potato Biological Control Extension Needs Assessment was conducted to help better target outreach efforts for this initiative. The Air Potato Biological Control Extension Needs Assessment:   (a) analyzed end users' perceived knowledge of air potato and the role of IPM and biological control in the plant's management, (b) analyzed end users' preferred methods of obtaining information on air potato IPM strategies, (c) determined the characteristics, needs and priorities of the target audience, (d) determined types and numbers of educational resources currently being used by end users to manage air potato.  Results of the Air Potato Biological Control Extension Needs Assessment will be shared with conference participants.  Survey methodology will also be discussed.

**The legacy of plant invasions: changes in the soil seed bank of invaded plant communities**

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Assessing the legacy of plant invasions on resident plant communities requires a thorough understanding of changes occurring in the standing vegetation as well as in the soil seed bank. Here, we present the results of a systematic review of current literature on the impacts of plant invasions on resident seed banks. The contribution of seeds of invasive species to invaded seed banks varies substantially (0–90%), with over 50% of seeds of an invader at the majority of sites (55.2%), and 70% of seeds at 34% of invaded sites. Native seed banks contribute to less than 20% of invaded seed banks at 30% of invaded sites and more than 50% at the majority of sites (57.5%). Invasive species tend to reduce native seed bank species richness and density (21 out of 28 sites) but alien species richness and density in the seed bank are often higher in invaded seed banks compared to non-invaded ones. Species composition differs between invaded and non-invaded areas in the majority of studies (16 out of 28 sites), with an overrepresentation of seeds of weedy and alien species. The similarity between the seed bank and the vegetation is lower in invaded vs. non-invaded plots at all examined sites. We discuss the potential long- term implications of such changes on native plant communities as well as in the control of invasive species and in the restoration of invaded sites. We also discuss the role of the seed bank as determinants of community invasibility, as they may be symptom of habitat degradation and/or promoting secondary invasions.

**Reproduction of *Kalanchoe pinnata*, a study of the mating and dispersal process in the invasion of a Mexican Seasonal Tropical Dry Forest.**

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1Consejo Nacional de Ciencia y Tecnologia

1.-Biological invasions are known to be a mayor issue worldwide, bringing ecological problems and economic losses. In the case of introduced or non-native plants, invasion success can lean on species' particular characteristics that facilitate dispersal, establishment and population growth. The non native plant *Kalanchoe pinnata*, has established on a relatively non-impacted patch of Seasonal Tropical Dry Forest(STDF) in east central Mexico. Due to the high ecological importance of the site and because *K.pinnata* is considered as an invasive in other ecosystems, an assessment of a potential invasion scenario is needed.

2.-In this study we focus our attention on reproductive traits of the invasive plant species. Artificial pollination treatments contributed information related to the sexual reproductive compatibilities of *K.pinnata*. Measuring empirical data, we constructed a life stage population matrix to estimate population growth, identify which life stages are more likely to support invasion, and determine whether vegetative or sexual reproduction is key for invasion.

3.-We acquire an important overview of invasion, a summary of percentages of viable and germinated seeds per pollination treatment in two consecutive years. We found that population expansion and survival rely on the growth of vegetative plantlets which will create a stable juvenile stage.

4.-Using demographic data and applying a simple life stage matrix model, we were able to simulate a *K.pinnata* population for a standard surface of one square meter. This virtual invasive population was used to test different efforts of harvest depicting a management scenario.  The methods presented in this study are procedures that can be performed by invasion managers and can provide valuable information for any eradication or containment plan.

5.-Synthesis and applications. Generalizations in invasion ecology are difficult to asses mainly due to specific interactions between novel species and each invaded ecosystem. We tried to overcome the lack of simple and/or general procedures by assessing biological invasions with classical ecological methods and population models. This approach provides a simple and  feasible procedure to assess invasion and gather information to execute pre-management actions.

**Considerations of demography and habitat type on Medusahead (*Taeniatherum caput-medusae*) control**

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The winter annual grass *Taeniatherum caput-medusae* (L.) Nevski, commonly known as medusahead, has invaded over 20 counties in California, significantly decreasing livestock forage production, reducing biodiversity, and promoting increased wildfire frequencies. Targeted control efforts are highly variable, and have not demonstrated long-term success. Contributing to the limited success of controlling medusahead is an absence of fundamental demographic knowledge about this noxious weed, which is essential for predicting the behavior of future invasions. By gaining a better understanding of the life cycle of medusahead, we can assess the susceptibility of life stages to different abiotic factors, and create models to assist with combating future invasions.

We examined the demography of medusahead across its life cycle within oak woodland and open grassland habitat types at different seeding rates (0, 10, 100, 10,000, and 50,000 seeds per m2), both with and without targeted defoliation, in a randomized design. Survival, growth, and fecundity data was collected to construct periodic matrix models over 1 year. Perturbation analysis was used to determine the sensitivity of each stage to experimental treatments.

We found overall population growth rate of medusahead to be lower in oak woodland habitats compared to open grasslands, as a result of reduced germination and seedling establishment. We also found that defoliation served to decrease overall medusahead density in both habitats. However, this reduction in density led to an increase in flower production by individuals that escaped the defoliation treatment (due to a late phenology). We expect that this increased flower production will be a positive feedback on population growth for the following year. This work highlights the importance of integrating demographic considerations into invasive weed management efforts. Specifically, our work suggests that effective eradication methods for medusahead require a series of defoliation treatments in order to target both early and late phenology individuals.

**Novel methods to optimise spray deposition for invasive weed control.**

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This presentation describes the use of a controlled environment, laboratory method, to conduct spray application research to optimise pesticide deposition and efficacy. This approach reduces the problems associated with field trials, i.e. variable ambient weather conditions and high experimental costs. Scion's Track Sprayer allows for isolating and testing of key variables that may influence spray deposition before field testing or chemical control application. Herbicide rates for invasive weed control can be adjusted and optimised, according to weed canopy characteristics and tested within the Track Sprayer. For some invasive weed species like *Ulex europaeus* (gorse), there are clear advantages if aerosol spray can penetrate through the plant canopy to optimise herbicide efficacy.

The Track Sprayer's size and application speed allows for treatment of live and artificial plant canopies in a 3 m high x 3 m wide by 3 m long sample area. Artificial "trees", created by layering stainless steel plates along a metal "stem", were used to quantify the influence of canopy density on the spray deposition profile, including ground deposits, for two droplet sizes. The use of artificial trees allowed for easy manipulation of leaf area index and stem density. The effect of droplet size and canopy density on total deposition was highly significant ($p < 0.0001$). There was a significant interaction between droplet size, canopy density and tree layer ($p = 0.0083$). As the droplet size and density increased, deposition decreased. On average 12% more spray was captured by the artificial tree collectors for the fine droplets than for extremely coarse droplets. Results from this work can be applied to improve operational herbicide applications to control invasive weeds. Data and knowledge obtained from track sprayer deposition experiments can be used when planning weed control operations. For example, wilding conifer control was significantly improved by a reduction in spray droplet size and an increase in application volume.

**Phenotypic plasticity of invasive *Spartina densiflora* (Poaceae) along a broad latitudinal gradient on the Pacific Coast of North America**

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The invasion of *Spartina densiflora* across a wide latitudinal gradient provides a natural model system to study potential mechanisms influencing invasive plant success in response to changes in climate and resulting physiological stress. Linking functional trait-based responses of invaders to environmental variation can elucidate their potential niche breath and improve our understanding of mechanisms promoting invasiveness. Phenotypic acclimation of individual plants and genetic differentiation within invasive populations are potential mechanisms that may confer fitness advantages and allow plants to persist and succeed with environmental variation. We conducted a field study examining habitat conditions, morphological and physiological leaf traits, and tussock architecture of *S. densiflora* plants at invaded sites across broad latitudinal and climate gradients, and then in favourable growth conditions in common garden experiments. Finally, in a common garden, we measured plant traits associated with growth and allocation, photosynthesis, leaf pigments and chemistry and calculated plasticity indices across imposed salinity treatments. Our results suggest the wide variation of foliar and tussock traits recorded across variable climate and sediment conditions at field sites are a plastic phenotypic response, as little trait variation was observed under common garden conditions. In response to three levels of aqueous salinity, the majority of measured traits expressed similar plastic responses, when averaged across sampled populations. For over one third of the measured traits, populations differed in the magnitude of plasticity expressed. Leaf chemistry and adaxial leaf rolling trait responses demonstrated the highest degree of plasticity, while growth and allocation measures were less plastic. Phenotypic plasticity of leaf functional traits to salinity indicates the potential of *S. densiflora* to maintain invasive growth in response to rising estuarine salinity with climate change.

**Can Airborne Laser Scanning enhance the ecological outcomes of large-scale *Salix cinerea* control?**

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We investigated the potential of Airborne Laser Scanning (ALS) to enhance the ecological outcomes produced by herbicides aerially broadcast for the large-scale control of grey willow (*Salix cinerea*), an invasive weed of New Zealand's palustrine wetlands. In particular, we focused on two metrics, tree height and canopy density, both of which influence the efficacy and non-target impacts of herbicides aerially broadcast by helicopter to control tree weeds. We compared ground-based measures of *S. cinerea* height and canopy density with ALS-derived data, and canopy density as estimated by each method with the deposition of herbicides aerially broadcast at three wetland sites in New Zealand. Analysis revealed strong linear relationships between ground-based and ALS metrics, indicating that ALS data could be used to produce accurate, high-resolution digital maps of *S. cinerea* height and canopy density. These maps could be uploaded to helicopter navigation computers to guide the optimal placement of herbicide, maximising *S. cinerea* mortality and reducing the mortality of non-target indigenous plants. The ability to quickly and accurately assess tree stand architecture over large areas and the development of computer-guided variable flow rate technologies that allow precise herbicide application suggest that ALS could play an increasingly important role in the conservation management of *S. cinerea* and other tree weeds.

**Aerial application of herbicides for large scale *Salix cinerea* control and restoration of wetland plant communities.**

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*Salix cinerea* is widely distributed in New Zealand and poses a significant threat to New Zealand's wetlands.  To manage the ecological impacts of *S. cinerea* and to control further spread cost-effective large-scale control methods are needed.  We investigated the efficacy of two aerially broadcast herbicides; triclopyr and glyphosate, for large scale S. cinerea control and the restoration of native wetland plant communities.   We found the application of triclopyr at 6.48 kg a.i. ha-1 reduced *S. cinerea c*over and increased light availability one year after control.  But, three years after control *S. cinerea* cover did not differ from pre-control levels, and light availability had decreased.  Further, triclopyr application had no effect on the density and distribution of native sedges or ferns, and reduced native shrub density and distribution.  Consequently, we do not recommend aerial application of triclopyr for large scale *S. cinerea* control.  In contrast, the application of glyphosate at 3.24kg a.i ha-1 resulted in greater reductions in *S. cinerea* canopy cover and greater increases in light availability than triclopyr, and these metrics did not change with time since control.  The application of glyphosate also promoted increased density and distribution of native sedges and shrubs, and had no effect on native fern density and distribution.  These results suggest that the aerial application of glyphosate has potential as a large scale *S. cinerea* control method where the restoration of native sedge and shrub communities is desired.
However, glyphosate application also resulted in increased density and distribution of *S. cinerea* seedlings and exotic grasses (*Glyceria declinata, Cortaderia jubata, Agrostis* spp., and *Holcus lanatus*) suggesting positive ecological outcomes are temporary.  Research on factors that influence *S. cinerea* seedling establishment, and the development of large scale grass specific control methods are needed to sustain and enhance the ecological outcomes of large scale *S. cinerea* control.

**Abiotic and biotic soil legacies of *Cytisus scoparius* impact reforestation**

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*Cytisus scoparius* is a nitrogen-fixing invader that imparts soil legacies that inhibit reforestation success. With a series of experiments we evaluated the presence and persistence of these legacies such as N-enrichment, as well as their implication(s) for the mycorrhizal community on which the establishment of Douglas-fir depends. In greenhouse experiments we found soils previously invaded by Cytisus harbored less ectomycorrhizal fungi (EMF).  In the field we assessed two strategies to maximize EMF colonization and improve reforestation success following Cytisus removal: planting near forest edges and transplanting local uninvaded forest soil into invaded clearcuts. Edge seedlings had higher survival and more EMF than clearcut interior seedlings. Transplanting forest soils did not increase EMF colonization or Douglas-fir success but did increase EMF richness; this suggests inoculation of invaded areas can restore EMF, but is not necessarily sufficient to restore the functionality of the mutualism.


Nitrogen-enrichment may be a mechanism by which Cytisus affects the Douglas-fir-mycorrhizal mutualism.  In a field experiment we measured the persistence of N-enrichment following Cytisus removal over a 2-yr period. One month after removal, there was a large pulse of inorganic N, presumably a result of rapid decomposition of N-rich Cytisus biomass.  Ten months following removal, this pulse of N declined by 70%.  However, over the following year, there was no additional decline of N.  Unexpectedly, Douglas-fir seedlings performed worse in plots that had been Cytisus-free the longest. This pattern was likely caused by competition from a second wave of invasive grasses and forbs, whose cover increased with time following Cytisus removal. It appears that Cytisus-derived N, rather than providing a lasting fertilization effect for slow-growing natives like Douglas-fir, favors the invasion of exotic grasses and forbs that compete with Douglas-fir.

**Ecological adaptation of an exotic aquatic plant (*Myriophyllum aquaticum*) across experimental nutrient gradients**

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In recent years, *Myriophyllum aquaticum*, an exotics species, has covered many lakes and rivers in South China due to deterioration in the ecological environment and eutrophication of surface waters. The detrimental effects of *Myriophyllum aquaticum* are closely linked to its capacity to multiply and spread very rapidly. To understand the spread and impacts of invaders, a comparative approach has usually been used which involves pairing invasive species with native species or noninvasive congeners. In this paper, simulated and controlled experiments were employed to study the physiological and ecological adaptation of native (*Hydrilla verticillata*) and exotic (*M. aquaticum*) aquatic plants in response to nutrition addition. The results showed that impacts of nutrient availability on growth and clonal propagation were significant. Total ramet number, different-order ramet number and biomass in different tissues increased with the level of nutrient supply. The biomass allocation pattern  was also affected by nutrient-availability.  *M. aquaticum* allocated more biomass to leaves in high nutrient-environments, and more biomass was allocated to roots in low nutrient water . Nutrient-enriched water accelerated the *M. aquaticum*'s growth rate, which resulted in reduced growth of *H. verticillata*, which was restrained significantly by lack of light ($p<0.01$). Comparing nutrient concentrations in dead and live leaves, the difference was significant, suggesting *M. aquaticum* not only has a higher nutrient acquisition rate, but also a higher nutrient resorption efficiency, allowing it to hold more nutrients when in higher nutrient environments.

**Influence of warming water on expansion of a *Nymphoides peltata* population in Taihu Lake, China**

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A slow warming process has been observed in Taihu Lake with global warming since the 1970s, and a sharp rise in mean annual temperature has occurred since 1991. A significant increase in degree day accumulation could be caused by minor increases in water temperature, and this can affect the growth and reproduction of aquatic plants. In the present study, controlled experiments were employed to investigate depth-related differential responses of water warming(from 24 to 32℃) on *Nymphoides peltata*'s seed germination, vegetative growth, photosynthesis, and competitive potential with submerged plants. The results showed *N. peltata*'s germination rate decreased significantly when the temperature was too high or too low, and reached a peak rate at 30℃（$P<0.05$）. The  rates of shoot initiation in *N. peltata* stolons significantly increased ($P <0.05$) with the water warming in the range from 24℃ to 30℃, and these temperatures are favorable for plant morphogenesis and root biomass accumulation. *N. peltata* showed a larger accumulation of biomass and plant height under higher temperature conditions (30℃). By analysis of root morphology, a more developed root system was observed with warming conditions, but the growth of *N. peltata* was lower at 32℃. In the process of photosynthesis, the maximum photosynthetic rate (Amax), transpiration rate and stomatal conductance showed significant differences between different temperatures, and reached a peak at 30℃, decreasing above or below this temperature. The competition results between *N. peltata* and other co-existing submerged plants with water  warming showed that *N. peltata* had an apparent competitive advantage due to its larger leaf area and higher growth rate in the process of community succession.

**Alien ornamentals and climate change: an inventory of European garden flora and the impending invasion debt**

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The majority of plant species currently naturalized in Europe, including many harmful invasives, were originally introduced for horticultural purposes. In addition to further naturalizations through continued introductions, Europe may face a large invasion debt from many not-yet-naturalized species—climate change may increase habitat suitability and invasion probability for many ornamentals which are widely planted, but less suited to current European climates. Identifying species with high future naturalization potential is highly important for land managers seeking to prevent impending invasions. In order to identify likely determinants of future naturalization potential, we assessed the naturalization success of 2,493 ornamental aliens in Europe and globally (as extracted from the Global Naturalized Alien Flora database). We tested the effects of propagule pressure (from sales at 246 European nurseries), the extent of current climatic suitability (based on species distribution models), global naturalization success, and life history traits including plant height, growth form, storage organ presence, hybridization, native range size and propagation method on the probability of naturalization success within Europe. We found that nursery sale frequency, climatic suitability, plant height, growth form, storage organ presence, and global naturalization success all influenced European naturalization success. For those species not yet naturalized in Europe, we estimated suitability to projected future climates and applied the optimized model to predict naturalization success for these species in 2050 Europe. With these results we created a ranking of species' likelihood to naturalize in Europe by 2050. Despite the uncertainties associated with climate change, we hope this assessment will provide policy makers with accurate, suitable tools and information for evaluating and mitigating future invasion risks.


**Inhibitory effect of *Eichhornia crassipes*, *Pistia stratiotes* and *Alternanthera philoxeroides* on *Microcystis aeruginosa***

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Nowadays, eutrophication in China is very severe. Some invasive plants (*Eichhornia crassipes, Pistia stratiotes* and *Alternanthera philoxeroides*) were used in the remediation of eutrophic lakes. Microcystis aeruginosa was the dominant toxigenic species of algal bloom in China. The purpose of this study was to investigate the impact of *E. crassipes, P. stratiotes* and *A. philoxeroides* on *M. aeruginosa*. Our results indicated that these plants could inhibit the growth of *M. aeruginosa* in the symbiotic condition. When density of plants was 6.3g/L, the inhibitory rate of *M. aeruginosa* by *E. crassipes, P. stratiotes* and *A. philoxeroide*s were respectively 86.8%、90.1% and 75.7% after 6 days. The effects of filtered culture medium from these plants on *M. aeruginosa* were also observed. Data showed that culture medium from *P. stratiotes* could promote the growth of *M. aeruginosa* when its concentration added into algal culture lower than 40%, while it could inhibit the growth of *M. aeruginosa* when adding concentration higher than 80%. But the medium of *E. crassipes* and *A. philoxeroides* only had the inhibitory effects on *M. aeruginosa*. When adding concentration was 80%, the status of inhibitory rate was *E. crassipes> A. philoxeroide> P. stratiotes*. In addition, the water extracts from these plants were also had inhibitory effect on the growth of *M. aeruginosa*. The inhibitory rate of *M. aeruginosa* by root extracts from *P. stratiotes*, stem extracts from *P. stratiotes*, root extracts from *E. crassipes*, stem extracts from *E. crassipes*, whole plant extracts from *A. philoxeroides* were respectively 22.0%、48.35%、18.1%、17.6% and 100% after 12 days.

**Do invasive pines affect the soil microbial community in the Cerrado?**

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At least 20 Pinus species are considered to be invasive in at least one region of the southern hemisphere. In Brazil, several species of Pinus were introduced for commercial exploration and subsequently have spread into preserved areas. In our study area, in the Botanical Garden of Brasilia, Brasília, Brazil, some Pinus species were planted in a 8 ha stand near the public visitation area and currently there is evidence of invasion through spontaneous regeneration into adjacent native Cerrado vegetation. Previous studies have established that invasive pines can have a direct impact on the physical and chemical characteristics of the soil and the hypothesis tested in this study was that the litter layer produced by the pines in the natural area could alter the microbiological diversity of the Cerrado soil. We collected 21 soil samples, 10 in native cerrado and 11 under the canopy of invading individuals of Pinus. In these samples, we determined the concentration of P, K, Ca, Mg, Al, Fe, Zn, Mn and Cu, along with soil organic matter and pH. These variables were correlated with functional diversity (calculated as the average well color development (AWCD) of 31 carbon sources using BIOLOG Ecoplates). Of the measured variables, only $Al^{+3}$ had a significant difference between the samples collected under pine litter ($1.14\pm0.16$ cmolc/dm3) and those in native Cerrado ($0.90\pm0.26$ cmolc/dm3) ($F_{1,19}=6.767$, $p=0.0175$). A redundancy analysis with spatial autocorrelation removed showed no effect of the nutrient concentration on the physiological profile of the bacterial community ($\alpha = 0.05$, $R^2 = 15.53\%$). In conclusion, the variability in the bacterial community is specific to each collection point and this initial occupation by Pinus did not alter the bacterial community.

**Mechanical removal of *Arundo donax* L. in the Ipanema National Forest, São Paulo, Brazil**

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*Arundo donax* L. is an invasive grass present in several countries including Brazil although there are no data on when it was introduced or on the extent of its invasion. A part of a management plan submitted by Holcim (Brasil) S. A. and approved by IBAMA (National Institute for Environment and Natural Resources) in June 2008 included removal of Arundo during the closure of two calcareous mines in the Ipanema National Forest, SP, Brazil. Within the management area two adjacent sites covering approximately 0.5 ha (20 x 100 m) with a high density of *Arundo donax* were identified. Due to the lack of legislation regulating the use of herbicides on exotic species in Brazil, Holcim chose to use mechanical control to remove this invasion. In November 2008 a backhoe loader was used to removed the patch of Arundo. This process included aerial biomass and soil and roots to a depth of between 0.5 and 0.7 m. During this process the soil and plant biomass were separated. All biomass was deposited in an industrial landfill, approximately 50 km distant, and the soil left at the site. The process took approximately 100 hours and total cost was estimated to be around US$10,000.00. In January 2009 over 300 saplings of 40 different native species from the region were planted in the site. After one year, approximately 15% of the saplings had died, due to localized flooding, and these were subsequently replaced with new saplings. Mortality of saplings also occurred in subsequent years, but without replacement. The area has been continuously monitored for the reoccurrence of Arundo and also Urochloa but the frequency of occurrence of these species was low and when encountered any individual was manually removed.

**Dominance has a biogeographical component: plants exert stronger impacts in their invaded rather than native ranges**

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The impacts of three species invading from Europe to North America and three invading from North America to Europe were studied in their reciprocal native and invaded ranges. By using species that form a dominant component of the communities in which they occur in both ranges, we aimed at (i) analysing whether the strength of impact of the same species depends on the range, and (ii) assessing the role of the direction of invasion by comparing the impacts of species invading from Europe to North America and vice versa. The degree of species' dominance was expressed as its percentage cover in the community and the relation between this characteristic and richness of other species present was tested using marginal and LME regression models. In North America, species richness responded negatively to the increasing cover of all three species invading from Europe (*Agrostis capillaris, Bromus tectorum, Cirsium arvense*), but in the native European range of these species, only *Agrostis capillaris* dominance caused a negative response in species richness that was, in addition, weaker than in the invaded range of this species. In Europe, species richness responded negatively to the increasing cover of two of the three species invading from North America, *Aster novi-belgii* and *Lupinus polyphyllus*; for the latter, the negative response of species richness was stronger in the invaded range. The dominance of the third invader to Europe, *Solidago canadensis*, resulted in suppressed species richness only in its native range in North America. These results show that (i) species tend to have stronger impacts on the richness of plant communities they dominate in their invaded rather than native ranges and (ii) European invaders in North America suppress the richness of co-occurring species more than those invading in the opposite direction, from North America to Europe.

**Similarities and differences between native and invasive plant functional traits across environmental gradients in Hawai'i Volcanoes National Park**

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The question of why some non-native plants become invasive while others do not is a key question in ecology. Recently, functional traits have gained traction as a tool to investigate this question and propose invasion mechanisms by examining the similarities and differences between resident species and invaders. Generally, differences suggest that invaders succeed by occupying different niches than resident species while similarities suggest that invaders possess fitness differences that allow them to successfully compete for resources. We studied the differences in functional traits of invasive species and the resident species in the communities that they occupy in Hawai'i Volcanoes National Park, USA across a temperature and precipitation gradient. We found that invasion mechanisms vary widely among invasive plant species. Some common invaders, including *Morella faya* and *Psidium cattleianum* occupy a similar trait space as resident communities across the environmental gradient while others, including *Hedychium gardnerianum* and *Melinis minutiflora* occupy very different trait spaces than the resident communities which they invade. Notably, the invaders who occupy the same trait space as resident species are found across a greater length of the environmental gradient than other, more specialized, invasive species. Additionally, the generalist invaders displayed greater intraspecific trait plasticity, suggesting that invaders with a high degree of trait plasticity rely on fitness differences to invade more than the specialized invaders, which rely more on niche differences. Overall, these results suggest that invasion mechanism varies across species. Because of this, simply comparing traits of potential invaders and resident species may not necessarily predict whether a species is likely to invade, although case studies such as these can offer insight into species selection for restoration projects. Further research on how general this pattern of invasion mechanism of specialist vs generalist invasive species would be useful in further understanding this question.

**The potential for compliance-based inspection protocols in Australia's biosecurity system**

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As the volume and range of products traded globally continues to expand, managing the spread of invasive species becomes more challenging. Each year the Australian government spends significant amounts of money designing and implementing inspection rules that govern importing processes in order to reduce the likelihood of biosecurity hazards entering Australia. These intervention activities are expensive and increase costs on various import-supply chain participants, and at least some of these costs will be passed on to consumers.

The Australian government has recently replaced full inspection on several plant-product pathways with an adaptive-sampling protocol where the sampling frequency is based on an importer's inspection history. The new inspection protocol may also provide impetus for behaviour change, as importers have an incentive to decrease the likelihood of biosecurity hazards being present in their consignments in order to reduce future inspection costs, both monetary and non-monetary. This paper discusses the potential for compliance-based inspection protocols to increase efficiency of Australia's biosecurity inspection system, focusing on several case-study pathways.

**The expansion route of alien Lolium species into sandy coasts in Japan**

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Most studies of the evolution of invasive species have been conducted by comparing genetic structures between their native and introduced ranges. However, alien species undergo an array of selective filters to be invasive, and are often introduced through multiple pathways. The lag period, from establishment to range expansion, is important for adaptive evolution of invasive species. Moreover, introduction of diverse lineages of an alien species along different routes would influence its post-invasion process. Therefore, comparisons considering introduction routes in their invaded ranges are necessary.
In this study, we investigated the expansion route of outcrossing *Lolium* spp. which are introduced as forage, as well as contaminants of trading wheat in Japan. Previous studies showed individuals derived from forage were established in croplands, while individuals from contaminants were established in trading ports. These species are now expanding to sandy coasts nationwide. Different environmental conditions of the coast from other habitats may cause a selective response in plant populations.
We compared population structures of croplands, ports and coasts in three geographically separated regions in Japan, using morphological characters, nuclear microsatellite markers and chloroplast DNA sequences. Microsatellite analysis showed high genetic diversity in all populations. Coastal populations had similar genetic structures and morphological characters with the port populations throughout these regions, but not with cropland populations. However, chloroplast DNA haplotypes were not significantly differentiated among habitats and/or regions.
Our results revealed genetic structures differed depending on introduction routes, and coastal populations were suggested to have originated from port populations derived from contaminants. As these expansions have not been followed with severe bottlenecks, port populations are able to invade coasts multiple times, while cropland populations are not. Adaptation may be involved with the difference of genetic structure.

**Biological control of invasive alien plants: any delay is opportunity lost**

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A disproportionate number of invasive plant species in South Africa are perennial trees, many of which are economically important sources of timber, fodder and fuel.  Biological control remains the only feasible way to control invasive trees but, because of the commercial value of the plants, only agents that reduce seed production can be used.  Several biological control projects against invasive trees in South Africa have been running for many years, some since the early 1980s, and are gradually showing trends that have exceeded expectations.  Initially it was hoped that by reducing seed production with biological control the invasiveness and dispersal rates of the trees would be curbed.  While this is undoubtedly happening, other mortality factors, especially fire, are enhancing the impact of the biological control agents and have resulted in substantial declines in the extent of some of the tree species, with reductions in other species expected.  The process is slow, taking decades rather than years, so there is a tendency to overlook the true value of the contribution by the introduced biological control agents.


**Multi-generational impacts of the psyllid *Arytinnis hakani* on the invasive weed French broom, *Genista monspessulana***

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Biological control agents may require several generations to strongly impact target weeds. The multivoltine psyllid *Arytinnis hakani* (Loginova) is under evaluation in the USA as a prospective biological control agent for French broom, *Genista monspessulana*, an invasive shrub from the Mediterranean area. Anecdotal reports indicate that *A. hakani* is helping to control French broom in Australia, where it was accidentally introduced before it could be approved for release. However, impacts over time periods longer than one psyllid generation have not been examined. We conducted an experiment in a quarantine greenhouse in Albany, California, to examine the multi-generational impacts of *A. hakani* on French broom growth and mortality. Two treatments were established, including a no-psyllid control and a psyllid-addition treatment, and trials continued for three psyllid generations (~130 days). Plant growth and mortality were strongly affected by the presence of the psyllid: 23 out of 28 plants that received psyllids died, while all of the no-psyllid control plants survived, and growth of surviving psyllid-infested plants was reduced by 68.3% relative to the controls. Several small plants died during the first generation, but larger plants did not die until the third psyllid generation. These results corroborate observations from Australia, and suggest that *A. hakani* would be an effective biological control agent for French broom if released in the USA. Host specificity testing for *A. hakani* is ongoing.

**Rapid death of a dominant native tree, caused by an introduced pathogen, facilitates transformation of native forest to alien forest in Hawaii**

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*Metrosideros polymorpha* ('Ohi'a) is Hawai'i's most important and widespread native tree. As the keystone species of our native forests, it is the first flowering plant to colonize new lava flows and provides the foundation for native plants and animals that establish thereafter. Recent forest inventories illustrate 'Ohi'a's dominance; on average, 'Ohi'a accounts for 52% of total basal area and 45% of stem density across forests of Hawaii Island. Throughout the past and continuing to this day, 'Ohi'a forests have been reduced by land use, introduced alien plants and animals, and, most recently, plant pathogens. Currently, natural resource managers, policymakers and landowners across Hawaii are becoming increasingly alarmed by rapid mortality of tens of thousands of mature 'Ōhi'a trees (*Metrosideros polymorpha*) across thousands of hectares of Hawaii Island. This epidemic appears to be escalating rapidly. Analysis of remote sensing imagery from 2012 revealed that ca. 1000 ha of 'Ōhi'a forest had suffered mortality across the Puna District of Hawaii Island; by 2014 this area of 'Ōhi'a mortality had expanded to over 6000 ha. We have definitively identified the causal agent of Rapid 'Ōhi'a Death (ROD) to be the non-native fungal pathogen, *Ceratocystis fimbriata*. This pathogen has consistently been isolated from stained xylem tissue collected from dead or dying 'Ōhi'a exhibiting rapid mortality symptoms. Koch's postulates were successfully completed using isolates of Ceratocystis which confirmed that this fungus is pathogenic to 'Ōhi'a trees and responsible for ROD across extensive areas of native forest. Ongoing widespread 'Ōhi'a mortality will transform formerly native dominated forests into those dominated by invasive alien plant species. It is imperative to follow proper sanitation and containment measures in order to slow the spread of Ceratocystis-caused 'Ōhi'a mortality across Hawaii Island and to keep it from establishing on other Hawaiian Islands where it is not currently found.

**Defining invasiveness and invasibility in ecological networks with trait-mediated interactions**

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The success and failure of a biological invasion is context based, and yet two key concepts – the invasiveness of species and the invasibility of recipient ecosystems - are often defined and considered separately. Here, borrowing the concept of fitness landscape from evolutionary ecology, we propose a framework that can elucidate the complex relationship between invasibility and invasiveness. It is based on trait-mediated interactions between species and depicts the response of an ecological network to the intrusion of an alien species. Here, invasiveness of an introduced species with a particular trait is measured by its per capita population growth rate when the initial propagule size of the introduced species is trivial. The invasibility of the recipient habitat or ecosystem is dependent on the structure of resident ecological network and is defined as the total width of opportunity niche in the trait space susceptible to invasion. Invasibility is thus a measure of network (evolutionary) instability. We also correlate invasibility with the asymptotic instability of resident ecological network, measured by the leading eigenvalue of the interaction matrix that depicts trait-based interaction intensity multiplied by encounter rate (a pairwise product of propagule sizes of all members of a community). We further examine the relationship between invasibility and network architecture, including network connectance, nestedness and modularity. We exemplify this framework with a food-web model under perturbations in ways to emulate fluctuating resources and random trait composition in ecological networks. The maximum invasiveness of a potential invader was found to be positively correlated with invasibility of the recipient ecological network, and ecosystems with high network modularity and high ecological stability tend to exhibit high invasibility (i.e., low evolutionary stability). In cases when quantitative data are lacking we propose using a qualitative interaction matrix of the ecological network perceived by a potential invader so that the structural network stability and invasibility can be estimated from expert opinion. This approach links network structure, invasiveness and invasibility in the context of trait-mediated interactions, such as the invasion of insects and plants into mutualistic and antagonistic networks.

**Making an impact: what do we really know about the ecological consequences of alien plant invasions**

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Considerable interest and momentum has gathered to better understand the environmental impacts of alien plants. Quantitative assessments of alien plant impacts are essential to inform management to ensure resources are prioritised against the most problematic species. Yet at the same time, the importance of alien plants in diminishing conservation outcomes is increasingly being questioned.  Such concerns include the proposition that alien plants are no better or worse than widespread native species, their effects are often localised and that, far from leading to species extinctions, alien plants likely increase species richness. Plant invasion ecologists need to mindful of these criticisms and address them in the approaches to quantify impacts in order to better inform conservation strategies. Here, I use recent critiques of invasion ecology to sketch out a more refined quantitative approach to address criticism and provide conservation benefits.  I ask whether we need to have a more robust conservation rationale for our research in terms of the species and ecosystems investigated; if our current methodological approaches, often based on correlative studies, are sufficient to present convincing evidence of impacts, and if the metrics we choose to examine impacts provide adequate guidance for species management.  The evidence suggests that there is substantial scope to improve our quantitative knowledge of alien plant species impacts on threatened species and protected ecosystems, to adopt methodologies where we might distinguish situations where alien plants are drivers rather than passengers of ecosystem change, and better incorporate such information into improved management of alien and threatened species.

**Intercontinental exchanges of weeds determined by habitat residence time and native richness**

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Biological invasions are a global phenomenon but the exchange of species among regions is rarely symmetric.  Why some regions act primarily as donors while others act as net recipients is frequently attributed to the global expansion of colonial powers.  Evidence supporting such an assertion is scant and requires analyses that carefully match the donor and recipient habitats at a global scale. Wheat is widely cultivated and its anthropogenic habitat has been colonised by a wide range of native and alien weeds.  Understanding the global exchange of weed floras in this ecosystem presents a unique opportunity to understand the pathways of weed invasion.
We present results drawn from a database describing the status (native or alien) of 2,000 weed species found in wheat fields in 44 countries worldwide.  We analysed the current distribution of weeds in relation to their native donor regions and the recipient regions where they are alien.  The number of native weeds recorded in each country was positively correlated with the harvested area and the historical length of wheat cultivation. Strong one-way alien weed introductions, both in number and proportion, were observed from regions with a long history of wheat cultivation (i.e. Old World) to regions where wheat cultivation is relatively recent (i.e. New World). We also found regions that had a rich native weed flora received fewer alien weeds.
The development of arable agriculture following colonial expansion brought with it an associated alien flora but the magnitude of alien invasion reflects the length of time that wheat has been cultivated and the size of the native pool of potential invaders. The longer that wheat field habitat has existed, the more native species have adapted to that habitat. These native species may impose biological resistance to invasion, while invading regions with a shorter history of wheat habitat.

*Cinchona pubescens* **invasion increases soil phosphorus in the Galapagos Islands**

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Nutrient availability affects plant distribution and abundance, and invasive species can alter, and capitalize on the alteration of, soil nutrient status. Most work on the relationship between invasives and soil nutrients has focused on nitrogen (N), particularly N-fixing species invading on N poor substrates. The potential impacts of invasive species on the supply of phosphorous (P) have received less attention, despite the role of P in limiting many biogeochemical processes in tropical soils.
We assessed the effects of the invasive quinine tree, *Cinchona pubescens* Vahl, on soil nutrients in the highlands of Santa Cruz Island, Galápagos. Nutrient analyses were carried out on soil, leaf litter and resin bags buried in the soil underneath Cinchona trees and 10 m away, as well as on leaf samples from Cinchona and dominant native species. Surprisingly, the P concentration and content were always significantly higher in senescent compared to green (mature) Cinchona leaves, opposite what is typically found in senescing leaves. The P concentrations in resin and soil samples were significantly higher under Cinchona trees than in surrounding areas, indicating that the high P in senescent Cinchona leaves was transmitted to adjacent soils through decomposition.

Our findings stimulate further research questions: (i) Does the invasion-mediated increase in soil P translate to negative impacts on the native flora, which is adapted to P-poor soils, and at the same time facilitates introduced species which typically stem from nutrient-rich soils? (ii) By which mechanisms does the invasive tree manage to take up high amounts of P in generally P-limited volcanic soils? Possible explanations include its association with mycorrhizal fungi and carboxylate exudation. To our knowledge, this is the first example of an invasive plant species increasing P concentrations in the soil and indicates a novel pathway of invasion-modulated P cycling.

**The invasive *Lupinus polyphyllus* and pollination in natives – effects mediated through pollinator behavior and changes in pollinator population sizes**

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A comprehensive understanding of how invasive plants affects natives requires identification of both the mechanisms of interaction and the spatial scale over which they act. Indirect interactions involving mobile organisms such as pollinators are likely to be scale-dependent, but despite this many studies have used a single distance when examining effects of invasive plants on native pollination. Moreover, most attention has been paid to pollinator behaviour during the flowering period of the invasive, and it remains fairly unexplored whether the sometimes abundant resources provided by the invasive affects pollinator population sizes and thereby pollination of natives flowering later in the season.

We examined effects of the invasive *Lupinus polyphyllus* on native pollination in two field studies using potted native plants. First we monitored visitation and seed production in natives at 0, 5 and 200 m from experimentally created populations of Lupinus. Second, we investigated effects on pollinator population sizes and pollination in a native using a before-after design with control areas. We monitored wild bee abundance, visit rate and native seed production in invaded and uninvaded sites, before and after the flowering period of Lupinus.

Pollinator visits to natives was highest in close vicinity to the invasive, and facilitation occurred at a very local spatial scale as effects dropped off already at a distance of 5 m. Both bumble¬bee abundance and visit rate increased manifold in the invaded sites over season but not in the un-invaded sites. Presence of Lupinus could thus benefit both pollinators and pollination of native herbs, both through effects on pollinator behaviour and effects on pollinator population sizes. However, the total impact of an invasive species on native plant pollination is complex and difficult to predict, and future studies should include effects on the total pollinator community, both during and after the flowering of the invasive.

**Biological control of weeds in Pacific island forests**

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Our Forest Service team focuses on development of natural enemies for long term suppression of invasive plants in forests of the Hawaiian Islands and elsewhere across the Pacific. Here we summarize the current status of biological control projects targeting some of the most disruptive weeds in Pacific ecosystems: *Psidium cattleianum* (strawberry guava), *Miconia calvescens*, and *Falcataria moluccana* (albizia). We are collaborating with forest managers in Hawaii to monitor efficacy of *Tectococcus ovatus*, a leaf-galling insect from the Brazilian native range of strawberry guava, initially established in 2012 and now increasing gradually at sites on four islands. Our goals are to slow the spread of strawberry guava in native forests and develop strategies for combining the biocontrol with other approaches for restoration of degraded areas. From explorations in Costa Rica and Brazil, several potential agents for biocontrol of miconia have been identified and are being evaluated for host specificity. Our strategy for miconia is to develop a suite of biocontrol agents attacking stems, leaves and fruits, selecting the most damaging among available host-specific herbivores. We have just begun exploring for natural enemies of albizia, which as a fast growing N-fixer has a long history of commercial use, but also threatens ecosystems and infrastructure in Hawaii and other Pacific islands. In addition to conventional foreign exploration, we plan to identify potential biocontrol agents using the knowledge of commercial timber producers and agroforestry specialists within and adjacent to the native range (eastern Indonesia, New Guinea and surrounding islands). Our hope is to find a highly specialized herbivore, such as a gall-former, that can severely suppress reproduction of albizia without causing rapid mortality of immense, hazardous mature trees.

**Strategic management of cactus invasions in South Africa**

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Cactus species are among South Africa's most widespread and damaging invaders. The 34 species known to be invasive in the region cause considerable economic, social and ecological impacts. Successful management of cactus invasions requires an integrated approach based on prevention, early detection and control. However, there are three major issues that need to be addressed in South Africa to overcome the unique management challenges which cacti pose. Firstly, some invasive cactus species are valued and much-utilized as commercial crops and ornamentals. This leads to conflicts of interest and if left unregulated can undermine management efforts. Secondly, cactus invasions are often difficult to control as there is no history of control on which to base best practice; and recent changes to herbicide legislation has meant that the highly effective herbicide MSMA is no longer permitted without a new technique. Lastly, limited resources and a lack of strategic prioritisation have led to poor allocation of management efforts. In response to these and other issues, a national cactus working group was formed in 2012, comprising all major stakeholders directly involved in cactus management and policy. A national strategy for managing cacti was developed by the cactus working group, in collaboration with external stakeholders such as cactus growers and horticulturists. The aim of this strategy is to reduce the negative impacts of invasive cactus species to a level where the benefits of having cacti in the country outweigh the losses. The three key strategic objectives are outlined and the future of cactus management in South Africa is discussed.

**The future of *Solanum elaeagnifolium* Cav. (silverleaf nightshade), one of the worst alien invasive plants in the Mediterranean basin**

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*Solanum elaeagnifolium* Cav. (silverleaf nightshade, SOEL) is a prominent alien, invasive weed in many countries of the Mediterranean Basin since its introduction in the mid 20th Century. Originating from the southwestern United States and northern Mexico, it reproduces vegetatively from root fragments and sexually by seeds that disperse in hay, water or animals. The plant is poisonous to some livestock and produces toxins that might affect desirable plants including crops. Silverleaf nightshade occupies arable, pastoral, urban and sub-urban areas with a geographic range that is likely to increase under climate change. The weed has dense populations in some protected areas such as the delta of Axios river in northern Greece It is a serious threat to already fragile ecosystems in the Mediterranean regions. An extensive and deep perennial root system makes the weed extremely competitive for moisture and nutrients with many crops. Silverleaf nightshade is resistant to drought and tolerates saline conditions. Infestations are serious in dry lands, but also in irrigated croplands creating a serious threat to the Mediterranean basin where water availability is a critical issue for agriculture and people. The use of herbicides and mechanical removal are effective but uneconomical for controlling large and dense infestations. As a result, long-term and affordable options, such as biological control that can be used over large areas are required for a sustainable management. In 2013, several organizations involved in SOEL research and management throughout the Mediterranean Basin agreed to work together to develop a guidance document for managing SOEL in the region. Here we will present a part of this document as an update of the current situation of the SOEL invasion, its threats to agriculture, ecology and human welfare in this region.  We will identify the research needs, including biological control, chemical control and prevention and early detection.

**Current Research at the European Biological Control Laboratory**

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The European Biological Control Laboratory (EBCL), located near Montpellier France, with a satellite laboratory in Thessaloniki Greece, is operated by U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS) to conduct research on biological control of invasive weeds and insect pests.  Weed research targets currently include *Arundo donax* (giant reed), *Centaurea solstitialis* (yellow starthistle), *Genista monspessulana* (French broom), *Lepidium draba* (white top), *Onopordum acanthium* (Scotch thistle), *Salsola tragus* (Russian thistle), *Taeniatherum caput-medusae* (medusahead), *Tamarix* spp. (saltcedar), and *Ventenata dubia* (African wire grass). Other recent projects include *Dipsacus* spp. (teasel), *Euphorbia esula* (leafy spurge) and *Vincetoxicum* spp. (swallow-worts).  Research involves foreign exploration to discover prospective biological control agents (arthropods and pathogens), taxonomic identification, molecular genetics, plant pathology, and insect physiology and behavior to evaluate host specificity and potential efficacy.  EBCL also participates in related research on population ecology and genetics of invasive species.  Although the laboratory focuses on invasive species affecting the USA, it also participates in projects of international interest, such as *Solanum elaeagnifolium* (silverleaf nightshade), which is native to the USA, but invasive in the Mediterranean Region.

**Breaking down barriers to effective Albizia management; the Big Island's big weed problem.**

Springer Kaye1

1Big Island Invasive Species Committee, a project of the Pacific Cooperative Studies Unit of the University of Hawaii, Manoa, Hilo, HI.

Hurricane Iselle struck Hawaii Island in 2014, the third strongest storm to impact Hawaii since 1950, exhibiting heavy rain, sustained winds of 80 m.p.h., and gusts up to 110 m.p.h. Residents fled from homes in the night amid sounds universally described as exploding bombs. 30% of homes lost power, some for three weeks; an election was delayed; 19 tree trimming crews and 200 rescue workers flooded into the area; and damage estimates reached into the tens of millions. More than 90% of damage to inland homes and infrastructure was attributed to falling Albizia (*Falcataria molluccana*), a brittle, fast growing invasive tree species reaching 150 feet or more in height. A task force galvanized around mitigating future Albizia impacts in a cost effective, strategic way, and included operations managers with annual Albizia budgets of $200,000-$2 Mil (i.e. in non-hurricane years), arborists, ecologists, GIS specialists, legal advisors, and administrators. Within weeks, maps of high priority public infrastructure at risk from falling Albizia and detailed cost estimates were completed. The quick delivery was due in part to previous years' work on multi-agency Albizia control demonstration projects. A $6.8 million plan to eliminate the hazardous trees and control the spread of Albizia threatening 18 mi. (29 km) of primary electrical transmission lines and 31 mi. (50 km) of major state and county roads was put forward. The strategy involves cutting or heavily pruning hazard trees (i.e. those posing a direct threat to prioritized infrastructure), and treating non-hazard trees with cost effective herbicide applications, achieving cost savings of up to 85% compared to traditional methods. Within 6 months after the storm, the first priority project was complete, with more than 15,000 Albizia controlled. Here we present the current status of Albizia management on Hawaii Island and across the state, highlighting successful partnerships, hard lessons learned, and ongoing opportunities.

**Cheatgrass dynamics in ponderosa pine forests: insights into invasion theory from long-term data**

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Forest restoration efforts are challenged by controlling or mitigating exotic species invasion. Exotic species often directly compete with native species and can alter successional pathways and community assemblage. Ecological theory regarding mechanisms of invasion forms the basis for exotic species management, control, and mitigation. However, there is little consensus regarding these theories, which can be structured around three classes related to propagule pressure (PP), biotic processes (BP) and abiotic factors (AF). We use a unique study to examine the dynamics of cheatgrass invasion, testing the relative importance of factors related to these theoretical classes and invasion stage in interior ponderosa pine forests of Oregon, USA. Established in 1997, our study examines the influence of prescribed fire regimes on a suite of ecosystem variables. From 2002 to 2012, we measured forest understory vegetation response to a single fall and spring prescribed burn and repeat spring and fall burning. In 2012, we found both new local establishment and spread and an increase in the overall abundance of cheatgrass, although the invasion is not widespread. A single fall burn increased cheatgrass, but reburning every 5 years neither exacerbated nor mitigated this initial impact. Lower intensity spring reburning may increase cheatgrass. Factors important for explaining local fine-scale cheatgrass establishment and spread, and broader scale impact varied. Our results are consistent with suppositions by others that: 1) BR does not repel establishment and is more important later in the invasion process, and 2) PP is less important for establishment and spread with high levels of disturbance, but, it was key for explaining broader scale impact.

**Host-promiscuity but not provenance of rhizobial symbionts influences legume invasiveness in novel ranges**

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Mutualistic interactions can be important drivers of species invasions. In particular, the symbiotic relationship between legumes and nitrogen-fixing soil bacteria (i.e., rhizobia) may be influential in invasion success. Legumes, including Australian acacias, have been introduced around the world, becoming invasive, naturalized, or non-invasive in novel ranges. Our goal was to examine the acacia-rhizobia symbiosis to determine whether this mutualism plays a role in invasiveness of introduced acacias. We examined two aspects of the interaction with respect to invasiveness: 1) host promiscuity (i.e., degree of preference for specific symbiont strains) and 2) rhizobial provenance. We predicted that invasive acacias would be more promiscuous hosts than naturalized and non-invasive species, associating with a wider diversity of rhizobial strains. We also predicted that invasive acacias in their novel ranges would be associated with rhizobial symbionts from the acacias' native ranges, suggesting acacia-rhizobia co-introductions rather than development of novel associations abroad. To test acacia host-promiscuity we grew 12 Acacia species representing three categories of invasiveness (invasive, naturalized, non-invasive) with 12 rhizobial strains representing variation in symbiotic effectiveness and compared plant growth performance among invasive groups. We found invasive acacias had a greater growth response than naturalized and non-invasive acacias for six of 12 strains, indicating that host promiscuity is a likely mechanism influencing invasiveness of introduced acacias. To determine whether acacias were introduced abroad concurrently with native symbionts, we selected four species introduced to California (two invasive and two non-invasive in the region) and identified rhizobial strains associating with each species in their native and novel ranges. We found all Acacia species associated with rhizobia of Australian origin in their introduced range, indicating that concurrent acacia-rhizobia introductions have occurred for all species tested. Our results suggest that host-promiscuity, but not necessarily co-introduction of rhizobial symbionts, contributes to differential invasiveness of Acacia species introduced abroad.

**Effects of soil nutrient availability on competitive dynamics between non-native invasive and native species in Hawaiian dry forests**

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Hawaiian native ecosystems face constant pressure from nonnative, invasive plants that are often competitively superior. In a variety of ecosystems globally, evidence exists that nonnative plants typically outcompete natives under conditions of high resource availability (e.g., increased soil nutrient availability following disturbance). Therefore, one potential restoration technique for favoring native species over nonnatives could be to decrease soil nutrient availability via carbon amendments such as sawdust or sucrose. This is a particularly appealing concept in Hawaii where native species often have conservative growth strategies, but this idea has received very little attention in Hawaii. In this study, we evaluated survival, growth, and ecophysiology of three native and one nonnative, invasive species from Hawaiian dry forests in a greenhouse competition experiment. The density of plants was held constant and native species were grown by themselves and together with the invasive species in each of five soil nutrient treatments (control, high and low nutrient addition via fertilizer, and high and low nutrient reduction via carbon amendments). Preliminary results show significant differences in total biomass across all nutrient treatments for all but one of the native species, which grew slowly in all treatments. Moreover, the average relative growth rates of the invasive species was ~ 91% and ~80% higher than the native species in the high and low nutrient addition treatments, respectively. In turn, the average relative growth rates across all native species was ~26% and ~53% higher than the invasive species in the high and low nutrient reduction treatments, respectively. These results suggest that reducing soil nutrient availability may be a useful tool for restoring Hawaiian ecosystems where nutrient availability is high and invasive species are problematic.

**The PPQ Weed Risk Assessment Process**

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Plant Protection and Quarantine's (PPQ) weed risk assessment (WRA) process was created to evaluate the risk potential associated with plants that may be weedy or invasive. The tool was designed as a pre-border application for predicting invasiveness, however, it is also appropriate to use on species beginning to escape or naturalize. The WRA consists mostly of a series of yes/no questions organized into four risk elements: establishment/spread, impact, geographic, and entry potential. Score values from the first two risk elements are used in a logistic-regression model to evaluate the risk potential of the species. This model was developed and validated with 204 species with known invasive status from the United States. Analysis of a species' U.S. geographic potential is done separately so that resource managers can make decisions appropriate for their jurisdiction. Our WRA process provides three sets of results that help characterize a species' risk profile. The first is the species' risk scores, probabilities of invasiveness, and model conclusion. The second is the results from the uncertainty analysis that evaluates the sensitivity of the risk scores and model outcome to uncertainty. Finally, we also report where in the United States the species is likely to establish based on a simple climate matching model. Since we developed our WRA process, we have evaluated about 100 species. A few examples of some recent assessments are highlighted in the presentation.

**Some Recent Weed Risk Assessments Completed by Plant Protection and Quarantine**

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Weed Risk Assessment (WRA) is an important component of government regulatory programs that seek to prevent the entry and spread of weeds and invasive plants. Since Plant Protection and Quarantine developed its WRA model in 2010, we have evaluated the risk of about 100 plant species. These assessments were initiated for various reasons including: market access requests, new species detections, and emerging invaders. In this paper we report the results from ten recent assessments. *Oxalis hispidula* was recently detected along roadways in Alabama and represents the first report of this species outside its native range. Based on the available evidence it presents a low risk potential. *Rotala wallichii* is a low risk aquatic plant proposed for U.S. import. *Cryptocoryne beckettii* is another aquatic plant proposed for import but it poses a higher risk due to some evidence of invasiveness from a Texas river. *Triplaris melaenodendron* was recently detected in southern Florida and is the first known instance of this species outside of its native range. Due to high uncertainty associated with the WRA and a moderate risk potential, this species should be studied further. *Colophospermum mopane* was evaluated due to concern about its risk potential, and although it is sometimes problematic in its native range, it ranked as low risk because it has not yet naturalized beyond southern Africa. *Achyranthes japonica*, *Dittrichia graveolens*, *Geranium lucidum*, and *Nymphoides cristata* were first reported as naturalized for the U.S. between the 1970s and 1990s. These species have been rapidly spreading since and all present a high risk potential. *Ficaria verna*, a high risk species, has been in the U.S. since at least 1867 and has been problematic in the northeast. However, in the last two decades it has begun to spread to other states in the southern and western U.S.

**Effects of isolation on damage by above- and below- ground enemies of an invasive thistle**

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It often is suggested that geographically marginal populations of plants should experience less damage from their enemies than more central populations, while at a local scale spatially isolated populations should experience less damage than non-isolated populations. Here, we report results from studies of an invasive species, Canada thistle (*Cirsium arvense*). We examined the effects of local population isolation by measuring insect damage in experimental populations over short (100m) transects, and compared these with geographic trends over a 700 km transect from agricultural southern to boreal northern Ontario. As well, we investigated soil feedback using inocula sampled from both local (inside/outside populations) and geographic scales.

At a local scale, experimental plants separated from source populations by only tens of metres initially exhibited reduced levels of insect damage, indicating that very small scale isolation confers at least a temporary advantage. Similarly, plants grown in soils inoculated with samples from outside thistle populations performed better than plants inoculated with soil from inhabited areas only a few metres away. At a geographic scale, sampling indicated a strong decline in leaf damage with latitude, while stem galls were present only at southern sites. Seed damage varied irregularly, reflecting the presence of one pre-dispersal seed predator primarily at southern sites, and another mostly at northern locations. Plants inoculated with soils from the northern end of the range outperformed those inoculated with southern soils.

These results indicate that *C. arvense* often escapes natural enemies in isolated populations both at local scales and near its range limits, potentially benefiting colonizing populations. Mechanisms underlying escape at local scales likely differ from those operating at geographic scales; study of the life histories of natural enemies may provide valuable insights into the causes of these patterns.

**Alien species classification according to impact magnitude: filling the gaps**

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Alien species can cause a broad range of changes to the recipient environment. Classifying alien species according to the magnitude of impact caused can inform management decisions and aid the protection of native biodiversity. A generic impact scoring system which enables to compare highly diverse impact metrics between taxa has been developed for this purpose. It includes impacts caused through various mechanisms, ranging in intensity from Minimal to Massive depending on the level of organisation affected in the recipient environment (individuals, populations, communities, ecosystems). The classification of aliens according to this system relies on primary data collected on the focal species in the field. We reviewed different strategies, including specific experimental approaches and observational methods, for detecting and quantifying the ecological impacts of alien species. Our synthesis points out that different experimental methodologies are appropriate for different taxa due to particular properties of the species and ecosystems involved, even though most methods are theoretically possible for most organismal groups. Our recommendations to conduct experiments on impact include a four-way-plot experimental design (uninvaded, invaded, removal of natives, removal of aliens) – not only to reveal ecological and potentially irreversible impacts, but also to determine the potential success of restoration efforts. Furthermore, we identify hypothesis-driven parameters that should be measured at invaded sites to maximize insights into the nature of impact. Our recommendations aim to provide a basis for developing systematic quantitative measurements to allow comparisons of impact across alien species, sites and time, and to maximise the usefulness and outcomes of impact studies, also with regards to a generic classification system for alien species.

**Indirect interactions among environmental and agricultural weeds: shared herbivores complicate pest management and development of biological control**

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Plants in the mustard family (Brassicaceae) are among the most noxious and widespread weeds in ecosystems worldwide. Many species are alternate hosts for agricultural insect pests and serve as reservoirs, facilitating pest outbreaks at local and regional scales. Invasion by these weeds and insects can complicate pest management programs, as well as biological control development for invasive mustards in regions where economically important or native mustard species co-occur. The Hemipteran herbivore, *Bagrada hilaris* (Bagrada bug), is a recent introduction to North America that feeds on Brassicaceae weeds in riparian areas adjacent to agricultural fields where cole crops are routinely grown. Insect populations can persist in large numbers on weeds throughout the year and quickly colonize newly planted agricultural fields, reaching outbreak levels in only a few days. Several weeds, including *Lepidium latifolium* (perennial pepperweed) and *Brassica tournefortii* (Sarah mustard), are biological control targets, and although herbivory by *B. hilaris* appears to have a substantial impact on their growth, the numerical response of *B. hilaris* on weeds in natural areas may pose a significant challenge to effectively managing pest populations in crops. However, the accidental introduction of this insect provides the opportunity to examine plant–insect interactions with important implications for development of biologically-based control methods for weeds.


**Status of aquatic weeds associated with biological control agents in the southern Mozambique Rivers**

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The release of biological control agents has reduced the problems caused by many invasive weeds throughout Africa. In Mozambique, the first biological control agents released on the aquatic weeds were, *Neochetina eichhorniae* and *Neochetina bruchi* to control water hyacinth. Other biological control agents on aquatic weeds, including *Stenopelmus rufinasus* on *Azolla filiculoides*, *Neohydronomus affinis* on *Pistia stratioides*, and *Cyrtobagous salviniae* on *Salvinia molesta*, were also found but nothing is known of their establishment and impact. The aim of this study was to identify the biological control agents associated with water hyacinth, water lettuce, salvinia and red water fern and to evaluate the impact of the biological control agents on the weeds in southern Mozambique rivers. At six rivers, samples were taken once each in dry season, and in wet season to measure the damage caused by the biological control agents. It was observed that two arthropods fed on water-hyacinth plants, namely *Neochetina eichhorniae* and *N. bruchi*, and they varied from site to site, the number of weevils per plant showed that the number of weevils was different in different rivers but those numbers did not show significant seasonal differences. Surveys also showed that the weevil *Neohydronomus affinis* was found in the studied rivers but at a very low density, too low to effectively control *Pistia stratiotes*; It was very difficult to find *Stenopelnus rufinasus* on Azolla  and no *Cyrtobagous salviniae* was found on *S. molesta* along the studied rivers. This study serves as a baseline of biological control of aquatic weeds in southern Mozambique rivers and should be added to over time. It is recommended that the number of biological control agents for these weeds be increased and monitored further.

**Spatial pattern and Chl fluorescence of the invasive tree *Spathodea campanulata* on the island of Tahiti (French Polynesia)**

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The invasive tree *Spathodea campanulata* P. Beauv. (Bignoniaceae) was introduced on the island of Tahiti (Society Islands, French Polynesia) in 1932 as an ornamental species, and it now covers at least 1,141 ha, mainly on the leeward coast of Tahiti. Little quantitative information is available about the abiotic factors that influence the spatial pattern of Spathodea at middle-high elevation in a non-native range, whereas it has been listed as one of the world's worst invasive alien species (ISSG, 2013). In this study, we examined Spathodea abundance and Chl fluorescence in relation to slope steepness and micro-climate along an elevational transect of 140-1,301 m a.s.l. on the island of Tahiti. Our objective was to identify preferred habitats and suitable environmental conditions for Spathodea establishment at middle-high elevation. Major invasion of Spathodea on the island of Tahiti is currently reported on the leeward (drier) coast, mainly on the slopes of the northwestern valleys found above the urban area of Papeete. The most invaded valleys are also the ones where Spathodea has had a longer time to spread from cities and home gardens, suggesting a signal of introduction history. More recently, Spathodea has also been found on the slopes of the windward coast of Tahiti, but it is currently scattered in distribution. Chl fluorescence measurements indicated high photosynthetic capacity among Spathodea in wet environments on the windward coast, and the scattered plants there appeared to be thriving. We expect Spathodea will become an abundant invader of the wet windward coast of Tahiti.

**Applying a geographically differentiated approach to the management of invasive plant species in South Africa**

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Invasions of alien plants are recognized as a major threat to biodiversity, water resources and land productivity in South Africa. The Working for Water program was established in 1995 to manage invasive alien plants and has recently extended its mandate to cover all invasive species and to expand its scope to include prevention, eradication, containment and control (mitigation and/or suppression, also called asset Protection). The program has traditionally focused on clearing areas of land and all the species in them. The new regulations on invasive species require species management programs (SMPs) to be developed for all major species which requires understanding of pathways - sources, routes, vectors (carriers or dispersal agents) and destinations. The actions focus on early detection, eradication and containment. Guidelines for geographically differentiated approach to SMPs were developed using the aggressive and rapidly spreading Pompom weed (*Campuloclinium macrocephalum*). Using this approach we were able to define a set of zones based on its current and potential distribution and its abundance within different local authorities. Provided that sufficient resources can be made available for effective control, particularly in the eradication and containment zones (which should be given a high priority), then the approach should lead to a significant reduction in the current rate of expansion of Pompom weed. In combination with biological control, which is looking promising, it is possible to contain this species and even eradicate it in some areas of the country.

**Environmental heterogeneity causes divergence, but not cross-generational carryover, of epigenetically regulated gene expression in a clonal grass.**

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Phenotypic plasticity is often regarded as advantageous for the successful establishment and spread of alien plants. Using whole transcriptome sequence data, we investigated phenotypic plasticity by comparing genome-wide levels of epigenetically-regulated gene expression between populations at two extremes along an environmental gradient. We sampled invasive populations of genetically clonal fountain grass, *Pennisetum setaceum*, from areas characterized by semi desert- (S-D) and Mediterranean-type (M-T) climate in South Africa. To assess whether observed differences in gene expression between field populations are carried over to future generations, we also compared expression levels of field-collected individuals to their apomictic offspring grown under common garden conditions.
Fountain grass individuals from S-D regions significantly over-expressed 91 gene regions relative to M-T individuals. Highly elevated levels of gene expression in the S-D population, i.e. showing at least a 10 to 60-fold difference in expression, was observed for genes encoding proteins involved in drought response, heat stress and, in one instance, pathogen defense. Highest expression-level differences were observed for heat shock proteins and other stress-related proteins (e.g. peptidylprolyl isomerase and peptidase). Within the M-T population we found 97 gene regions with significantly higher levels of expression with many corresponding to those involved in herbivore and pathogen defense mechanisms and responses to wounding (e.g. mandelonitrile lyase and cytochrome P450 family proteins). A few over-expressed genes in M-T individuals relative to S-D individuals were related to growth regulation (e.g. MDR-like ABC transporter proteins) and abiotic stress (low soluble phosphate levels).
Interestingly, all genes differentially expressed in S-D and M-T populations appear to have similar expression levels among their apomictic offspring grown a common garden environment. Our results indicate that abiotic factors like temperature and rainfall are likely causing elevated gene expression levels in S-D individuals whereas biotic interactions (herbivores and pathogens) are mainly responsible for unique and elevated gene expression levels in M-T individuals. In the absence of these environmental stimuli expression levels for these genes converge, indicating rapid epigenetic rewiring without cross-generational carryover.

**Quantifying Outcomes Containing *Miconia calvescens* DC in the East Maui Watershed through the Adoption of Herbicide Ballistic Technology**

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The basic concept of Herbicide Ballistic Technology (HBT) is long-range, pneumatic delivery of 0.68 caliber herbicide-filled capsules (i.e., paintball encapsulating 200 mg triclopyr), directly to target. Miconia is a priority species of the Maui Invasive Species Committee with a 25-year management legacy across the 55,000 ha East Maui Watershed. Starting in 2012, The HBT platform became the primary utility in helicopter surveillance operations focused on an accelerated intervention schedule targeting high-value incipient miconia populations occupying the most extreme boundaries of the invasion front. In three years of operations, we have conducted 75 missions, approaching 400 hours of operational flight time (OFT), treating over 13,000 high-value, incipient miconia targets, covering a total net area >6900 ha (e.g., >17,000 acres). The basic unit of measure in this project is target density, which serves as an absolute value of progress, but also serves as a direct influence on operational efficiency values. According to the best fit exponential decay function, target densities encountered are reducing at a rate of 0.7% per hr OFT. Thus, search efficiency and herbicide use rates are improving with lower target densities. Variable costs of operation, by definition, correlate to production volume, which in this study, is directly proportional to target densities encountered and also show a negative exponential cost reduction over time that is highly congruent to target density reduction. In 2014, the average variable cost of operations was $21.20 USD per ha. The deployment of HBT with an accelerated intervention schedule is demonstrating strategic progress with metrics in target density reduction, protected area expansion and cost optimization. Consistency of a high-frequency intervention strategy has accommodated strong mathematical fits of the empirical data, which allows for critical assessments of projected future outcomes and establishes an institutional need for HBT in natural area weed control.

**Meta-analysis of invasive species impacts on nitrogen cycling, revisited**

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Exotic plant species can have important biogeochemical consequences on invaded ecosystems by altering litter inputs, the timing and location of nitrogen (N) released from decomposing organic matter, and by modifying N outputs. However, the results of an invasion event are often contingent upon characteristics of the invading species and characteristics the invaded ecosystem. We used a meta-analytical approach to (a) determine whether current literature supports the conclusion that exotic invasions tend to promote soil N availability (Liao et al. 2007), and (b) investigate the role of species traits, and ecosystem characteristics as potential drivers of what appears to be a widespread pattern.

Based on 164 publications, 82 of which were published after the Liao et al 2007 report, we found evidence to support the widespread pattern that invasive species are associated with increased inorganic N pools, increased mineralization rates, and total soil N. We also found evidence that some invasive species traits mediate some aspects of invader impacts on N cycling; for example, the magnitude that an invasion impacted ammonification rates increased with increasing invasive species litter N concentrations. Not all invader traits, however, are useful for explaining variation in invader impacts on N cycling. The idea that ecosystem characteristics drive variation in invader impacts on N cycling was also supported by some, but not all, ecosystem characteristics. Notably, native community-weighted mean plant tissue carbon-to-nitrogen ratio explained variation in invader impacts on nitrification and mineralization rates. Furthering this research will contribute to our ability to predict and plan for the impact of plant invasions on nutrient cycling in many contexts.

**Buried Alive: Assessing Soil Seed Bank Persistence to Assist in Invasive Plant Eradication**

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Understanding the seed biology of invasive plant species can assist managers in achieving eradication, particularly as it applies to scheduling treatment intervals (in conjunction with plant phenology) and monitoring for recruitment following removal of all above ground vegetation. Knowledge of how long seeds remain viable when in the ground, or their soil seed bank potential, is critical to defining eradication for a taxon. Some plant species form a transient seed bank, where seeds remain alive in the ground for up to 1-1.5 years. These seeds die if not exposed to germination conditions (light, moisture) within this time period. Other species have seeds that remain viable when buried for longer periods of time and can form short-term (less than 5 years) or long-term (greater than 5 years) persistent soil seed banks. To classify soil seed bank types for invasive species, over the last ten years, the Oʻahu Army Natural Resources Program (OANRP) collected mature fruit from nine invasive species that were either established or incipient to management areas. Fruits were cleaned and seeds were placed into durable bags and buried at depths of at least six inches and close to existing infestations of each taxon. Bags were retrieved at regular intervals over a five-year period and seeds were sown to assess viability at each interval. As a result, taxa were classified as having transient, short-term persistent, or long-term persistent soil seed banks. This information will assist in developing control strategies and determining eradicability, on a species and site level.

**Look and you will Find: Targeted Surveys Provide Opportunities to Assess Threats to Managed Areas**

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Surveys can be the first line of defense in detecting invasive plant species. Effort spent searching targeted areas can provide numerous novel specimens that can be assessed for management action. The Oahu Army Natural Resources Program (OANRP) uses inventory surveys to identify potential new threats to endangered species Management Units (MU) and to detect and prevent the spread of weeds on Army Training Ranges. These inventories area a low-tech method of detection and have provided valuable results. Each year OANRP surveys approximately 315 km along Army Training Range and MU access roads, 50 landing zones, 7 high-use field sites (such as campsites), and along 13 highly trafficked trails. With identification assistance from the Bishop Museum and the Oahu Early Detection program, OANRP has documented new island records for Oʻahu (30), new State of Hawaii records (9), and new records of naturalizing taxa (13) since 2004. Not all new species result in management actions, but early detection provides the opportunity to decide if a particular taxon requires management before it is a significant threat to resources in managed areas. The threats posed by new finds are assessed with the use of Hawaii Weed Risk Assessment program, collection and naturalization data from Bishop Museum and the Smithsonian website, "Flora of the Hawaiian Islands" http://botany.si.edu/pacificislandbiodiversity/hawaiianflora/intro.htm, and field expert knowledge. New taxa are assessed with a flow chart with the following output: target for eradication (island incipient), target for eradication in defined area (local incipient), monitor (map and refer to in instances of new detections), control in high value areas, and no control. Examples of new detections that have triggered major control efforts include: *Chromolaena odorata, Schizachrium condensatum, Cetaria setaceum, Senecio madagascariensis*.

**Soil disturbance rather than plant community composition triggers invasion of *Bromus tectorum* in sagebrush rangelands**

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The grass *Bromus tectorum* has invaded millions of hectares in western North America and has transformed former perennial grass and shrub-dominated communities into annual grasslands. It is well know that disturbance plays a key role in *B. tectorum* invasion and persistence on the landscape, but the critical type of disturbance that triggers invasion is less well understood. We conducted an experiment in a perennial shrub/grass/forb community in eastern Idaho, USA to examine the roles of plant community and soil disturbance on *B. tectorum* emergence and establishment. Our experiment consisted of a plant community disturbance treatment where we (1) removed the shrub component, (2) removed the grass/forb component, or (3) removed all shrubs, grasses, and forbs. We followed this treatment with seeding of *B. tectorum* onto the soil surface that was (1) intact, or (2) disturbed. Each experimental plot had an associated control with no plant community disturbance but was seeded in the same manner. The experiment was replicated 20 times in two sites (high and low aboveground biomass). We measured emergence by counting seedlings in late spring and establishment by counting, removing, and weighing *B. tectorum* individuals in mid-summer. We also examined the influence of plant community disturbance on soil environment by measuring extractable $NH_4+$ and $NO_3-$ four times each summer. Plant community disturbance did not influence emergence or establishment of *B. tectorum*, but more individuals emerged and established following soil disturbance. Plant community disturbance, however, influenced biomass of *B. tectorum* and soil N in the late growing season. We conclude that soil disturbance is important for initial establishment of *B. tectorum*, but plant community disturbance is important for subsequent growth.

**Invasive *Bromus tectorum* alters natural selection in arid systems; natives respond**

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The invasion of the annual grass *Bromus tectorum* in the Intermountain West of is one of the most extensive ongoing land conversions in North America. Present in millions of hectares of land in the west, this invader can replace native plant communities, growing in near monocultures after repeated fire and other disturbances. The ubiquity of this invader means that a majority of native species will encounter competition from *B. tectorum* at some point in their life, and the impact is most strong at the seedling stage, when native species are typically outcompeted by this fast growing annual. In my lab, we have asked to what degree this competition changes selective regimes, and asked whether native species have the capacity to evolve in response to this strong and new selective pressure. Focusing on seedling establishment in native perennial grasses, including *Elymus elymoides, E. multisetus,* and *Poa secunda,* we have found evidence for divergent selection in invaded and intact sagebrush systems. In invaded systems, surviving plants have early phenology, greater root investment, and changes in root morphology, relative to plants that survive in invaded systems. Additionally, we have found evidence that some invaded populations may be evolving in response to the presence of *B. tectorum.* Understanding traits that improve seedling establishment can improve restoration in these systems, as well as our understanding of how invasions affect the trajectory of natural populations.

**Fire does not promote cheatgrass invasion in the northern sagebrush steppe of Montana, USA.**

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Exotic plants can interact with their environment through positive feedback cycles to perpetuate themselves. *Bromus tectorum* (cheatgrass) in much of the Intermountain West of the USA is reported to have a positive feedback cycle with fire. Where *B. tectorum* is present fuel loads are increased, which then increases fire frequency. This is detrimental to native species, but it benefits *B. tectorum* in terms of both abundance and spread. We investigated the effects of one natural fire and one prescribed burn in the sagebrush steppe of Montana, USA on *B. tectorum* populations and the native plant communities. Response to fire was similar at both sites. One year after the fires, there were minimal differences in *B. tectorum* cover between burned and unburned plots, with fire increasing *B. tectorum* cover from 3% to 5%. Two years post-fire, *B. tectorum* increased to 8%. During the natural fire, a fire break was installed to contain the fire. Two years-post fire, *B. tectorum* cover along the fire break was more than 300% greater than in the burned or unburned areas. Fire resulted in minimal plant species shifts, with annual and non-native species each increasing by up to 5% cover. Principal coordinates analysis suggests that plant communities in the burned areas are becoming more similar to the unburned communities over time. However, the fire break plant community is on a different trajectory, becoming even less similar to the unburned communities. Our data do not support the idea that fire promotes *B. tectorum* dominance. Furthermore, data show that the soil disturbance due to fire containment has a much greater negative impact on the plant community than fire does, and is therefore not recommended as a management tool if the goal is to limit *B. tectorum* spread and dominance.

**Will alien plants be advantaged in a high CO2 world?**

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Atmospheric CO2 concentrations have been rising steadily since the Industrial Revolution and this increase is predicted to continue under a range of emission scenarios. Previous studies have suggested that alien invasive plant species are likely to be more responsive to elevated CO2 than native species as they have traits enabling rapid growth when resources are not limiting. This may result in a shift to more alien-dominated vegetation under future CO2 conditions. We have conducted a range of mesocosm experiments using mixed species assemblages to assess the effect of elevated CO2 on (1) competitive interactions between alien and native species, (2) resprouting responses after fire of native and alien species, (3) drought responses of native and alien species, and (4) invasion success of alien plant species after disturbance. Our results suggest that elevated CO2 can shift the balance of plant assemblages towards greater abundance of alien invasive species, but this is strongly dependent on the response of key species and on environmental conditions, with availability of resources such as soil water likely to be critical.

**From biological control agent to invasive species: An approach to risk assessment using *Cryptolaemus montrouzieri* as a model species**

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Introduction of exotic natural enemies for pest control is an important part of biological control programs. However, some introduced biological control agents can spread uncontrollably and bring great threats to the local environment and biodiversity. Thus,  risk assessment of these introduced species is urgently needed. *Cryptolaemus montrouzieri* Mulsant (Coleoptera, Coccinellidae) is native to Australia, and has been introduced worldwide  as a biological control agent due to its ability to control mealybugs. However, its environmental risk as an introduced agent has not been evaluated, and its genetic pattern of local adaptation is still unclear. We use *C.  montrouzieri*  as case study. Using population genetics methods, the mechanism of local adaptation of the introduced *C. montrouzieri* will be explored, and its history of evolution will be traced. Also, its ability to undergo host shifts and disperse will be assessed in order to  evaluate its potential influence on local environments and biodiversity. Our research will provide a general theoretical framework for better use of the introduced biological control agents.

**Plant diversity, soil biota and resistance to exotic invasion**

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High species richness has been proposed to increase productivity and resistance of  plant communities to exotic invasions through complementarity and selection effects, which are based on interspecific plant-plant interactions.  Recent evidence suggests a different mechanistic paradigm for the relationship between plant diversity and productivity– that productivity at low diversity can be suppressed by soil biota.  Thus, it is reasonable to assume that soil biota may also play a role in shaping the relationship between  plant diversity and resistance to invasion.  We tested this hypothesis though a plant-soil feedback experiment using the soil from native assemblages.  Ten native grassland species were used to create plant assemblages with either one species (monocultures) or ten species (polycultures) in a common garden at Fort Missoula, Montana, USA.  Soils cultured by these assemblages were collected and either sterilized or not to examine the combined effects of species richness and soil biota on the growth and competitive ability of the ten native species against the invader *Bromus tectorum* in a greenhouse.  According to our results, live soil from monocultures inhibited the growth of all native species as a group and native grasses as a functional group more than live soil from polycultures.  Sterilization eliminated the negative effects of soil from monocultures but not from polycultures.  Native species, especially native forbs, also competed with *B. tectorum* more successfully in live soil from polycultures than live soil from monocultures, and sterilization eliminated the competitive advantage of natives in live polyculture soil.  Our results suggest a mechanism by which species diversity might provide resistance to exotic invasion.

**Parallel evolution in an invasive plant: effect of herbivores on competitive ability and regrowth of J*acobaea vulgaris***

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A shift in composition of the herbivore guild, due to the absence of specialist herbivores, in an invasive plant's range, is expected to select for invasive plants with increased growth ability and a lower regrowth capacity, as invaders are expected to invest less in costly defenses against specialist herbivores and less in cheap defenses against generalist herbivores as predicted by the Shifting Defense Hypothesis. Here we studied the competitive ability and a defense strategy against specialist herbivores, regrowth, of invasive and native *Jacobaea vulgaris* in response to intra-specific competition with three treatments: herbivory by a specialist (*Tyria jacobaeae*), herbivory by a generalist (*Mamestra brassicae*) and no herbivory control. Invasive plant genotypes were compared from three geographically distinct invasive regions that differed significantly in climatic conditions. We examined herbivore preference, competitive ability and regrowth ability of each plant genotype and our results show that invasive genotypes have a higher competitive ability than native genotypes without herbivores. For the two herbivore treatments, since the invasive genotypes were more resistant to the generalist *Mamestra brassicae* and more susceptible to the specialist *Tyria jacobaeae*, their competitive ability was significantly increased by the first and reduced by the latter. Invasive genotypes also showed a lower regrowth ability in both herbivore treatments. Furthermore, we found all the studied traits measured in the invasive *J. vulgaris* genotypes from three geographically and climatically distinct regions changed consistently with the same magnitude and direction for all the treatments. It suggests that a shift in herbivore guilds (the absence of specialists) in the invasive ranges has been an important factor driving parallel evolution in competitive ability, investment in defense and regrowth ability in invasive populations of *Jacobaea vulgaris.*

**Parallel evolution in an invasive plant: Shifting from tolerance to growth and chemical defense in invasive *Jacobaea vulgaris***

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A shift in composition of the herbivore guild in an invasive plant's range is expected to select for invasive plants with increased growth ability and a lower regrowth capacity, as invaders are expected to invest less in defenses against herbivores. In this study we examined plant growth, the underlying growth-related traits such as specific leaf area and photosynthesis, anti-herbivore strategies such as pyrrolizidine alkaloids, and regrowth-related traits such as carbohydrate storage and root-shoot ratio in native and invasive genotypes of *Jacobaea vulgaris*. Our result showed that invasive J. vulgaris genotypes have evolved better growth performance and higher pyrrolizidine alkaloids concentration, while they invested less in regrowth ability. In addition, all the studied traits measured in the invasive *J. vulgaris* genotypes from four geographically distinct regions changed consistently in the same direction. This indicates that parallel evolution took place in the four invasive regions, which differed significantly in climatic conditions and makes it likely that the observed evolutionary changes were caused by shifts in herbivore guilds.

**Effects of the invasive vine *Vincetoxicum rossicum* on ecosystem multi-functionality**

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An emerging trend in the assessment of ecosystem functionality is the application of multi-functionality indices that integrate the simultaneous production of multiple ecosystem functions. Here, we present a synthetic approach that considers the impact of invasion on ecosystem multi-functionality in a semi-natural peri-urban ecosystem. Ontario's Rouge Park contains variable abundance of Dog-strangling vine (*Vincetoxicum rossicum*, Apocynaceae), an aggressive plant invader from Eurasia. Variable dominance of *V. rossicum* results in a diversity gradient throughout the Park. We examined how the relative abundance of *V. rossicum* affects multiple ecosystem functions and services in meadow communities throughout Rouge Park (biomass production, decomposition rates, nutrient availability, soil carbon, and pollinator diversity). We hypothesize that *V. rossicum* invasion will cause a significant reduction in ecosystem multi-functionality. Preliminary analysis shows that *V. rossicum* abundance has variable influence across the studied ecosystem functions. Across 14 study sites, the relative abundance of *V. rossicum* ranged from 3.8 ±2.1 % to 55.3 ±3.8 %. Biomass production ranged from 310.65 ±27.22 g to 1227.49 ±107.35 g per 1m2 plot but was not significantly related to *V. rossicum* abundance. We found that the decomposition rate of *V. rossicum* litter was significantly reduced with increasing *V. rossicum* abundance (r2=0.45, p <0.01), but the decomposition rate of litter from a native dominant, *Solidago* sp., showed no significant variation. We found no significant variation in total carbon or nitrogen, but inorganic nitrogen was significantly reduced with increasing *V. rossicum* abundance (r2=0.43, p <0.01). Average pollinator species richness was negatively correlated with increasing *V. rossicum* abundance, but only significant at p < 0.1 (r2=0.25). To fully assess the impact of invasion, further analysis will involve the integration of these effects into a multi-functionality index. In the context of species invasion, this will require a novel approach that considers the interaction between multiple ecosystem functions.

**Invasive Opuntioid Cacti in Western Australia**

Sandy Lloyd

Weeds Society of Western Australia

The opuntioid cacti (*Austrocylindropuntia* spp., *Cylindropuntia* spp. *Opuntia* spp except *O. ficus* indica) are Weeds of National Significance in Australia. Opuntioid cacti already infest large areas of southern and eastern Australia. In Western Australia (WA) the total area infested is relatively small; however, infestations occur from the Pilbara in the northwest to the south coast. There is great potential for opuntioid cacti to significantly increase their abundance, particularly in the southern rangelands. To date, infestations of about 20 different species of opuntioid cacti have been recorded in WA. They are still being documented but the collection and identification of specimens of weedy cacti is difficult. A project in October 2014 has contributed significantly to the knowledge of those species present and their distribution. One species, *Opuntia robusta*, has been identified as being highly suited to invade most of southern WA and is being targeted for eradication. Abandoned and unmanaged cactus gardens, unmanaged infestations and dumping of unwanted cacti are important sources of new infestations. Once established local spread by natural means is significant. A number of government agencies, NGOs and individual landholders are working together to deal with infestations but challenges still exist to achieving a coordinated approach to the management of opuntioid cacti in WA. Many infestations are in remote areas and further research is needed on control techniques. Examples of two successful projects are:
http://www.rangelandswa.com.au/733/coralling-the-coral-cactus-at-leonora
http://www.abc.net.au/news/2014-02-26/cactus-cull/5285896

A situation report was produced in 2014 but is now somewhat out of date:
https://www.agric.wa.gov.au/declared-plants/opuntioid-cacti-situation-report

New information will be available by September 2015, in time for the EMAPi meeting.

**Inquiry Based Approach to Invasive Plant Management -One Land Manager's Perspective.**

Rhonda loh

Hawaii Volcanoes National Park, National Park Service

Management of invasive plants to protect biological resources can be viewed as a series of  partially controlled manipulative experiments; often opportunistic and too site specific for scientists to generalize and seldom published in peer review journals... And yet an essential task of today's conservation-minded land manager.  Since its establishment in 1916, various attempts to conserve and protect indigenous species and habitats in Hawai'i Volcanoes National Park have been made, with particular focus on control of invasive plants and animals.  The success of these early efforts was  haphazard and seldom long-lasting.  Beginning in the 1970s, park staff adopted a systematic parkwide approach to managing species and habitats which continues today.  This includes prioritization of high valued habitats, known as Special Ecological Areas, or SEAs that are the focus of intensive weed management, reforestation, rare species reintroduction, scientific research and visitor enjoyment. Outside the SEAs, weeds with limited distributions are either eradicated or contained.  In some areas where weeds are widespread, park staff are able to refocus their efforts towards a goal of rehabilitation or partial restoration of the former habitat.  This redirect rests on the assumption that invasive plants and their impacts to the ecosystem may persist on the landscape for a long time if not indefinitely.  Common among all the strategies is an inquiry based approach that provides opportunities for scientific investigation on multiple scales (of time and space).

**Not all Invasives are Created Equal: Cogongrass (*Imperata* spp.) Invasion in the southern US and around the World**

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Considered one of the world's worst weeds and most prolific invaders, cogongrass (*Imperata cylindrica*) is unique in that it is a pest in both its exotic and native ranges. The southern United States (US), bordered by the Gulf of Mexico to the south and the Atlantic to the east, has been invaded by Imperata, resulting in significant losses in productive timberland, agriculture, and natural areas. The costs associated with Imperata invasion are extensive and well-documented. Since its introductions into the US during the early-20th century, the exotic invader now infests over a half-million hectares(5000-km2), spanning over 10 US states that comprise the majority of the region. The southern US is often considered the "woodbasket" of the nation as well as the world, with considerable forestland, timber and forest products. Recent research into the dynamics of the Imperata invasion in the US found propagule pressure to be a significant driver of this successful invasion via multiple introductions of unique, diverse parent material. Secondary spread across the region is spatially erratic and does not adhere to isolation-by-distance models; research suggested anthropogenic disturbance and dispersal facilitates additional invasions. Inter- and intraspecific hybridization events have also been posited as accelerators of this alien invader. Intraspecific hybridization has been supported by genetic studies in the US.  Furthermore, hybridization with a conspecific horticultural variety has been demonstrated and may increase the latitudinal range of this invader into cooler regions of the country. Congeneric hybridization has not yet been supported in the US, but a global phylogenetic reconstruction is underway to determine if invaders within the genus Imperata are of a single species or species complex. Few management options exist to control Imperata, much less eradicate it, and on-going research seeks to determine if differential responses to chemical treatment are genetically associated.

**Technology development to increase the efficacy of invasive propagule interceptions in the face of increasing trade volume**

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International trade increases every day.  The international movement of commodities *en masse* has an inadvertent consequence: invasive hitchhiking propagules.  Invasive hitchhikers on trans-oceanic vessels can be accidentally transported and introduced into novel environments.  This vector of invasion is well-documented in a wide range of systems (e.g., zebra mussels, Asian gypsy moth, wood-boring beetles); however, for invasive plant propagules, less data exist.  At present, USDA-APHIS-PPQ and US Customs and Border Protection (DHS) are tasked with the inspections and interceptions of invasive propagules of both imports and exports.  The primary concern for the protection of the United States' agriculture and economic viability are the interceptions of invasive propagules entering the country in a timely and accurate manner, such that the speed of trade is not hindered, while continuing the mission to adequately protect our interests.  At this time, cogongrass (*Imperata* spp.) seeds are regularly intercepted by USCBP, along with a number of other unknown plant propagules.  Our research is underway, in conjunction with USDA, USCBP, and Georgia Forestry Commission, to develop new technologies and products to assist in the rapid and accurate identification of intercepted plant propagules to increase the rate of successful interceptions, improve already implemented phytosanitary protocols, and ultimately, reduce the propagule pressure of listed, and potentially listed, Federal Noxious Weeds entering the country.  By doing so, we aim to reduce the number of active biological invasions in the USA by reducing and preventing new, or exacerbation of, invasions already present in the country.

**Return of the birds: Fynbos birds as an indicator of ecosystem recovery after alien invasive plant clearing in a riparian habitat of South Africa.**

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Invasive alien plant species pose a major threat to global biodiversity by displacing native vegetation and transforming habitats. A coupling of human activities and the dynamic nature of river systems has resulted in riparian habitats of the fynbos biome of South Africa to become highly prone to invasion by alien plants. The national invasive alien plant species program, Working for Water (WfW), has focused much of their clearing on riverine areas. WfW employs a passive restoration approach which involves removing invasive trees but leaving the land to "self repair" without initiatives such as planting native species. Consequently there is an urgent need to evaluate the recovery of native vegetation and ecosystem processes in cleared environments. We use, as a case study, the riparian habitat of the Berg River in the Western Cape of South Africa where clearing of mainly *Eucalyptus camaldulensis* has been on-going for a decade. We employ a chrono-sequence (space for time substitute) approach to assess the success of passive restoration by sampling plant and bird community abundance and species richness. Bird and plant surveys were conducted in sites cleared between 1 and 9 years ago. Invaded and native sites act as controls. Habitat characteristics such as vegetation structure, plant species composition, flowering and fruiting, surrounding land use, canopy cover and ground cover that influence bird assemblages are also assessed.  Results show that bird richness and abundance are very similar between invaded and cleared sites, but differ from native sites. Even 9 years after clearing, bird and plant communities differ from native communities. We conclude by making restoration suggestions on how actively reintroducing selected plant species could aid in restoring the full bird complement.

**Alien invasive plants species in Romania – an exhaustive review of taxonomical and ecological data**

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One of the important threats for Romanian biodiversity in the natural landscape is invasive alien plant species.  We compared the situation in European countries  (mostly from the Balkans region), presenting an exhaustive review from a taxonomic point of view. The alien plant species listed from different natural and anthropic ecosystems count more then 435 species, but the invasive status of many of them is unclear or controversial. The data from 2000 report up to 11.5% of species having an alien origin in the Romanian flora (compared with 28.6% from the European flora). The taxonomic distribution of species and families is presented. A high number of species (56 taxa) belong to the Asteraceae family. In the case of 316 species, we found and present their first mention  in the Romanian flora, and one new species is reported for the first time in the Romanian flora. Short considerations about introduction pathways, ecology, distribution and biological control are also given.

**Using Unmanned Aerial Vehicles sensors to detect flowering of an invasive plant as a proxy to assess the control efficiency of a biocontrol agent**

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Remote sensing technologies are an increasingly helpful tool for the detection and management of invasive species worldwide. Besides detecting the species per se, plant characteristics and phenology may be also explored using these technologies. *Acacia longifolia* is one of the most widespread invasive plants in the Portuguese coastal dunes, often forming extensive almost monospecific stands, but also co-occurring with pinewoods and other vegetation. This species produces a prolific long-lasting seedbank which prevents successful control and implies continuous efforts to control plant dispersion. The use of a gall-forming biocontrol agent (*Trichilogaster acaciaelongifoliae*) that significantly reduces flowering, and consequently seed formation, is currently being investigated in Portugal. The present work aimed to identify and map the distribution of *A. longifolia* in coastal areas using imagery collected with an Unmanned Aerial Vehicle (UAV). Additionally, we wanted to quantify plant flowering since flower reduction can be used as a proxy for the establishment of the biocontrol agent. The efficiency of this novel methodological approach was tested in several locations representing different land cover classes where the invasion by *A. longifolia* is commonly observed. Results showed great potential for the detection and mapping of *A. longifolia*. While flowering quantification was hindered in forests dominated by Pine trees, in habitats where A. longifolia was predominantly uncovered the quantity of flowers could be successfully estimated. This study highlights the possibility of using UAV's technology to map and quantify plant flowering and the consequent great potential of this tool to monitor the establishment of biocontrol agents that affect plant phenology.

**Using ecological networks to evaluate impacts of an invasive plant and planning biocontrol**

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In recent decades, networks have been increasingly used in Ecology, from studies exploring nature's complex web of interactions to a more applied perspective. Recently, they have started to be a valuable tool to assess the impacts of invasive species and to understand the complex interactions arising from the introduction of biocontrol agents. We used ecological networks to access the impacts of the invasive *Acacia longifolia* and as a tool to plan the introduction of a biocontrol agent for this species. *Acacia longifolia* is one of the most aggressive invasive plants in Portugal, transforming plant communities and soil functioning along coastal dunes. Extensive long-lived seedbanks accumulated in soil hamper successful control. The gall-wasp *Trichilogaster acaciaelongifoliae* prevents the production of seeds by *A. longifolia*, through formation of galls in flower buds, and has been successfully used as a biocontrol agent in South Africa. In Portugal, where the agent is not yet introduced, specificity tests did not predict interactions of this agent with non-target plants (direct non-target effects). However, the indirect non-target effects remains underexplored. For other species, indirect effects on interaction-networks after the introduction of biocontrol agents have been seldom shown; still, the invasive plants themselves have probably changed interaction-networks beforehand and this needs to be evaluated. Therefore, our first aim was to evaluate the impacts of *A. longifolia* on plant-galls interaction-networks, including gall inquilines and gall parasitoids from low, medium and highly invaded communities. Results showed that *A. longifolia* causes negative bottom-up effects and severely changes the structure of plant-gall networks, particularly by reducing species and interaction diversity, and increasing generalism and web asymmetry. These networks were then used to: 1)characterize the reference situation pre-introduction of the biocontrol agent; 2)identify native species that could potentially interact with *T. acaciaelongifoliae*, affecting biocontrol success; and 3)predict potential indirect non-target effects of the biocontrol agent pre-release.

**Using a WebMapping platform to engage volunteers to collect data on invasive plants distribution**

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Raising awareness amongst Portuguese population about biological invasions has been one of our priorities since we started working with invasive species in 2001. We´ve used different approaches to engage the public and in March 2013 a citizen science platform was launched, aiming to get public participation in the WebMapping of invasive plants in Portugal (http://invasoras.pt/mapa-de-avistamentos/). To support the WebMapping platform, a new version of the website invasoras.pt and a field guide (available both on paper and online), with species profiles to assist in the identification, were developed. Any citizen can register in the platform and report sightings, either on the website or through an App for Android devices. Data gathered is freely available both on invasoras.pt and on the GBIF database.
In order to actively engage the public in the mapping of invasive plants, the project is promoted through different media, Facebook and training workshops, targeting different groups (ENGO, schools, etc.). The outreach of this citizen science platform is being evaluated mainly considering the number of registered users and of sightings reported, but also visualizations of the map and online surveys. By April 2015, 565 users had registered in the mapping platform; 190 were active users and submitted more than 5400 sightings. The species registered more often were *Acacia* spp. (1739), *Arundo donax* (1120), *Ailanthus altissima* (322), *Cortaderia selloana* (335) and *Carpobrotus edulis* (237). The outcomes of the platform, the efficacy of each strategy used to boost the platform, and benefits and the limitations of the data collected will be discussed.

**Eradicability of *Cenchrus setaceus* infestations on Oahu Army lands**

Taylor Marsh, Jane Beachy, Julia Gustine Lee, Michelle Akamine

Oʻahu Army Natural Resources Program, Pacific Cooperative Studies Unit and USAG-HI Directorate of Public Works, Environmental Division, Schofield Barracks

Fountain grass, *Cenchrus setaceus*, is a listed State of Hawaii Noxious Weed.  It thrives in dry habitats, colonizing bare rock and peppering cliffs.  On Oahu, it is locally abundant around Diamond Head and Lanikai, but no established populations are known from the Waianae or northern Koolau Mountains.  The Oahu Army Natural Resources Program (OANRP) discovered small, isolated *C. setaceus* infestations at four military training ranges since 2000.  Extirpation of these infestations is a priority, given the high fire threat posed by *C. setaceus* to training ranges and surrounding areas.  Of nine confirmed infestations, seven likely were introduced via training activities, while the remaining two likely were introduced by recreational hikers.  All but one of the infestations have been small, less than 50 mature plants.  The largest infestation, at Makua, includes hundreds of mature plants scattered across steep ridges and cliffs.  To better direct control efforts, staff conducted a buried seed trial and discovered that *C. setaceus* seed persists less than one year.  This allowed staff to identify when an infestation could be declared extirpated and suggested that frontloading efforts is important to reaching this goal.  Staff conservatively define extirpation as three years (three times the seed longevity) of regular monitoring with no plants found.  By mid-2015, five sites were successfully extirpated.  The costs of extirpation vary widely between infestations; staff time cost varies from $100 for one of the smallest extirpated sites to more than $10,000 at Makua.  The large Makua infestation poses the greatest challenges.  A combination of ground treatment and aerial ball sprays are used to treat plants, although new techniques will be needed to reach certain plants due to steep terrain and proximity to a highway.  Gigapan photo stitching technology is being trialed both as a survey tool and to examine the efficacy of aerial sprays.

**No Need for Devil Weed: Eradication Efforts of *Chromolaena odorata* on the Island of Oahu**

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*Chromolaena odorata*, an Asteraceae commonly known as Devil Weed or Siam Weed, is native to North America, from Florida and Texas to Mexico and the Caribbean, and is a documented agricultural and ecological pest in tropical Asia, West and South Africa, and parts of Australia. The species has been referred to as one of the 100 worst weeds in the world (IUCN). Chromolaena was first reported in Hawaii by Oahu Army Natural Resources Program (OANRP) staff in 2011 when it was spotted on an annual road survey in the Army's Kahuku Training Area. Since detection, OANRP has repeatedly swept over 370 hectares across the Kahuku infestation, and spent over 1,531 person hours in this effort. Delimiting surveys were completed in Kahuku in 2013, and few populations outside the core infestation area were detected. However, smaller populations of Chromolaena have since been detected on Oahu at Aiea, Kahana, and two additional Army training ranges. OANRP current control strategy is to: 1.) survey and control across the defined infestation area every six months to a year; 2.) control locations with high densities of plants (hotspots) before the annual reproductive season (December - March); 3.) conduct annual aerial sprays of the core infestation (approximately 4 ha) before reproductive season; 4.) survey an 800 meter buffer around the infestation area and outlier populations, documenting and controlling new plants. Additional necessary but challenging efforts to eradicate this taxa from the island include surveying high-priority areas across the entire island of Oahu, securing funding and staff for control efforts, improving spray equipment, broadening public outreach efforts in high-use areas where Chromolaena is present, and supporting sanitation and inspection protocols within the Army. OANRP is dedicated to eradication of Chromolaena on Army lands, and supports eradication island-wide.

**Factors influencing *Cytisus scoparius* (L.) Link and *Ulex europaeus* (L.) invasiveness in South Africa**

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*Cytisus scoparius* and *Ulex europaeus* are widespread invaders in many countries around the world. Even though both species have been recorded in South Africa (S.A.) since the 1930s, they are currently restricted to a few locations. The present study investigated the invasiveness of both plant taxa in S.A. in relation to selected ecophysiological factors. After locating and characterizing the demography of a number of populations, parameters related to reproductive capacity (post-harvest seed physiology, seed bank density and pollination biology) were studied. Seed and seedling responses to elevated temperatures were also evaluated. Nineteen populations of *C. scoparius* and nine *U. europaeus* populations were identified, varying widely in size and coverage (96-6841 individuals over 44-5559 meter squared for *C. scoparius* and 52-1883 individuals over 3-7266 meter squared for *U. europaeus*). These populations occurred along disturbed roadsides and in commercial forests. There was evidence of high seed bank densities, seed bank viability and the presence of reproductively mature individuals and juveniles. Seeds of both species possessed physical dormancy, which once broken resulted in 100% germination. Seedlings yielded higher dry biomass, root length, shoot length, crown and stem diameters at ambient as opposed to elevated (2-3 degrees Celsius above ambient) temperatures. However, percentage seedling production was not compromised. The lack of evidence of reproductive limitation, limited residence time and the existence of substantial viable seed banks and reproductively mature individuals suggests that existing populations of both species should theoretically persist in S.A. if not eradicated. However, their reduced seedling vigour at elevated temperatures suggests that both species may not flourish in areas that are, or will be, subject to temperatures above their threshold of tolerance.

**Karyological diversity and invasion in the genus Phragmites**

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Phragmites is recognized as an important model genus in ecology and invasion biology because of its broad distribution and high genetic and karyological diversity at the local, regional and global scales. In a common garden in Denmark containing over 200 Phragmites populations collected globally, we tested the following. 1) Populations with larger genomes are less common in extreme environments; i.e., genome size decreases with increasing latitude. 2) Plant nutritional condition (%C, %N, CN ratio, %water), biomass and herbivore defense (leaf toughness, total phenolics) vary with phylogeographic group, genome size (GS), ploidy level, and geographic origin (latitude and longitude). 3) Palatability to the widespread and common herbivore, the aphid *Hyalopterus pruni*, varies with Phragmites nutritional condition, defense levels, GS, and phylogeographic group. Phragmites GS distribution was nonlinearly related to latitude but this was largely driven by populations with large genome sizes. Plants with large GS were most common at intermediate latitudes (~35-450). Across all groups and for both 4x and 8x plants, GS was consistently an important predictor of plant nutritional condition, biomass and herbivore defense. Most interestingly, the slope of the relationship between GS and the response variables was in the opposite direction for the 4x and 8x plants in 8 of 9 cases. These results suggest the possibility of an optimal GS for plant traits. Finally, comparing only NA groups, we found no significant relationships between GS and N, phenolics, and aphid colony size but did find significance for C, %water, toughness and aphid abundance. Our data suggest that phylogeographic group and GS (irrespective of ploidy level) are important in invasion success and that global change may play a key role in the future phylogeographic distribution of Phragmites.

**Genomic processes and invasion: intraspecific admixture and hybridization as substrates for evolutionary change.**

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The introduction of new plants into natural communities may alter community composition and ecosystem processes, and may be driven by post-introduction rapid evolution that drives changes in plant functional traits with ecological consequences. The genomic processes that underlie these changes are only now being elucidated. In this talk, we will highlight how processes at the genomic level such as admixture, recombination, and changes in genome size may be responsible for the rapid evolution of traits that facilitate invasiveness in introduced plants, and we will discuss whether these genomic changes are likely the result of selection at the genome level or neutral demographic processes. We discuss how these issues can be addressed by pairing population genomic approaches with experimental evolutionary ecology, and illustrate with examples from two invasive plant species, 1) the perennial grass, *Phalaris arundinacea* and 2) the invasive hybrid species *Centaurea monckonii. Phalaris arundinacea* is an aggressive invasive wetland plant in North America and also occurs in European wetlands but often not at high frequency. In North America, its invasive behavior has been ascribed to admixture between different European lines, giving rise to more invasive individuals that show changes at the genomic level that translate to differences in functional traits that can lead to ecosystem transformation. Meadow knapweed, *Centaurea moncktonii,* is a newly invasive hybrid species in the northeastern United States, and forms a hybrid swarm with its two introduced progenitor species, neither of which is highly invasive (*C. jacea* and *C. nigra*). Studies to understand the genomic processes giving rise to invasive traits driven by hybridization are currently underway.

**Biological control of arundo for habitat restoration and water conservation in the Rio Grande Basin and elsewhere in arid western North America**

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*Arundo donax* L., known commonly as arundo, giant reed, and carrizocane, is a perennial grass native from the Mediterranean to India, and invasive in North and South America, southern Africa, Australia, and parts of Asia. Arundo shoots form dense monotypic stands in riparian ecosystems along rivers, lakes and reservoirs, especially in arid agricultural regions where it threatens scarce water resources. In the Lower Rio Grande Basin of Texas, USA and Mexico, arundo occupies 30,000 ha along the Rio Grande and its tributaries, consuming water, obstructing access for law enforcement, altering stream flow, hindering flood control systems, increasing bank erosion, altering fire regimes, facilitating invasion of livestock disease vectors, spreading fires, and displacing native plants and animals. Arundo has similar detrimental impacts in the Sacramento-San Joaquin Delta and other drainages in California. A biological control program initiated by the U.S Department of Agriculture-Agricultural Research Service led to the Texas release of the shoot tip-galling wasp Tetramesa romana in 2009 and the rhizome- and shoot-feeding armored scale *Rhizaspidiotus donacis* in 2011. By 2014, the release of T. romana had led to a decline in live biomass, decreased main shoot height, and increased mortality of main and lateral shoots at 10 sites on a 300-km transect along the Rio Grande. The armored scale is decreasing live shoot density in release plots. The decrease in arundo population vigor is saving millions of dollars of year in water for agriculture and natural ecosystems. Positive effects on plant community biodiversity are developing over time as negative impacts of biocontrol of arundo continue. Both biocontrol agents are being released in northern California in the Sacramento-San Joaquin Delta. An additional agent, a cecid leaf miner, is under regulatory review.

**The USDA-ARS Areawide Pest Management Project for integrated control of aquatic weeds in the Sacramento-San Joaquin Delta**

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Water resources flowing into the 28,000 ha- Sacramento-San Joaquin Delta of northern California support $25 billion in irrigated agriculture and drinking water for 25 million people. Floating water hyacinth (*Eichhornia crassipes*), Brazilian waterweed (*Egeria densa*), and the riparian grass known as giant reed or arundo (*Arundo donax*), each occupy several thousand ha in the Delta, consuming water, hindering water resource use, obstructing recreational and commercial navigation, reducing environmental quality, displacing native plant species, harboring disease-vectoring mosquitos, and (in the case of arundo) spreading fires and increasing erosion. In June 2014, a USDA-ARS-funded Areawide Pest Management Program was initiated to develop and implement integrated assessment and decision-support tools to improve Delta-wide management of these three weeds using chemical, mechanical, physical, cultural, and biological methods. Satellite- and aerial-based remote sensing tools and analyses of water quality and flow data are being used to prioritize water hyacinth control locations, leading to improved early-season control in 2015. Information on weed growth and response to control with existing and new herbicides is being used to optimize the timing of chemical and mechanical control. Three new insect agents are being released for biocontrol of water hyacinth and arundo. Coordinated aquatic weed-mosquito control operations are being implemented to reduce the ability of live and decaying weeds to support mosquito outbreaks in areas where human health is most at risk. Cascading effects of the control programs on aquatic food webs are being monitored. Site selection and baseline monitoring for restoration of native aquatic plants is being initiated.  The economic impacts of aquatic weeds in the Delta, and the benefits of the Areawide approach, are being modeled to predict and document project impact. By integrating research with weed management operations, this USDA-ARS Areawide project is expected to help protect scarce water resources in the Delta.

**Role of thermal characteristics in juvenile phenological development of native and introduced plants**

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Phenological development in plants is a function of a given temperature and time, called thermal time (TT), over which it is acting. The linear approximation of the relationship between the rate of development and temperature allows calculating two constants: the sum of effective temperatures (SET), i.e. the amount of heat needed to complete a developmental stage, and the lower developmental threshold (LDT), i.e. the temperature below which the development ceases. Thermal window (TW) represents the range of temperatures between which the minimum and maximum developmental rates occur.
Here we explore whether thermal characteristics can be used to find the differences between native and alien species development and to predict the invasiveness of plant species. We collected data on TT requirements of 120 wild growing plant species (native and alien) in the Czech Republic. The experiments were carried out in growth chambers under stable regimes differing only in temperature. The treatment temperatures were 10, 14, 18, 22, 26, 30 and 34 °C under 14/10 hours light/dark regime, to cover the range of temperatures and day lengths in the temperate zone during the development of juvenile plants in the field (spring and late summer). To assess the time between appearance of the 1st and 5th stem leaf, or pair of the leaves the plants were checked and measured daily.
We found that under high temperatures invasive alien plants develop faster than their native congeners, and vice versa, native plant species develop faster under low temperatures. Faster development under high temperatures might represent an adaptation favouring the rapid start of invasion in warm regions. Ongoing climate change could therefore accelerate the dispersal of invasive plants to new regions. The differences in thermal characteristics of alien and native plants are compared and discussed with regard to their phylogeny, invasion status, life history and habitat.

**Controlling invasive plants in an era of climate change: New decision-support tools help set EDRR focused landscape-level strategies in California**

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California Invasive Plant Council

In an era of climate change, controlling invasive plants is recognized as an immediate action that can reduce ecological stress and support resiliency and adaptation. Climate change also becomes an important factor in setting control strategy, because the suitable range for each species is shifting. Employing online mapping and database applications, the California Invasive Plant Council (Cal-IPC) developed two decision-support tools: CalWeedMapper and WHIPPET. These tools provide land managers with the spatial analysis needed to set strategic priorities at the landscape-level. These tools incorporate data on distribution, pathways of spread, cost of control, shifts in suitable range, and value of habitat to prioritize particular species and populations for management.

CalWeedMapper contains the information about abundance, spread and management for the 200+ species on the Cal-IPC inventory.  It also contains information about the suitable range in 2050 for 79 species.  This information can be translated into Management Opportunities for regions at several scales such as watersheds, Weed Management Areas, National Forests, and State or National Parks.  Land managers are using this tool to focus their invasive plant management efforts on the early end of the invasion curve, looking for the most effective surveillance and eradication for Early Detection and Rapid Response (EDRR) programs.

Individual management units (such as wildlife refuges) as well as regional partnerships (such as Cooperative Weed Management Areas) are using these tools to plan—and secure funding for—strategic early eradication projects that provide long-term conservation benefits.

I will demonstrate how CalWeedMapper (www.calweedmapper.cal-ipc.org) has benefited regional efforts in California. CalWeedMapper, used in conjunction with the WHIPPET online tool, can also benefit regional eradication efforts  (see Gina Darin's poster).

**Changes in impacts of Heracleum over time due to negative plant-soil feedback**

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Plant invasions often change the structure and functions of invaded ecosystems and pose a serious threat to native communities.  However, little is known about the dynamics of their impacts over time. Longitudinal data from the Protected Landscape Area (PLA) Slavkovský les, Czech Republic, central Europe, made it possible to reconstruct the spread of an invasive plant *Heracleum mantegazzianum* (giant hogweed) and explore temporal changes in its impact on the diversity and composition of invaded communities. To obtain the key information on how long a particular site is invaded, we used a series of aerial photographs spanning over the 50 years of hogweed invasion (1962 to 2006) which allowed to follow the invasion from the very beginning. Photographs were ortorectified and hogweed mapped using semi-automated object-based classification algorithm. Based on the knowledge of invasion process we chose five types of grassland sites invaded by giant hogweed for different time period (from 0 up to 50 years) in different parts of the PLA. At each site, we recorded plant species composition and cover, performed the total productivity analysis, and sampled the soil for a common garden experiment. Native species' richness and productivity were initially reduced by hogweed invasion but started to recover after ~30 years of hogweed residence at the sites. Hogweed cover declined linearly over the whole period assessed. A complementary common garden experiment suggested that the dynamics observed in the field were due to a negative plant-soil feedback. Hogweed plants showed lower survival, biomass and competitive ability when growing in soil inocula collected from earlier-invaded grasslands. These results indicate that the initial strong dominance of an invasive plant species and its negative impact can later be mitigated by stabilizing processes.

**Detection, monitoring and control of alien plant species: an unmanned aircraft mission**

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Many plant invaders spread rapidly, outcompete native species and their removal or containment is difficult. To successfully fight plant invasions, new methods enabling fast and efficient monitoring are needed. By improving opportunities for early detection of invading plants, a remote sensing approach can make their management more efficient and less expensive. In an ongoing project in the Czech Republic, we aim at developing innovative methods of mapping invasive plant species (semi-automatic detection algorithms) by using purposely designed unmanned aircraft (UAV) combined with aerial and satellite optical RS data. We examine possibilities for detection of several invasive species: *Heracleum mantegazzianum, Robinia pseudoaccacia, Ailanthus altissima*, and *Fallopia* s.l. (*F. japonica, F. sachalinensis* and *F. × bohemica*). Our aim is to establish fast, repeatable and efficient computer-assisted methods of timely monitoring applicable over large areas, reducing the costs of extensive field campaigns. We compare imagery of different origin (satellite, aerial and UAV), spectral (panchromatic, multispectral and color), spatial (very high to medium) and temporal resolution, and various technical approaches (object-, pixel-based and hybrid approaches) to choose the best strategies for invasive species monitoring. Thanks to its flexibility and low cost, UAV enables us to assess the effect of phenological stage and spatial resolution on the recognition of the species, and is most suitable for monitoring the efficiency of eradication efforts. However, several challenges exist in UAV application, such as geometrical distortions, radiometric differences during the flight, the high amount of data to be processed and legal constrains for the UAV flight missions over urban areas (often highly invaded). In our study, we address trade-offs between spectral, spatial and temporal resolutions required for balance between the precision of detection and economic feasibility. The resulting data enable us to assess the invasibility of different types of habitats, model the potential species distribution and identify the drivers of spread. This knowledge will serve as a basis for prediction, monitoring and prioritization of management targets.

**Simulations of management to control African grass in cerrado: Effects of clipping and fire under different environmental conditions**

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In the Cerrado, the Brazilian savanna, one of the greatest threats is imposed by the African grass *Melinis minutiflora*. The development of control techniques is thus imperative to sustain biodiversity in conservation units. A good management approach should be inexpensive and easily applicable to extensive areas. In this context, clipping and fire have been applied in the Cerrado region. Nevertheless, we must bear in mind that the management effects might be influenced by other stress factors present in the environment. For instance, water and nutrient availability should also be regarded during management . The aim of this study was to assess the effects of clipping and fire in different conditions of soil moisture and fertilization for two grass species, one native and one invasive to the Cerrado. Two-month-old clipped/burned plants were left to recover for four weeks under the same conditions prior to clipping: three different irrigation regimes (constant moisture, intermittent watering, and intermittent watering with fertilization) combined with four levels of water availability (severe drought, mild drought, control and flood). The fire caused more damage than clipping did. The invasive species recovered more rapidly and presented higher net assimilation rates and less lipid peroxidation than the native species. However, clipping reduced the discrepancies in length and dry weight between the species when compared to pre-clipping values. Soil moisture proved to be more detrimental than fertilization. Leaf pigment and Fv/Fm values were not affected by any factor, and enzymatic activity showed a stronger antioxidative response by the invasive species. Clipping management seems the most feasible and is more efficient when applied in a condition of low resources. In such condition, clipping reduced the difference in growth between species and could equalize the competition between them.

**Fire effects on leaf components: a case study comparing cerrado native and invasive grasses**

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In the Brazilian savanna, the Cerrado, the grasses are the most representative species of the herbaceous layer, both in richness and density. Within this biome, they sum to over 500 species. The majority of them present the C4 metabolic pathway. That is also the case of the invasive African grasses, which are widespread in the biome. These grasses threaten the Cerrado biodiversity and,  *Melinis minutiflora* is one of the biggest problems. *Echinolaena inflexa*, a native C3 grass, has been frequently observed coexisting with *M. minutiflora* . Fire has been present in the biome for millennia. As native flora should be resistant to burning, fire has been suggested as a control technique of invasive grasses. This work is a case study reporting the effects of an accidental fire on those two grass species. The main objective is to assess the concentration of macronutrients, micronutrients, photosynthetic pigments and the oxidative profile (GPOX and APX activity and MDA concentration) on burned and unburned individuals. In unburned vegetation, *M. minutiflora* presented a higher concentration of nutrients. Four months after the burning, there was a higher concentration of macronutrients in both species than in unburned vegetation. Pigment concentration tended to be higher in the invasive species in the burned site. The antioxidant activity was higher in native species than in the invasive and, in turn, the damage to the membrane was lower. Fire reduced the difference between native and invasive species GPOX activity. The species show different strategies to cope with fire at the biochemical level. The native seems to invest less in leaf nutrients and pigments to resprout after fire and present lower cell-membrane damage. These results may help understand their coexistence despite *M. minutiflora*'s aggressiveness.

**Genetic segregation of native and non-native ecotypes of *Solidago gigantea***

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Rapid evolutionary changes of invaders can explain their success in the introduced range, creating genetic and ecological differentiation between the native and introduced range. We examined differences at both genetic and ecological levels among *Solidago gigantea* populations. The plant is native to North America but is a serious invader in Europe. We collected seeds from the native and the introduced ranges. Seeds were germinated and grown under controlled conditions for the first two months and set into common gardens for two complete seasons to determine the effects of origin on ecological parameters of the species. Ploidy and microsatellite analyses were carried out on the same individuals that were used in the common gardens. We found clear genetic segregation between native and non-native populations of *Solidago gigantea* both at ploidy and microsatellite levels. There was a strong similarity within the non-native range while a slight separation within the native range.  The ecological segregation appeared between continents but not within them.  Our results showed strong differentiation between the native and non-native range, which could help us to explain ecological separation between regions. Our results are consistent with the theory that rapid evolutionary changes play an important role in the success of plant invasion.

**The risk of alien grass invasion across the Antarctic Peninsula: thermal niche potential and human pressures**

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Alien species are a global threat to biodiversity, even in Antarctica. Several non-native vascular plants and invertebrate species have already established on the continent. Under the Antarctic Treaty, Antarctic ecosystems have high conservation status. We studied the invasion potential of two non-native grasses (*Poa annua* and *Poa pratensis*), which have been established in Antarctica for several decades. We took a global niche approach, considering their current realized distributions worldwide based on temperature features. Nine comparative bioclimatic variables related to daily temperature records were created for the ice free soils of the Antarctic Peninsula. To our knowledge this is the first time that Antarctica has been incorporated in a global bioclimatic niche modelling approach. Bioclimatic thermal ranges were built first from species' occurrence data, including the Antarctic Peninsula, with a MultiDimensional Envelopes technique. Next, both MaxEnt and Mahalanobis Distances Analysis (MDA) were separately used to obtain a quantitative prediction of the distribution. Summer temperatures were the most limiting factor in the Antarctic Peninsula in comparison to other areas of the world. Moreover, species with fast growth rates (i.e. *Poa annua*) can expand under such conditions, while slow growing, persistent species (i.e. *Poa pratensis*) can endure very low winter temperatures. MaxEnt analysis identified areas at high risk of invasion given temperature features. Interestingly, MDA showed that Antarctic records are on the verge of their ranges. Thermal envelopes were combined with human spatial pressure metrics showing a convergence of risk factors in the Northern Peninsula. This was then used to create a biosecurity risk index for all human sites in the Antarctic Peninsula. We conclude that bioclimatic niche modelling is an effective tool both for biogeographic understanding of species invasive potential and effective biosecurity management in the region.

**The rise and fall of exotic species: why time dynamics of species introductions should be included in predictions of invasiveness**

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The ecological performance of exotics in their introduced range is known to change over time, which can either enhance or decrease their invasiveness. Here we present a novel framework to explain and generate expectations of these possible changes in the invasive status of introduced aliens over time. There are myriad factors potentially involved in these temporal changes and ecological theory is not yet fit to integrate so many factors'. Here we use principles used in microeconomics to explain individual expending decisions between two complementary goods under budgetary restrictions to explain the change on invasion status over time as a shift in the investment into growth and defense. The framework is based on the idea that invasive status (casual-naturalized-invasive) is a time-dependent response regulated by two processes: (1) short-time ($10^{-1}$ to $10^{1}$ years) changes in the constraints imposed by the environmental and biotic setup (changes in the realized environment and the strength biotic interactions), and (2) long-time ($10^{2}$ to $10^{4}$ years) changes in functional and physiological constrains determining the trade-off between the investment in growth (competition) and defense. Our aim with this framework is to provide a conceptual description of the path from introduction to invasively dominant, and in some cases a subsequent decline phase of invasiveness (i.e., "ecological assimilation"). Evaluating the temporal dynamics of exotic species can help to improve predictions of successful invasive plants. These considerations will contribute not only to the development of a mechanistic understanding of invasion and a comprehensive predictive theory of invasions, but also the understanding of speciation mechanisms and the effects of climate change on ecological communities.

**Can restoration using a functional trait based approach provide invasion resistance? An example in novel ecosystems of Hawaii**

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Community assembly theory predicts that an ecosystem with more diverse species, or more diverse functional traits, should be more resistant to colonization by competitors. A challenge in restoration is to pick species that can restore site 'functionality' and keep out undesired competitors (generally invasive species), especially because species-choice in restoration is often carried out with limited ecological information. We present a general, flexible method for species selection in restoration, based on the collection of plant functional trait data. To illustrate this approach, a project called "Liko Nā Pilina" is presented. In this lowland Hawaiian rain forest type, no reference site exists, due to land-use change and non-native species invasion, and thus it is a novel ecosystem. Using a mixture of native and non-native (but non-invasive) species, four experimental treatments (hybrid ecosystems) were created, each with 10 tree species. The present, invaded forest serves as a control. Treatments contain four species that either have slow carbon turnover (slow) or slightly faster carbon turnover (moderate) as core species, and additional species are either mixtures of species whose traits are more dissimilar (complementary) or similar (redundant) to the core species. We predict that invasion resistance will be greatest in the two complementary treatments.  Seed trap data from the first year of the experiment shows no significant difference in invasive species seed mass among the four restoration treatments, but growth rates are lowest in the slow redundant treatment. Native seedling survival was originally greatest in the slow complementary treatment, but a drought equalized the treatment effects. Long-term monitoring will provide numerous insights into the role of functional diversity in tropical forests.

**The effectiveness of control methods on giant goldenrod (*Solidago gigantea*) invasion**

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Giant goldenrod (*Solidago gigantea*) significantly reduces species diversity by forming dense monocultures in its invaded range. Solidago is one of the most aggressive invasive neophytes in Central Europe. The plant occupies mainly wet habitats but can also take over semi-dry and disturbed areas. It spreads long-distance by seed dispersal and locally by rhizomes. Therefore, controlling this species raises difficult issues, and so far there have been no generally applicable methods to combat this problem. We surveyed the effectiveness of different control methods against Solidago that are commonly applied at the Hungarian national parks (grazing, mowing, flooding, and their combinations) in different habitat types. We also set up a three years controlled experiment (in 50×50 cm plots) in a common garden, with six different control methods (mowing once or twice a year, selective herbicide treatment, and their combinations). Linear mixed models were used for statistical analyses. Our results show that all methods applied at the national parks had positive effects on species diversity (df=11; F=75.519; P<0.001) compared to the untreated controls. However, grazing had the largest positive effect (t=-16.849; P<0.001). In our experiment every treatment decreased Solidago stem number significantly (df=6; F=4.713; P=0.00347). Herbicide application had completely eliminated Solidago by the second year, but it also decreased species diversity the most. Mowing also had a negative effect on Solidago stem number in the second year, but species diversity remained similar to the control plots.  Based on our results, Solidago invasion can be controlled by most methods; however, the actual site characteristics and integrity of the native community should be considered when selecting the most applicable one.

**A global assessment of functional changes in urban plants communities**

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Urbanization involves intense detrimental changes to the environment. These changes can lead to species extinctions and invasions, alteration of plant community composition and potentially biotic homogenization across cities. In this work, we examined whether urban environments consistently select for and against plant species with particular traits. We hypothesized that: i) in contrast to extinct native plants, exotic and extant native species share common characteristics that allow persistence, and ii) exotic plants have particular characteristics that promote invasion. We categorized plants recorded in eleven cities around the globe as locally extinct natives, extant natives or extant exotics. We analyzed how these groups of plants varied in their values of ten traits that have been linked with plant responses to environmental conditions. We independently compared exotic plants with extant native plants, and with locally extinct plants using individual city-level Bayesian logistic regressions. Finally, we combined the city-level results using meta-analysis to assess the consistency of the traits' effects across urban areas. We found that exotic plants in urban areas showed higher values of height and seed mass, and were more often annual species, than native plants, especially when compared to the extinct native fraction. In addition, urban exotic plants had a generalist nutrient strategy more often than extant (but not extinct) native species. Our results suggest that processes related to urbanization select for species with a particular suite of traits, leading to common patterns of functional change in urban plant communities. Plant persistence seems to be promoted by short life-history, tall stature and heavy seeds. Exotic species may be exploiting high values of these traits to fill novel niches that result from urbanization. Information on which traits favor plant persistence in cities may be useful for developing strategies that aim to reduce native plant extinctions and exotic species' success..

**Evolution of anti-herbivore defense in invasive plants: a meta-analysis**

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Plant-herbivore interactions play an important role in invasion success of exotic plants. Based on the EICA hypotheses and specialist-generalist dilemma, it is predicted that plants introduced into areas where their specialist herbivores are absent but generalist herbivores are present, may evolve increased defences against generalist herbivores and decreased defences against specialist herbivores. On the other hand, most plant defense theories predict the occurrence of trade-offs between resource investment in different types of defenses (constitutive and induced resistance vs. tolerance) against different herbivores (generalists vs. specialists). In order to find possible patterns of the evolution of anti-herbivore defense in invasive plants, we performed a meta-analysis of 56 field or common garden studies (on 29 species) published in 1999–2014 that provided data on different measures of defenses (insect performance, leaf consumed and chemical defenses) for both in native and introduced populations of invasive plants.

On average, introduced populations exhibited decreased constitutive resistance, but increased induced resistance and tolerance to specialist herbivores. Introduced populations also showed increased constitutive and induced resistance to generalist herbivores, but tolerance of generalists did not differ between native and introduced populations.

Thus, the absence of specialist herbivores in introduced populations may result in the evolution of decreased constitutive resistance, but increased induced resistance and tolerance of specialists; meanwhile, introduced populations showed both increased constitutive and induced resistance against generalists. Our results unfortunately show that the present control practice for alien invasive plants by introducing specialized natural enemies will face great challenges in the future. Our results may help to further our understanding of why biological control efforts have been successful in some environments, but not others. Understanding the defense mechanism of invasive plants under different environmental conditions will be important for improving and predicting management efficiency.

**Pereskia aculeata: early detection and rapid response of an incipient weed by the Big Island Invasive Species Committee**

James Parker

Big Island Invasive Species Committee, Research Corporation of the University of Hawaii

*Pereskia aculeata,* or Barbados gooseberry, is an invasive plant pest that has proven to be extremely difficult to eradicate, evidenced by work done in South Africa and Australia.  It is a vining, sprawling cactus with two types of spines, fleshy leaves that will potentially root if dropped on the ground, self-compatible flowers, and an animal-dispersed berry.  It is extremely aggressive and can potentially wreak havoc anywhere it becomes established by forming impenetrable thickets of thorny scrub.  After discovering *P. aculeata* on an early detection roadside survey in 2010, the Big Island Invasive Species Committee prioritized it as a Rapid Response target, began researching control techniques and working to find the extent of the invasion.  To date, there is still only one known population on the Big Island.  When sources from Molokai all the way to South Africa said that it would be impossible to eradicate, BIISC realized that there was a necessity to research new control techniques.  Across the state, other invasive species committees are attempting to slow the spread of this pest and the battle ranges from the nurseries in Kauai to the Halawa Valley of Molokai.   This presentation will discuss a new effective control method for the treatment of *Pereskia aculeata,* highlight observations from the field, and give a synopsis of the current state of the Pereskia invasion in Hawaii.


**Direct and indirect effects of invasive non-native plants and flood disturbance, on the dynamics of riparian zone vegetation**

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Riparian zones are dynamic habitats with complex disturbance regimes. They are also highly prone to invasion by non-native plants, such as Himalayan Balsam (*Impatiens glandulifera*) in NW Europe. There is much concern over the potential impacts of invasive non-native plants (IAPs) on native riparian vegetation yet IAPs might essentially be passengers, rather than drivers of community change at fluvially disturbed sites. Future increases in river flows are expected to increase mobility of sediment and plant propagules suggesting that climate change and invasion will together have important effects, on the stability of native riparian vegetation.

To assess the effects of fluvial disturbance (as indicated by over-winter sediment deposition on Astroturf mats) and invasion on native vegetation, sites on twenty rivers were each surveyed in summer 2013 and spring and summer 2014. Sites covered a gradient of sediment deposition and IAP cover. Higher cover of IAPs was associated with lower diversity of native species in all seasons. However, the diversity of native spring vegetation was more sensitive to IAP cover in the previous summer. Greater sediment deposition was associated with significantly higher cover of IAPs the following spring, as well as increased short-term turnover of native species.

Our results reveal a legacy effect of IAP dominance that is associated with decreased diversity of native spring vegetation the following year. This may be due to winter sediment deposition introducing an influx of IAP propagules and supressing recruitment from local sources. Sediment-mediated disturbance favours IAPs and results in a less stable and potentially more invadable native community. Most ecosystems are affected by both direct and indirect stressors. Effective management of IAPs depends on recognising these effects, how they interact, and how they are likely to change over time.

**Quantifying pine invasions impacts and legacies using observations and experiments: *Pinus contorta* in Chile.**

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Measuring the impacts of pine invasions is a priority for invasion ecology because they are one of the most transforming invasive groups in plants. *Pinus contorta*, a native species from North America has been widely introduced around the world during the past two centuries for production and reforestation, and is now considered an ecosystem transformer. Thus, *Pinus contorta*, may serve as a species model to advance in the quantification of the impact of tree invasions. Here, we describe a study design comprising two sites in southern Chile, the subalpine *Araucaria araucana* open forest and the Patagonian steppe. We are measuring specific impacts of pines in microsite environmental variables (i.e. light, soil temperature and humidity, nutrients), vegetation and mycorrhizal community. We use a set of observation and experiments in permanent plots along the invasion gradient, including the removal of pines to study the persistence or legacy of pine invasion impacts. Our method is framed in the larger context of the Global Invader Impacts Network (GIIN) and has the potential to quantify impacts using multiple approaches and networking with researchers in other regions of the world. In this presentation, we inform our first findings. We have found a strong pine biomass gradient reaching up to 200 ton/ha in the forest and 50 ton/ha in the steppe. Litter accumulation increases with pine density, from 1.2 to 7.4 cm in the forest and from 1.4 to 3.9 in the steppe, and gradually pine litter replaces native litter. Plant diversity decreases with pine invasion, in association with increased tree cover and reduced light. We expect not only to quantify the magnitude of pine invasion impacts, but also the mechanisms and legacies of such impacts to inform management and ecological restoration. Funded by Fondecyt 1140485, CONICY PFB-23, ICM P05-002.

**International Collaboration Delivers a Weed Biocontrol Programme for the Cook Islands**

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Much of the Cook Islands' natural habitats and agricultural land are affected by invasive weeds. A five year weed biocontrol programme for the Cook Islands started in November 2013, funded by the New Zealand Partnerships for International Development Fund. Eight invasive weeds were selected for the programme by a panel of regional experts in agriculture, biodiversity and biosecurity plus representatives from local interest groups. Five species selected are 'repeat programmes' using proven agents developed in other countries, namely: giant reed (*Arundo donax*); cocklebur (*Xanthium strumarium* sp. agg.); grand balloon vine (*Cardiospermum grandiflorum*); mile-a-minute vine (*Mikania micrantha*) and strawberry guava (*Psidium cattleianum*). Novel programmes have commenced against red passionfruit (*Passiflora rubra*) and African tulip tree (*Spathodea campanulata*). Preliminary surveys in Ghana (funded by the SPC) had already identified promising candidate agents for *S. campanulata* and three species were collected in Ghana in March 2014. Host-range testing of two species; an eriophyid mite cf. *Colomerus spathodeae* and a flea-beetle *Paradibolia coerulea* is well underway and both are likely to be sufficiently specific for use as biocontrol agents in the Pacific region. Published host records indicate several Heliconius butterfly species that feed on *P. rubra*, should not attack other Passiflora species that are grown for their edible fruits in the Cook Islands. The current programme will fund specificity testing of these butterflies, which will be obtained from a commercial butterfly supplier. The final target is Merremia (*Merremia peltata*) and the main objective is to verify where it is native and where it has been introduced, using DNA technologies, to determine whether it should be a target for biocontrol in the Cook Islands. This programme was enabled by other nations freely sharing biocontrol agents with New Zealand. The long term objective beyond the current programme is to share successful agents with other Pacific nations.

**Modelling of IAS spread as management tool in protected areas**

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Numbers of alien taxa in the Czech Republic (Central Europe) constantly increased during the last two decades. Alien plants pose significant threats to biodiversity and special attention should be paid to invasions into protected areas. Management planning for regional authorities requires an understanding of invasion process across protected areas, but available data on invasive species presence and abundance is often incomplete. It is important to identify localities at most risk of invasion, as well as potentially endangering invasive species. Discovering newly invaded localities is difficult and almost impossible in larger areas, it demands for the precise field work. In order to predict the invasion on local scale it is necessary to distinguish sites prone to invasion of particular IAS. Habitat-oriented studies show the dependence between successful invader and the environment on large scale, but the use of habitat-invasion relation on local scale is missing. Species distribution models (SDMs) allow for probabilistic prediction of invasive plant spatial spread. SDMs are based on combination of environmental factors, occurrence data (presence/absence) and statistical approach. Employing habitat types as predictors, we use unique information about environmental conditions, vegetation cover, management and successional stage of the site. The aim of the study is to find suitable model for prediction of invasive species spread based on environmental variables and habitat characteristics. The European network Natura 2000 habitat mapping, combination of environmental variables and occurrences of selected invasive species (*Solidago* spp., *Reynoutria* spp., *Heracleum mantegazzianum*) were used for creation of prediction models. The combination of the most important environmental variables, Natura 2000 habitats and the best models were applied to selected sites of Community Importance (SCIs) and thus we obtain the tool to predict invasive species spread and target management of IAS. The results obtained for the different types of SCIs and using different models were compared.

**Use of exotic plants to control *Spartina alterniflora* invasion and promote mangrove restoration**

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We used exotic *Sonneratia apetala* Buch.-Ham and *S. caseolaris* (L.) Engl. to control invasive *Spartina alterniflora* Loisel through replacement control for 5 years, which concurrently promoted the restoration of native mangroves. This process includes three stages. I: In lost mangrove area invaded by *S. alterniflora*, native mangrove are unable to grow; however, exotic *S. apetala* and *S. caseolaris* grew rapidly owing to relatively fast-growing characteristic and an allelopathic effect on invasive *S. alterniflora*. II: Fast growing *S. apetala* and *S. caseolaris* control and eradicating of *S. alterniflora* through shading and allelopathy. III: *S. apetala* and *S. caseolaris* promote the growth of indigenous mangrove; the underlying mechanism is after forest establishment, exotic plant seedlings grown in the understory shade can't regenerate, yet it contribute to better growth of seedlings in the majority of native mesophytic mangrove plants; when the area experiences extreme low temperatures in winter or other events, *S. apetala* dies and fails to regenerate, but native mangrove species grow to restore the communities. This mode has great implications for addressing the worldwide problems of "how to implement ecological control of invasion using exotic species" and "how to concurrently promote native community restoration during control of exotic invasion".

**Planting the Seed: A Place-based Curriculum on Maui Raises Awareness about Invasive Plants**

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Maui Invasive Species Committee

For many decades, high school science classes in Hawaiʻi relied on textbooks and lessons drawn from the U.S. mainland. Island students struggled to relate to plants, animals, and natural phenomena they had never experienced. Few students had ever seen a native Hawaiian forest, thus had little context for understanding the difference between native and invasive plants. In 1996, a group of field biologists, researchers and teachers began working on a curriculum that linked state science standards with locally relevant examples. Each module in the Hoʻike o Haleakalā curriculum, named for Maui's tallest mountain, focuses on one of the island's diverse ecosystems and related management issues; invasive species topics are woven throughout the curriculum and are also the subject of a separate module. Activities such as Raindrops and Watersheds, Weed Risk Assessment Bingo, Ecosystem Engineers, and Survivor Island introduce students to the larger concepts of invasion biology while using specific examples from their island home. The Maui Invasive Species Committee (MISC) uses the curriculum during classroom visits and field trips, and hosts teacher workshops to promote its use. The curriculum project is part of MISC's comprehensive outreach program to engage the public on invasive plant issues. We highlight the importance of working with all age groups and offer both survey and anecdotal evidence that demonstrate the effectiveness of ongoing outreach and education efforts.

**Once upon a time: long-term survival of alien plants in sites of abandoned former villages**

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Grasping the ability of planted species to persist in natural or semi-natural habitats can contribute to better understanding of the naturalization/invasion process. By using a model system of abandoned villages in the Czech Republic we analyzed the effect of succession on the persistence of once cultivated plants. Forty villages were visited in 1970s, 30 years after their abandonment, when the then persisting species were recorded, and after another 40 years, 15 of those villages where no human activities occurred during that period, were resampled.  The two inventories were analysed to find out (i) what attributes of the villages (e.g. climate, distance to the closest populated settlement) affect the diversity and persistence of the species and (ii) are there species biological traits (e.g. species' life history, relationship to ecological factors expressed by Ellenberg indicator values, ability of vegetative reproduction, tolerance of disturbances) associated  with the ability of plant species to persist for decades after the village has been abandoned.  In the 1970s there were ~400 species assumed to have been persisting as the result of pre-1970s cultivation. The most frequent were apophytes and utility plants and trees. Some currently very common species were quite limited at the time of first inventory, indicating the lag phase needed for them to spread in the surroundings and build abundant populations. Other species such as geophytes were slowly disappearing despite their former popularity. The inventory carried out 70 years since abandonment focused mostly on alien species. Interestingly, the survival of recorded species does not depend on the life history, with trees and long-lived species surprisingly not showing higher persistence than short-lived herbs. Our results can be used in assessing the risk of plant species' escape from cultivation, and consequently in predicting which combination of species traits and environmental factors is likely to result in invasion into seminatural vegetation.

**Biodiversity, biomass and resistance to plant invasion across eastern U.S. forests**

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Biological invasions and their impacts are likely to increase with the expansion of global commerce, making the need to identify key drivers and regulators of invasion perhaps greater than ever.  One of the most enduring, and tested, hypotheses for explaining invasions is the "biotic resistance hypothesis."  Broadly, this hypothesis states that communities having greater biodiversity have fewer unfilled niches, making them less invasible. Using data from 46,071 Forest Inventory and Analysis plots located across the forests of the Eastern United States, we tested for associations between native trees and invasive plants that would suggest the presence of biotic resistance.  In addition to tree species richness, we quantified biodiversity in ways that incorporate the evolutionary relationships among co-occurring species. For both invasive species richness and cover, we determined: 1) if accounting for the spatial heterogeneity nested within a large geographic area improves models of biotic resistance, 2) if the direction, magnitude, and spatial variability of associations pertaining to biotic resistance differ based on how biotic resistance is measured, and 3) if the direction and magnitude of associations pertaining to biotic resistance vary with either scale or location.  We found that accounting for heterogeneity allowed for better models of biotic resistance, and that both invasion measures were negatively associated with native tree biomass and with phylogenetic evenness (the degree to which co-occurring species are dispersed across the phylogenetic tree of life), but positively associated with native tree species richness. A few sub-regions, however, exhibited opposite associations. Association size tended to be greatest for phylogenetic evenness. Strong negative associations were aggregated within and near the Appalachian Mountains.  As forests and the services they provide are increasingly harmed by invasive plants, particularly in our study region, the findings of this investigation will have implications for both invasive species management and policy.

***Melaleuca quinquenervia* in Florida: the end of an error**

Paul D. Pratt

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The adventive Australian tree *Melaleuca quinquenervia* (melaleuca) is an invasive weed in the greater Everglades region of Florida. Public agencies and organizations responsible for natural areas management have developed effective chemical and mechanical strategies for treating infestations, but these methods can be costly and labor intensive. Meanwhile, many infestations on privately held lands remained unmanaged. The melaleuca biological control program, developed to complement conventional removal tactics, reduces reproduction and growth of the tree and functions on unmanaged lands. But the full impacts of the biological control program are only realized when private landowners and public land managers become familiar with its benefits. Dr. Pratt and colleagues designed an areawide pest management project for melaleuca to promote regional implementation of biological control as the basis for integrated management. The T.A.M.E. project conducted 8 workshops and field tours that were attended by 41 different agencies and private organizations, representing managers of >1.4 million acres of the state's natural areas. The team also gave 98 presentations to end-user groups, developed brochures, informational videos, surveys, extension bulletins, fact sheets, public displays, newsletters, and a handbook to promote the concepts of integrated management applied to Melaleuca.

**Weed biocontrol for Hawaii – tackling two of the toughest**

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The yellow Himalayan raspberry (*Rubus ellipticus* Sm: Rosaceae) and Kahili ginger (*Hedychium gardnerianum* Ker–Gawler (Zingiberaceae) are two of the most serious threats to the unique habitat of the Hawaiian Islands. Considered beyond chemical and mechanical control, these large, thicket-forming invasives are capable of altering ecosystem processes and displacing natives across a range of habitats, including native montane rain forests. Both species are hugely adaptable and aggressive vegetative colonisers whose fruits are also readily dispersed by birds, both are of Asian origin and both are valued ornamental/commercial plants in the Hawaiian community which make their proposed biocontrol potentially contentious. Although mechanical and herbicidal control has been performed on a limited scale for both species, large scale eradication is not feasible across such extensive and rugged terrain and the infested areas are growing unchecked. Classical biological control is widely believed to be the only long term solution to both of these intractable invaders. A biocontrol initiative for Kahili ginger was initiated by CABI in 2008 for Hawaii and New Zealand whilst Rubus biocontrol prospects for Hawaii were rekindled in 2014 after a short hiatus. Rubus biocontrol research is at a relatively early stage, with native range surveys described and prioritised agents presented. Progress in the ginger biocontrol research programme is discussed and the potential of two prioritised agents (a stem-mining fly and a rhizome-boring weevil) reviewed with regard to the key stakeholders, Hawaii and New Zealand. Perceptions of Kahili ginger and related species vary between these countries, as do native plant communities, resulting in differing testing requirements and agent-specificity thresholds. Host-specificity results are discussed in the context of potential applications to the Environmental Protection Authority in New Zealand and the benefits of these activities for progress in Hawaii discussed.

**Weed biocontrol for Europe – research, releases and future prospects**

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Biological control is practiced widely against invasive non-native weeds in regions including Asia, Australasia, the USA, South America and South Africa, with the latter celebrating its weed biocontrol centenary in 2013. Despite the many success stories and large benefit: cost ratios of weed biocontrol programmes in these regions, Europe has been slow to follow suit. To date there have been just two formal classical biological control releases against weeds in the EU: a psyllid against Japanese knotweed in 2010 and a rust fungus against Himalayan balsam in 2014, both in the UK. Further weed biocontrol research for the UK is ongoing, supported by the Water Framework Directive (WFD) which requires water bodies to be in good health, necessitating effective management of invasive weeds. Those being targeted for biocontrol to meet WFD aims in the UK include floating pennywort (*Hydrocotyle ranunculoides*) and Australian swamp stonecrop (*Crassula helmsii*). Increasingly, countries in continental Europe are showing interest in the potential of biocontrol against invasive weeds that are difficult to manage using traditional approaches such as manual and chemical control. A new regulation requiring the effective management of key invasive species in Europe that is currently being drafted will only increase the pressure to identify safe and effective control methods for invasive weeds. The weed biocontrol research being conducted in the UK is presented, along with the curious case of Azolla biocontrol and its demonstration in continental Europe through the recent RINSE (Reducing the Impact of Non-native Species in Europe) programme. Biocontrol of *Ambrosia artemisiifolia* in Europe is also described and potential future targets for biocontrol research in Europe detailed.

**The gregarious caterpillars of *Euselasia chrysippe* as potential biological control for *Miconia calvescens* in Hawai'i and the Pacific**

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The butterfly, *Euselasia chrysippe* (Lepidoptera: Riodinidae) has defoliating caterpillars that have shown promising specificity in host testing for biological control of *Miconia calvescens* (Melastomataceae) in Hawaii and the Pacific. The Neotropical tree *M. calvescens* is considered one of the world's worst weeds and is a growing problem throughout Hawai'i, several Pacific Islands Nations, and Australia. Due to the scale and rate of spread of the current Miconia invasion and its potential to damage sensitive ecosystems, biological control is thought to be the best strategy for long term management. Gregarious E. chrysippe caterpillars hatch from large egg masses, move, feed and molt together in sibling groups of up to 110 individuals throughout their development. These behaviors are thought to improve feeding on tough leaves, optimize foraging, and deter enemies, while group feeding potentially leads to more effective biocontrol from extensive defoliation. Field observations and no-choice host testing of 73 plant species conducted in the native range of Costa Rica and in the quarantine facility in Hawai'i Volcanoes National Park have indicated sustained feeding only on close relatives of *M. calvescens*. Development of larvae beyond the second instar on intact plants was achieved only on a few close relatives in the tribe Miconieae, while there was no survival on the old-world genera Melastoma and Medinilla. There are no native Melastomes in Hawai'i, and all native and crop species tested have been unacceptable to both neonate and late instar larvae. Host testing of such a wide variety of Melastomataceae and more distant relatives, including economically important species in the Order Myrtales has provided evidence of the suitability of this insect for biocontrol. Here we discuss these results and the challenges developing mass rearing techniques and the future hurtles that must be overcome before release of this promising agent in Hawaii.

**Naturalized flora of the world: geographic distribution of species richness, global flows, taxonomic and phylogenetic structure, widespread invaders**

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Despite intensive research on plant invasions, a robust global database of regional alien floras has been missing up to now. Statements about the importance of plant invasions were thus usually supported by referring sources containing data from only a few regions, and in the vast majority of instances based on species numbers, not the composition of complete alien floras. Here we introduce the Global Naturalized Alien Floras (GloNAF) database covering the whole world, and summarizing information on naturalized floras for over 800 terrestrial regions. Therefore, GloNAF allows us to quantify, for the first time, the global biogeographic and phylogenetic patterns of naturalized alien plants. We now have robust evidence that in total, ~12,000 plant species, which correspond to ~5% of the extant vascular flora, have become naturalized somewhere on the globe. Europe has accumulated the largest number of naturalized species and the Northern Hemisphere is the major donor to other parts of the world. Families that are over-represented among naturalized species are clustered throughout the vascular plant phylogeny. The database also makes it possible to focus on the taxonomic structure of the global naturalized flora, and identify the most widespread species, genera, and families within broad geographic regions and biomes. GloNAF data provide information on patterns that may seem trivial but were not really known up to now; for example, the most widespread aliens are naturalized in ¬~40% of global regions, which corresponds to 15–20% of the world terrestrial area. On a more general level, our results demonstrate, for the first time at the scale of the whole world, that naturalization processes are not random phenomena, but exhibit clear phylogenetic and biogeographic patterns that need to be taken into account in order to progress towards a more thorough understanding of the global drivers of plant invasions.

**Invasive plant species and drought: challenges and opportunities for the restoration of native plant communities**

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The recent prolonged periods of drought in the Western United States, including the Hawaiian Islands, present challenges and opportunities for the control of invasive plants and restoration of native plant communities. We present examples from our research in Hawaii and Southern California that illustrate three interactions that occur between native and non-native, invasive plants during times of drought. First, periods of drought pose a significant barrier to all plant growth. Results from our experimental restoration in a Hawaiian Mamane-Naio woodland where *Senecio madagascariensis* is invasive showed that native and invasive plant recruitment and growth was low during drought. Second, invasive species may exacerbate the effects of drought and other elements of global change on native plant species. We show evidence from an invasion experiment with *Pennisetum setaceum* in a lowland Hawaiian dry forest that the rate of plant invasion was related to the mortality of native plants and an overall reduction in native plant diversity; and that these relationships were strongest in the driest environmental conditions. Nitrogen deposition had a negative effect on a native species, *Stipa pulchra*, and a positive effect on invasive grasses, *Bromus hordeaceus* and *Bromus diandrus* in an experiment in Southern California grassland. In addition, the invasive grasses exacerbated the negative effects of drought and nitrogen deposition on *Stipa pulchra* by reducing soil water availability. These interactions led to a dramatic decline in the native species and resulted in a rapid expansion of the invasive grasses in the experiment. Thus, the potential for invasive species to expand their ranges during drought is a third interaction that may occur. We discuss how some of these interactions may present windows of opportunity for managing invasive plant species, whereas others create conditions that facilitate the spread of invasive plants and create barriers for native plant restoration.

**Invasive giant goldenrod (*Solidago gigantea*) population growth and management**

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*Solidago gigantea* (giant goldenrod) is one of the most serious invasive plants threatening central European natural areas. The population dynamics of this troublesome invader are not well understood, although many studies have examined various important characteristics of this invasive plant. Recent and ongoing studies are improving our understanding of the impacts of management on populations of *S. gigantea*. To understand the consequences of various management techniques on the population dynamics, we combined data from experiments on the demography and spread (via seeds and clonally) with new information on management efficacy. A series of stage-based matrix models were developed for small, medium and large vegetative shoots as well as flowering adult shoots. Models were parameterized for both dryer and wetter sites, as *S. gigantea* survival and reproductive output varies considerably with site characteristics. The population growth rates and elasticities were examined. In the model, *S. gigantea*'s rapid growth was only reduced strongly if control was highly effective. Mechanical control, which is the most typical management, required a nearly 95% stem reduction to halt population growth. The environment influenced the stable age distribution; the more productive wet environment had almost no small vegetative shoots. Population growth rates were most responsive to changes in transition rates between flowering shoots and medium vegetative shoots, and between flowering shoots and large vegetative stems. It appears that very efficient control (high stem density reduction) is required to suppress populations of *S. gigantea* in the long-term, and related work shows that under certain circumstances, these requirements can be met by either chemical or mechanical control.

**Potential distribution and habitat suitability of the new emerging alien species in South Africa.**

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South Africa's natural ecosystems are under threat from invasive alien plants (IAPS) which pose a serious threat to local biodiversity and cultural values and can be costly to control. In South African environmental policy, potential new invasive alien plant species are listed as Category 1a invasive alien plant species. The legislation calls for specific management strategies to control Category 1a IAPS before they become established.  Conservation managers currently face the challenge of determining where new introductions of IAPS are likely to occur, and how they will spread across the landscape. In response to this challenge, the South African National Biodiversity Institute is currently exploring the development and implementation of a management strategy for emerging IAPS in South Africa. Understanding invasive species ecology to identify emerging IAPS and the habitats susceptible to invasion, i.e. potential distribution of the emerging IAPS, is an important precursor for successful management. Using species distribution modelling and vegetation maps, we are determining the habitat suitability for the Category 1a IAPS listed for South Africa. Records of the 1a IAPS species and 19 climatic variables were ere used to fit four climatic models. Models were able to predict suitable climatic areas for 27 species; 21 terrestrial and 6 aquatic species. Results show that The Eastern and Western Cape are the provinces that would host higher number of species compared to the Northern provinces. Regarding to vegetation types, the Grassland, Forest and Azonal vegetation biomes would be the most affected. One of the outcomes from this research include the development of a practical tool to aid decision-making and optimum use of resources in the control and eradication of emerging IAPS in order to conserve biodiversity. This approach may help guide early detection, rapid response and containment of harmful IAPS, both emerging and established, at local and national scales.

**Variable non-native species impact across occurrence gradients offers possibility for site-specific population management**

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The growth and impact of non-native species on the surrounding plant community is likely to vary according to the suitability of the environment in which the population occurs.  Consequently the effectiveness of weed management may also vary along the same gradient, such that management should be directly focused towards more site-specific, population level recommendations. We have created species distribution models, representing a species niche, that include vector and disturbance variables such as roads and land-use, as well as abiotic and biotic variables, at the local scale (e.g. 10 to 30 m scale) for several invasive species in the Greater Yellowstone Ecosystem (GYE). We assessed frequency and abundance of all species along target non-native species probability of occurrence gradients.  Target species abundance increased along their probability of occurrence gradients, while richness and total cover of other species decreased along the same gradient. We cannot prove causality but these results suggest that non-native species are having more impact on the surrounding vegetation when growing at the center of their niche, in the higher probability of occurrence areas. We also imposed a herbicide treatment on target species along the same gradients.  Chemical control of the target weedy species was most effective (i.e. the abundance declined more) when the non-native species was growing at the center of its niche in the high occurrence areas. In some situations effective control of one species resulted in secondary invasion by other non-native species. In an era where the magnitude of non-native invasive species problems far exceed the financial and human resources available for management, such information should be used to prioritize populations for management.

**Is a "model group" focus the key to progress in plant invasion science?**

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Despite substantial progress in many facets of plant invasion science in the last few decades, it is becoming clear that very general explanations and theories are unrealistic goals. Invasions are highly context-specific and further attempts to fit very general models to plant invasions or to find "silver bullets" to guide management are futile.

This presentation discusses the potential value of "integrative invasion science" which involves the examination of model systems, focused meta-analyses and the elucidation of invasion syndromes. This approach posits that the performance of introduced species along the introduction-naturalization-invasions continuum, and opportunities for management, are best understood by studying the roles of biotic, abiotic and human-activity factors as drivers and mediators within closely-related groups of species.

Work conducted over the past decade at the Centre for Invasion Biology in South Africa on a series of "model groups" is reviewed to illustrate the value of this approach. Examples of key model groups that have been studied are Australian Acacia species (c. 1012 species), bamboos (Poaceae; subfamily Bambusoideae; c. 1400 species), bottlebrushes (genus Callistemon; c. 50 species), cacti (Cactaceae; c. 1800 species), eucalypts (genera Angophora, Corymbia and Eucalyptus; c. 800 species), mesquite genus Prosopis; c. 45 species) and pines (genus Pinus; c. 111 species).

Reviews of the introduction and invasion ecology of all these groups yielded interesting, but different, generalizations. Despite the context-dependencies of generalizations that emerge from each model group, findings of these studies are extremely useful for regulating introductions and for guiding management of already invasive groups.


**What we still don't know about invasion genetics**

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We review the past 50 years of invasion genetics to assess what we have learned and what we still don't know, focusing on the genetic changes associated with invasive lineages and the evolutionary processes driving these changes. We now know, for example, that rapid adaptation of invaders is common and generally not limited by genetic variation. On the other hand, and contrary to prevailing opinion 50 years ago, the balance of evidence indicates that population bottlenecks and genetic drift typically have negative effects on invasion success, despite their potential to increase additive genetic variation and the frequency of peak shifts. Numerous unknowns remain, such as the sources of genetic variation, the role of so-called "expansion load", and the relative importance of propagule pressure versus genetic diversity for successful establishment. While many such unknowns can be resolved by genomic studies, other questions may require manipulative experiments in model organisms. Such studies complement classical reciprocal transplant and field-based selection experiments, which are needed to link trait variation with components of fitness and population growth rates. We conclude by discussing the potential for studies of invasion genetics to reveal the limits to evolution and to stimulate the development of practical strategies to either minimize or maximize evolutionary responses to environmental change.

**The impacts of *Andropogon gayanus* (gamba grass) invasion on the fire danger index and fire management at a landscape scale**

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Effective fire management relies on the ability to assess the potential risk that a fire event poses to the community so that fire managers can ensure sufficient resources are available to respond to unplanned fires. Fuel loads are a major contributor to fire risk and any significant changes to fuel load should be incorporated into fire risk models. An example is the invasion of Australia's tropical savannas by the high biomass African grass *Andropogon gayanus* (gamba grass) where fine fuel load in a heavily invaded landscape has increased from 6 tha-1 to 10 t ha-1. Consequently, in 2010, the Bureau of Meteorology created two 20km2 radius 'primary response zones' which are defined areas of dense invasion in the greater Darwin region which fire risk is assessed using the increased fuel load. In this paper, we quantify the effect of the increased (invaded) fuel load on the assessment of fire risk. We do this by modelling the daily McArthur Mark 4 Grassland Fire Danger Index (GFDI) for the fire seasons in 2012 and 2013 using both native (6 t ha-1) and invaded fuel loads. We quantify the consequent cost to fire managers. We show that the number of days with GFDI>50 (the threshold for fire weather warnings & fire bans) increased substantially and the length of the high-risk fire season has extended resulting in substantial increases in fire management costs. This has significant safety and resource implications for the fire management agencies as the area of invasion increases across northern Australia.

**Monitoring the distribution and dynamics of an invasive grass in tropical savanna using airborne LiDAR.**

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The spread of an alien invasive grass (Gamba grass - *Andropogon gayanus*) in the tropical savannas of Northern Australia is a major threat to habitat quality and biodiversity in the region, primarily through its influence on fire intensity. Effective control and eradication of this invader requires better insight into its spatial distribution and rate of spread to inform management actions. We used full-waveform airborne LiDAR to map areas of known A. gayanus invasion in the Batchelor region of the Northern Territory, Australia. Our stratified sampling campaign included wooded savanna areas with differing degrees of *A. gayanus* invasion and adjacent areas of native grass and woody tree mixtures. We used height and continuity based metrics to classify returns from *A. gayanus* and developed spatial representations (1 m resolution) of *A. gayanus* occurrence and canopy cover (10 m resolution). The cover classification proved robust against two independent field-based investigations at 500 m2 ($R^2=0.87$, RMSE = 12.53) and 100 m2 ($R^2=0.79$, RMSE= 14.13) resolution. Our mapping results provide a solid benchmark for evaluating the rate and pattern of *A. gayanus* spread from future LiDAR campaigns. In addition, this high-resolution mapping can be used to inform satellite image analysis for the evaluation of *A. gayanus* invasion over broader regional scales. Our research highlights the huge potential that airborne LiDAR holds for facilitating the monitoring and management of savanna habitat condition.

**Introduction and Establishment of Diorhabda Beetles in Oklahoma as a Biological Control Agent of Tamarix: A Saltatory Process**

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Saltcedar (*Tamarix* spp) is an invasive plant species that was introduced into Oklahoma prior to 1920 and now covers nearly 35,000 hectares of riparian habitat in Oklahoma, mostly in the western third of the state.  In 2009, we attempted to release and establish the beetle, *Diorhabda carinulata*, in the Great Salt Plains Wildlife Refuge of Oklahoma as a biological control agent for Tamarix.  Our initial releases resulted in failed establishment, and in 2010, our permit from USDA APHIS that allowed us to release Diorhabda beetles was rescinded. In 2012, populations of *Diorhabda carinata*, a sibling species that originated from prior releases made in Texas, were first discovered in seven counties in western Oklahoma.  Populations of *D. carinata* expanded to additional areas of Oklahoma, and by 2015, have become established in 19 counties.  Current research is focusing on: determining the level of interspecific genetic exchange among established sibling *Diorhabda* species in the southern Great Plains, studying the adaptation of selected indigenous arthropod predators in utilizing *Diorhabda carinata* as a new, increasingly abundant food source, and documenting the long-term impact of the *Diorhabda carinata* on Tamarix in Oklahoma.

**Removal of invasive grasses and direct seeding of native trees, shrubs and grasses to restore invaded Brazilian savannas (Cerrado).**

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The control of invasive grasses species (IGS) by weeding is highly expensive, especially for species with persistent seed bank and resprout ability. Germination from seed bank and resprouting from roots enable some IGS to recolonize infested areas just after mechanical and/or chemical control efforts. In such situations, restoration efforts to replace invaders by native species are essential for effective control of the invasive populations. We aimed to develop effective techniques to restore a degraded Brazilian savanna ecosystem, dominated by African invasive grasses (e.g. *Andropogon gayanus*, *Urochloa* spp., *Hyparrhenia rufa*). We tested a combination of IGS removal techniques: control burning, herbicide or mowing, followed by plowing. After removing IGS we seeded native species to colonize the area, cover the soil and prevent IGS re-infestation. We seeded eight possible 'covering species' (3 native grasses, 4 shrubs and 1 tree) and planted combinations of these species in 3 densities: 1,250 seeds/m2; 2,500 seeds/m2; and 5,000 seeds/m2. Additionally, 32 native species of trees were seeded. Direct seeding was carried out in November 2013, in 20×20m plots, with three replicates per treatment, in three study areas within Central Brazil. After 18 months (2 rainy seasons), the treatments reduced invasive grass cover from 100% up to 7%. The best 'covering species' was *Lepidaploa aurea* (Asteraceae), which seems to displace IGS by shading them out and/or due to allelopathic effect. A total of 33 native species established through direct seeding in the treated plots (tree densities varying from 13 to 6 plants/m2). Restoration through direct seeding of native species associated with IGS removal techniques can reduce costs and enhance IGS control in savannas, where native grasses are a major component of the ecosystem.

**Tolerance of an invasive plant in a copper saturated environment: Local adaptation as an evolutionary response?**

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The cumulative effects of certain metals in the environment are an important issue to understand how plants face new environmental conditions created by human disturbance. Faced with these new environmental conditions, the persistence of plant populations could be due to phenotypic plasticity or local adaptation. Invasive plants present a rapid evolution of some traits, whether morphological or physiological, where are mainly exposed to stressful or changing environments; this feature could allow that *Eschscholzia californica* colonize highly polluted areas, such as sites localized near mining activities. It is unknown whether the persistence in sites poor in nutrients or with high concentrations of metals in populations of *E.californica* is due to processes of local adaptation or simply the inherent ability to tolerate these conditions. To answer this question, was conducted a reciprocal transplant field and laboratory experiments (common garden) to determine levels of tolerance to heavy metals such as copper. The results of common garden experiments indicate that do not exist a genetic basis of tolerance to copper, regardless the source population was negative effects on the performance of individuals; this effect was greater in extreme levels of copper. At the reciprocal transplant experiments the results were also negative in the contaminated site and this site was stressful for both populations, in the control site seedlings belonging to the contaminated site improve their performance compared to its origin site and compared with seedlings from the same site. Our results indicate that doesn't exist local adaptation in the population exposed to copper nor phenotypic plasticity; there wasn't change in phenotype when comparing populations to varying degrees of stress, therefore the persistence of the population may be explained by other ecological or evolutionary process.

**Nitrogen depositions strongly increase the competitive advantage of invasive ragweed**

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Increases in atmospheric nitrogen depositions form an ecologically highly relevant component of global change. There is increasing evidence that enhanced soil nitrogen levels affect both the invasiveness and competitive potential of invasive species. Ragweed (*Ambrosia artemisiifolia*) is a North American herb which was introduced into China in the 1930s, naturalized and successively became a noxious invasive species. To reveal the impact of nitrogen changes on competition relationships between invasive ragweed and two native species, *Artemisia annua* and *Artemisia mongolica*, replacement series experiments were carried out with three levels of nitrogen addition. The results showed that height growth of the three species significantly increased, but total biomass did not respond to the enhancement of nitrogen levels in monoculture plantings. When planted in mixtures, however, the height and total biomass of some species responded to increasing nitrogen levels; ragweed significantly increased, *Artemisia annua* exhibited no difference, and *Artemisia mongolica* first increased and then decreased with the increase of nitrogen levels. The growth response of ragweed led to a competitive advantage over the two native species. The dynamics of this competition differed at different nitrogen levels: ragweed was a weaker competitor than native species at low levels of nitrogen availability, but was a stronger competitor under high nitrogen levels. Moreover, the competitive effects of ragweed on *Artemisia annua* were stronger than on *Artemisia mongolica*. Nitrogen addition significantly enhanced the competitive ability of ragweed and altered competition relationships between these species, tipping the scales in favor of ragweed. Our study indicated that nitrogen deposition associated with global change may facilitate the invasion of ragweed, and may enhance the vulnerability of native communities to invasion.

**Native allelopathy against alien invaders: a possible ally on the Neotropical savanna restoration**

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Controlling invasive grass species (IGS) is particularly challenging in savanna ecosystems, naturally characterized by the coexistence of native grass, herbs, shrubs and tree species. IGS usually present high regeneration potential, through sexual and clonal reproduction. In savannas, IGS control efforts associated with ecological restoration tend to be more successful. Restoration efforts focused on substituting IGS by trees are not only inadequate, but inefficient since savanna trees are naturally slow growing and are rarely successful competitors against IGS. Therefore, identifying fast growing native species that are able to compete against IGS is key. *Lepidaploa aurea* (Mart. ex DC.) H.Rob. (Asteraceae) is a fast growing (up to 1m tall) perennial shrub, able to reproduce at 5 months age. Within direct seeding restoration experiments in Central Brazil, L. aurea has successfully established and occupied the soil, apparently decreasing IGS establishment and growing success. Facing such promising results in field experiments, we carried out laboratory experiments to investigate if L. aurea produces allelochemical compounds and their effects on other plant species. Water extracts made from L. aurea leaves and roots have alkaloids, phenol and tannin compounds (detected with Anisaldehyde-sulphuric acid reagent [AS]; *Dragendorff reagente* and Iron Chlorine, respectively). Through high-performance liquid chromatography (HPLC), we also identified ferulic acid in L. aurea extracts. We performed germination and initial growth experiments with water extracts from L. aurea leaves and roots in four concentrations (10%; 5%; 2.5%; 1.25%) and control, using four cultivated species (*Solanum lycopersicum*; *Raphanus sativus; Sorghum bicolor; Lactuca sativa*), standardly applied in laboratory trails to detect allelopathic effects. L*epidaploa aurea*'s leaf and root extracts significantly affected germination and initial growth, even at low concentration levels. Initial growth was more affected than germination and leaf extract caused higher inhibition than root extract. Laboratory and field experiments to quantify *L.aurea* effects on IGS are being performed.

**The 5th Edition of "Biological Control of Weeds – A World Catalogue of Agents and Their Target Weeds: Use and Analysis**

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During the past five years, a team of colleagues with support from 125 national and international collaborators has assisted Rachel Winston in a monumental effort that has resulted in the completely revised 5th edition of Julien & Griffiths (1998), "A World Catalogue of Agents and Their Target Weeds". The comprehensive revision and expansion of the catalogue now includes information on 551 biological control agent organisms released on 224 target weeds in 130 countries. The information is based on 2042 release entries and the catalogue uses 2083 cited references. Because of the sheer amount of information we planned from the beginning of the project to also make the catalogue available to users online as an interactive database. In this presentation, we will introduce the new catalogue, and discuss its usability for land management and research, current data analysis focusing on worldwide nontarget effects and target impact, and future upkeep and expansion.

**Alien plant invasion alters carbon cycling in an Australian tropical savanna**

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Gamba grass (*Andropogon gayanus* Kunth.) is regarded as one of Australia's worst weeds because of its invasiveness, its potential for spread across the vast savanna region, and its economic and environmental impacts. In 2008 it was listed as a Key Threatening Process under the Environment Protection and Biodiversity Conservation Act and in 2011, it was listed as a Weed of National Significance. A major impact from gamba grass invasion is increased fuel loads and changed fire regimes in the pyrogenic tropical savannas. This threatens a major carbon offset market in northern Australia, where the Federal government has approved a savanna burning methodology. The methodology provides a financial incentive to both reduce greenhouse gas emissions and increase carbon stores through reduced fire frequency and intensity. We will report on the impact of gamba grass invasion on the above and belowground carbon stores and implications for greenhouse gas emissions. We found that sites invaded by gamba grass had up to a five-fold reduction in the above-ground carbon stores due to the fire-induced death of trees and shrubs. There was also a significant change in belowground carbon stores resulting primarily from the reduction in coarse roots. An increase in fine-roots occurs in invaded areas but does not compensate for the substantial and rapid loss of other carbon stores. The results have significant land management and policy implications in northern Australia; particularly through the threats to carbon offset programs.

**Managing alien invasive grasses in Australia's Kakadu National Park: determining control costs to underpin strategic management planning**

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Para grass (*Urochloa mutica* (Forssk.) T.Q.Nguyen) is an alien invasive grass that forms dense monocultures on Australia's tropical flood¬plains. It is a weed of particular concern for Kakadu National Park managers and the Indigenous Traditional Owners. To inform the design of a large-scale manage¬ment program of para grass in Kakadu, we collected distribution and control data. This information will be incorporated into a weed risk and management model for Kakadu. Here we report on the initial data collection findings.
The large-scale aerial survey to map the distribution of para grass across the Kakadu floodplains showed extensive areas of infestations in a range of density and size classes. The cover of para grass in Kakadu is now estimated to be over 3200 ha. A field trial was established using six management plots (6.25 ha) to estimate the cost and effectiveness of para grass control. The density of infestations ranged from low (1–10%), medium (10–50%) and high (>50%). Fol¬lowing the current 'best practice' management, plots were burnt and sprayed one month later with glypho¬sate. Data including labour, vehicle and chemical costs were recorded. Treatment cost for high, medium and low density plots was approximately $2770, $1150 and $520, respectively. Based on the current distribution of para grass it would cost over $2.3 million for an initial treatment of all infestations in the park. Because of the large costs of this approach, this information is now being used to explore more cost effective management strategies including containment areas and aerial spraying.

**Save Our Forest From Invasive Alien Plant Species**

Titiek Setyawati 1 and Adi Susmianto 2

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Indonesia's forest extends from Sabang to Merauke islands and comprises of more than 13,500 islands, hosting a great number of endemic flora and fauna. It also contains a very diverse unique ecosystem. However, mismanagement of forest causes forest degradation. One among factors affecting forest degradation in Indonesia is the presence of invasive alien plant species (IAPS). Invasive plant species covers weeds and microorganisms posing threats to habitats and the ecosystem, including to other species, when they have established and dominated in new areas. Almost all production and protected forest has been experiencing disturbance from their presence, such as the massive spread of *Chromolaena odorata* that hampers the growth of seedling in plantation forests and *Acacia nilotica* that takes over the only savanna ecosystem in Java. Unfortunately, weak policy instrument and lack of government attention cause to low awareness of all stakeholders, including local communities, in understanding the negative impact of their infestation. In fact, IAS presence can be a sign of poor forest management. Some protected forest is not well managed by relevant government agencies, while production forest is mainly managed by the permit holder with lack of supervision from the government. In addition, lack of information on IAPS has worsened the decision making process once IAPS become serious issue. There is not much being done by people to prevent the massive spread of invasive plant species that have already been introduced, but timber companies participating in forest certification have already done some work to stop IAPS spread. In the context of forest management, a number of strategies to avoid forest degradation from IAPS are proposed.

**Threats of Invasive Alien Plant Species in Indonesia**

Titiek Setyawati 1 and Adi Susmianto 2.

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In the last decade, forest coverage in Indonesia has been declining from 104,747,566 hectares in 2000 to 98,242,002 hectares in 2011. This condition has worsened with more forest land degradation due to global warming and climate change, including increase of forest conversion for industrial purposes. More than 60% of the world's biodiversity is in the forests and at the global level, forest plays an important role to provide various valuable services. One among factors affecting forest degradation is the presence of invasive alien plant species. Invasive plant species habitats and ecosystems, including other species when they have established and dominated in new areas. Their occurrence can be due to intentional or unintentional activities. A number of exotic plant species has been introduced to Indonesia for various purposes such as water hyacinth (*Eichhornia crassipes*) that was first brought in from Brazil in 1886 to Bogor Botanical Garden as an ornamental plant and *Mikania micrantha* that was brought for medicine but later spread out and suppressed the local *Mikania cordata*. Others came in unintentionally as contaminants of coffee seed from Brazil such as *Erechtites valerianifolia* and *Chromolaena odorata*, originally from South America that was accidentally brought in to Indonesia through shipping and trading. Invasive alien species can be easily recognized by these following performances: rapid growth and reproduction, ability to wide spread extensively, highly adaptable either physiologically or capability of surviving with various competitors. Based on recent study, there are at least 362 plant species from 73 families that have been identified as invasive, and extensive research will be proposed to further determine their distribution in Indonesia, including studies on their impacts.

**Reproductive capacity of the new invasive species *Ipomoea carnea* Jacq. in Nile Delta, Egypt**

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*Ipomoea carnea*, a native of South America, became a naturalized species along canals, drains, road sides and field edges in Nile Delta, Egypt. The rapid growth rate, spread, and adaptability from aquatic to xerophytic habitats indicate that it may potentially become another ecological disaster like water hyacinth.  Fifty stands were established to cover seven habitats in Nile Delta (railway sides, waste lands, road sides, drain and canal banks, road dividers and field edges). In each stand, a number of ramets were permanently marked to estimate the monthly variation in its phenology, height and diameter of the ramet canopy; number of flowers, leaves, fruits and inflorescences. The results indicated that its growth follows a seasonal pattern, where it was fastest during September and October. Significant habitat differences were depicted, regarding its growth (e.g. height and crown diameter) and reproductive variables (e.g. number of flowers and fruits). Generally, *Ipomoea carnea* populations along the railway sides and field edges had the lowest means of most of the growth and reproductive variables; while those of the road dividers, road sides and canal banks had the highest. On the other hand, the highest values of most of these variables were attained during September and October, while the lowest were during June and July. The highest flower and fruit production occurred during September to December. The flowering began earlier in some habitats (e.g. road sides and canal banks) and later in some others (e.g. railway sides, road dividers and waste lands). Generally, *Ipomoea carnea* population in the wet habitats (e.g. drain and canal banks) had leaf area larger than those of the other habitats.

**Both direct and indirect allelopathic activities of the invasive plant *Xanthium italicum* might facilitate its invasion success**

Hua Shao

Xinjiang Institute of Ecology & Geography, Chinese Academy of Sciences

The direct and indirect allelopathic effects of the invasive plant *Xanthium italicum* were studied. Our results showed that X. italicum can release volatile organic compounds (VOCs) into the air to suppress seedling growth of amaranth, lettuce, wheat and ryegrass; GC-MS analysis revealed the presence of thirty two compounds in its essential oil, with limonene (51.61%), germacrene B (6.98%), δ-cadinol (5.94%), β-pinene (5.23%), α-caryophyllene (5.1%) and bornyl acetate (3.15%) being the main constituents. Both aqueous and ethanol extracts of *X. italicum* exhibited strong plant growth inhibitory activity on test plants, which led to the isolation and identification of three xanthanolides as the major allelochemicals: xanthinosin, xanthinin and xanthatin; their presence was also confirmed by HPLC in *X. italicum* infested soil. Besides, the aqueous extracts (0.025~0.1 g.mL-1) of *X. italicum* also altered the diversity of soil microorganisms as well as soil enzyme activities and soil nutrients: total bacteria and fungi in treated soils increased significantly, whereas total actinomycetes was consistently lower than the control (distilled water treatment). Biolog analysis revealed that average well colour development (AWCD) of treated soils was lower than the control, and polymer and phenolic acids tended to be the main carbon sources of the microbes growing in treated soils. The aqueous extract of *X. italicum* significantly increased soil available N, available K as well as the activities of soil urease and invertase. Correlation analysis revealed that soil urease activity, soil invertase activity and soil bacteria were positively correlated with each other, whereas soil urease activity was negatively correlated with actinomycetes. Organic matter was correlated with soil urease activity, soil invertase activity and soil bacteria, and soil available N and K were correlated with soil urease activity, soil invertase activity and soil fungi. Our results suggested that both direct and indirect allelopathic activities of *X. italicum* might facilitate its invasion success in China.

**Working smarter, not harder: Disturbance ecology and the management of invasive species**

Katriona Shea

The Pennsylvania State University

Disturbances are ubiquitous in nature, and are believed to be both a cause and a consequence of species invasions.  The need to address the impacts of environmental perturbations is increasingly urgent in the face of anthropogenic alterations to existing disturbance regimes.  I will discuss how a framework involving six interacting aspects of disturbance regimes (frequency, intensity, duration, extent, timing and pace) can be used to study a wide range of issues related to basic and applied invasion ecology. This framework can be used to improve experimental design and biological interpretation in invasive plant systems, which in turn leads to more efficient management. Ongoing research not only informs us about when disturbances are likely to exacerbate invasions, but also lets us assess how we can manipulate disturbances to achieve desired management outcomes.

**Predicting plant invasions under climate change: combining models and experiments to assess the potential risk of alien plants in New Zealand**

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Climate change and plant invasions have been studied extensively as individual factors, but few studies have considered their combined and potentially synergistic impacts. This study aimed to test if climate change may provide opportunities for alien plants to expand into regions where they previously could not survive and reproduce. Using three recently naturalized plants in New Zealand from warmer native ranges as model species (*Archontophoenix cunninghamiana, Schefflera actinophylla* and *Psidium guajava*), we assessed their potential invasiveness under climate change. We modelled potential distributions of these three species under a range of climate change scenarios. To validate the models, we conducted field trails to test whether these alien plants performed as expected in sites of differing climate suitability (as identified by the models). Furthermore, we investigated effects of competition on closely related native species. The species distribution models indicated that the alien plants are likely to expand their range (by 2090) on average by 101% (*A. cunninghamiana*), 112% (*S. actinophylla*) and 70% (*P. guajava*). The field trials showed high performance of the alien plants in the sites identified as suitable, and growth and survival were high even during a severe drought. Moreover, plant biomass and survival generally correlated well with predicted suitability of the models. Additionally, effects of competition from the alien species under high densities were strong compared to intraspecific competition among the native species, particularly for *A. cunninghamiana*. Overall, we found strong evidence of the potential invasiveness of these plants. Combining the results from climate-based models with field trials growing the alien species within and beyond predicted ranges results in more reliable predictions of potential spread. By having higher confidence in the potential risk of new invasive plants, cost-effective management actions can be taken to control alien plants at an earlier stage of their naturalization.

**Invasion biology and the dynamics of biological invasions**

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Biological invasions are a fascinating phenomenon but also pose major threats to biodiversity and ecosystem services. Substantial research effort has been invested to explain why some introduced species become invasive. However, invasion biology has not yet been able to identify general determinants of invasion success, which led some researchers to conclude that invasions are idiosyncratic. Reviewing the literature on invasion biology, we found that although biological invasions continue to be an important research topic in ecology, the proportion of studies considering invasion dynamics was consistently low throughout the last 20 years. We argue that progress in invasion biology rests on the ability to understand large-scale invasion dynamics, that is the population and range dynamics of invaders. We considered recent progress towards a more dynamic invasion biology and identified five key challenges: to understand how demography, biotic interactions and evolution shape invasion dynamics (i) at the early stages of introduction, (ii) during invasive spread and (iii) over long timescales, using data from (iv) small-scale experiments and (v) large-scale observations. Addressing these challenges should not only help to manage biological invasions but should also contribute to a tighter integration of invasion biology with other branches of ecology and evolutionary biology.

**Fine-scale genetic structure within a continuous population of *Lolium* species caused by human-mediated dispersal**

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Human-driven movements of organisms now have more impact on species distribution than the movements of organisms by natural forces. Many worldwide alien plants were introduced accidentally or intentionally through global commerce. A typical example of unintended introduction is weed seed contaminants transported with international grain shipments.
  The genus Lolium includes three economically important species: the perennial *L. perenne* and the annuals *L. multiflorum* and *L. rigidum*. These species are cultivated for forage, lawns and revegetation. Yet, they are also major agricultural weeds worldwide and their seeds are introduced into grain-importing countries as contaminants in imported grain.
 Therefore, we investigated establishment and expansion of *Lolium* species that spilled from imported grain in two international seaports in Japan. We compared the genetic variation of naturalized populations at seaport areas with those of contaminant seeds in imported wheat and cultivated varieties for fodder crops or revegetation materials using SSR polymorphism.
  The genetic structure analysis detected two clusters. All port populations growing within a 2-km radius of unloading areas of imported grain were assigned to the same cluster with contaminant seeds. Whereas, the populations growing at the surrounding areas were assigned to the other cluster, which also included cultivated varieties. This genetic heterogeneity indicated that individuals derived from contaminant seeds were locally established in seaports but individuals derived from cultivated varieties widely were distributed in inlands. Though both types are self-incompatible and can cross each other, gene flow between them is likely to be limited. This study revealed that the fine-scale genetic structure of Lolium species is shaped by trends of international trade.

**Direct and indirect effects of *Hedychium coronarium* J. König (Zingiberaceae) invasions.**

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There is no doubth that biological invasion is a threat to biodiversity. Understand how species become invasive in different environments are essential for controlling invasion processes. *Hedychium coronarium* J. König (Zingiberaceae), native from the Himalayas, was introduced in several countries mainly due to ornamental uses and is considered an invasive plant worldwide. In Brazil, this species is an aggressive herbaceous, specialy in wetlands (wet soils) but we hypothesize that it also presents high invasiveness in riparian communities (dry soils). We studied the morphological plasticity, production and mortality of ramets along two-years at five different sites, decomposition of *Hedychium coronarium* in relation to soil humidity and its influence on the native vegetation through split-plot removal experiments. Rhizomes showed histological responses to different soil moistures, indicating plasticity to colonize wet and dry soils. In wet soils we found great intercellular spaces development while in the dry one, rhizomes presented high starch granules accumulation. Ramet diameter was greater in wet than in dry soils. The number of new ramets in the dry soils was higher during the rainy season while in wet soils the production of new ramets was higher in the dry season. Mortality of ramets was higher in dry than in wet soils, but the number of ramets didn't vary in relation to soil humidity. The in situ and in vitro decomposition experiments demonstrated low mineralization rates comparing with same niche native macrophytes in both wet and dry soils. Removal experiments presented alternations between vegetative or reproductive investments according to soil moisture and species composition. We also note the use of rhizomes as food resource by capybaras during the winter season. So *Hedychium coronarium* can also successfully invade the riparian vegetation.

**Analysis of the invasiveness of African grasses at multiple spatial scales in the Brazilian Savanna**

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Many conservation efforts seek to identify and control causes of biodiversity loss. More or less diverse communities are spatially heterogeneous at different scales, and their diversity may be determined by regional diversity of propagules and also by the proximity of dispersal routes or source of seeds. In Brazilian savanna, hereafter called cerrado, a global biodiversity hotspot, the invasion by exotic grasses is a threat to native species, especially to the highly diverse herbaceous layer. Our goal was to assess whether the effects of two major invasive grasses (*Melinis minutiflora* and *Urochloa decumbens*) in the presence of native grasses is consistent at two spatial scales in a protected area of cerrado in the southeast of Brazil, and to identify pathways of introduction and establishment. We obtained the density of exotic and native grasses in 1 x 1 m plots distributed in four vegetation types of cerrado (fine scale), and in 48m2 hexagonal plots along transects across vegetation types (coarse scale). We estimated the relationship between cover of invasive grasses and cover/richness of native grasses at both scales using Generalized Linear Mixed Models, and analyzed the relation between the cover of invasive grasses and the distance from fire trails in the coarse scale sampling. In both spatial scales we found a negative relationship between density/cover of both invasive grasses and cover/richness of native grasses, but there was no relationship between cover of invasive grasses and distance from fire trail. While our results show that the negative effect of invasive grasses occurs at multiple spatial scales, they also suggest that in this area, distance from paths of invasion drive the invaders' spread, since they could represent pathways of seed dispersal for the regional pool. This study suggests that a focus on the suppression of incipient invasion could be an effective approach against the spread of invasive grasses in the cerrado.

**Invasiveness of *Phragmites australis* as a function of population dynamics, physiology, karyology and response to herbivory: a common garden experiment**

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In this paper we address multiple factors assumed to affect plant invasiveness by using the model grass species *Phragmites australis*. In a common garden experiment, we grew 5 replicates of 100 clones collected from all over the world for three years under standardized conditions. We measured a wide range of plant traits related to demography and population dynamics (shoot emergence, height and density, flowering intensity, above- and below-ground biomass production and allocation, rhizome length), herbivory (aphids, chewing herbivores, stem gallers), physiology (leaf chemistry, toughness, water content, photosynthesis rate, specific leaf area) and karyology (ploidy level, genome size). We explore whether these characteristics can be used to distinguish between native (European, North-American) vs invasive (mainly North-American, and Australian) populations, to obtain insights into ecological, physiological and karyological mechanisms operating during between- and within-continental invasions. We hypothesise that plant traits directly affect invasiveness and are co-shaped by evolutionary history in the population's geographic origin and by environmental variation in the introduced range. In addition, cytology and geography also affect invasiveness indirectly by influencing ecological traits. Disentangling these complex issues can provide novel insights into the mechanisms of invasion at the population level.

**Mapping of two invasive plant species on the island of Sylt in Northern Germany using airborne hyperspectral and LIDAR data**

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The western coast of the island of Sylt in northern Germany mainly consists of protected heathlands. In the last decades, the moss *Campylopus introflexus* and the shrub Rosa rugosa have progressively invaded this ecosystem. While there is previous work on R. rugosa invasions, *C. introflexus* has not been mapped or investigated up to date and is difficult to map with traditional approaches for the whole island, the same applies for early invasion stages of *R. rugosa*.
Advanced hyperspectral and LIDAR remote sensing data in combination with field data may enable us to use a straight-forward mapping approach that requires presence-only data for the target species. Our goals are thus to (1) develop an approach that allows us to map species invasions that are difficult to detect with traditional mapping approaches over large areas and (2) use this approach to create distribution maps for *C. introflexus* and *R. rugosa* on the island of Sylt. These maps are intended to offer the basis for further analysis of the impact of invasions on the heathland and for deriving possible management options.
For this purpose, we collected vegetation data for 120 plots with a size of 3 m x 3 m with different cover fractions of *C. introflexus* and *R. rugosa* across the whole island during a field campaign in 2014. The airborne hyperspectral data (APEX), which were simultaneously acquired in summer 2014, provide 285 spectral bands covering the visible, near infrared and short-wave infrared region with a pixel size of 1.8 m x 1.8 m. The airborne LIDAR data have an average point density of 21 points per square meter. We use these data and a maximum-entropy modeling approach to create distribution maps for the detection of the two invaders. Here, we present the concept, data, and first results of our study.

**Technology for the Prioritization of Weed Populations for Eradication: Desktop and Online WHIPPET**

Gina Skurka Darin

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Land managers often face the problem of having more weed infestations than resources to effectively manage them, and may benefit from using the new prioritization tool, WHIPPET. WHIPPET stands for Weed Heuristics: Invasive Population Prioritization for Eradication Tool. WHIPPET is a post-border risk assessment model designed to prioritize environmental weed infestations for eradication based on potential threats to the surrounding region and feasibility of control, thus helping land managers cost-effectively prevent range expansion of the most potentially damaging weed infestations. WHIPPET utilizes the Analytic Hierarchy Process and is the first weed eradication prioritization tool to take into account not only the inherent characteristics of the weedy species under consideration, but also the location of the infestation on the landscape.

WHIPPET has been used successfully by various California non-profit and government agencies, providing efficiency and defensibility to the prioritization process. At my poster, I will demonstrate how WHIPPET benefits programs in California particularly when used in coordination with other landscape-scale weed management planning tools, such as CalWeedMapper (www.calweedmapper.cal-ipc.org) (see Dana Morawitz's poster).

I believe other eradication programs will benefit from this science-based, repeatable, and transparent decision-making tool for natural resource managers. WHIPPET is available as an online Web application for use in California (www.whippet.cal-ipc.org) and in a desktop software package for use worldwide. Contact Gina at gina.darin@water.ca.gov for a copy, training, or if you have any questions.

**What happens after the animals are gone? Investigating ecosystem function post the removal of non-native ungulates.**

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Throughout the Pacific Island region, land managers fence and remove nonnative ungulates as a first step towards re-establishing desired ecosystem services and management objectives. However, the outcome of animal removal is variable and often does not achieve management goals. Not surprisingly, the trajectory of ecosystem function post animal removal is driven by the underlying ecological processes driving plant community composition, how these processes were influenced by the presence of the nonnative animal, and the degree to which there are legacy affects post animal removal. In this study, we have conducted field and greenhouse experiments to investigate how ecosystem processes, especially nutrient regeneration, change after animal removal and have begun to explore strategies to alter ecosystem nutrient availability to promote desired management outcomes. We have established a paired-plot chronosequence of animal removal and examined a suite of soil physical and chemical properties inside and outside of fenced units in wet forests on the Island of Hawaii. Along this chronosequence, pig removal had large impacts on soils that last for >20 years following pig removal. Specifically, pig removal: (i) improved soil structure via increased soil aggregation, decreased bulk density, and decreased soil moisture; and (ii) enhanced nutrient cycling and availability via increased net N mineralization and increased labile soil carbon and extractable cations in soil solution. We hypothesize that disturbance by feral pigs initially opens the forest understory to invasion by nonnative plants, and that alterations in soil properties facilitates a continued competitive advantage for invasive plants. We have now conducted greenhouse competition experiments assessing the competitive outcome of native and invasive plants over a range of nutrient availabilities. The combined results of these two efforts suggest that management solutions can be best achieved by both the removal of the nonnative animal and techniques (e.g., increasing soil carbon) that slow nutrient regeneration.

**Resilience of plant communities after disturbance in native European and invaded North-American range: species richness, composition and traits**

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Biogeographic comparison of invasive alien species (IAS) can provide important insights into mechanisms of plant invasion. We used this approach to study three species from the Asteraceae family that are native to Europe and invasive in North America. Unlike many IAS that are rare in their native range, the species we selected are dominant and form high-density stands in both ranges: *Cirsium arvense, Leucanthemum vulgare* and *Tanacetum vulgare*. This arrangement allowed us to ask whether the negative impact on resident plant communities that these species have in the invaded range, is also the case in the native range, and compare the magnitude of these impacts. We hypothesize that there might be a fundamental difference in how resident plant communities respond to their dominant species and in community resilience following disturbances. We tested these mechanisms in three experimental sites for each species in each range. The sites were predominantly located in grasslands with at least 50% cover of the dominant species under study, and in each, six blocks with four randomized treatments, i.e. combination of disturbance event and seed addition. The resilience of plant communities after disturbance was followed for three years. We found that the impacts in both ranges differed in dependence on the response of the resident plant community and time available for coevolution with its dominant species. The species richness was generally lower in the invaded range but it is not clear if it was suppressed by the effect of the dominant species itself or as a result of "invasional meltdown" because of the higher proportion of alien species in plant communities in North America. Our results, by combining information on the invader and resident species richness, composition and functional traits changing over time could be of use to restoration practitioners in charge of IAS management.

**The relative impacts of generalist versus specialist herbivores: comparison between native and invasive dominants**

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The enemy release hypothesis (ERH), which argues that introduced plants can become invasive in their new ranges due to their lower regulation by herbivores compared to native counterparts, is one of those in invasion ecology that has often been tested but with different results. Within this study we looked at the effects of insect herbivores (generalists vs specialists) on native and invasive alien plant species (hereinafter IAS) dominated in grasslands of North America. We chose three model species from the Asteraceae family (*Cirsium arvense, Leucanthemum vulgare* and *Tanacetum vulgare*), native to Europe and invasive in North America, which have been studied for two years. We found no shoot and root damage by specialists on *Leucanthemum vulgare* and *Tanacetum vulgare* in the introduced range. Only leaf damage by generalists (especially Orthoptera) was presented. Contrary to that, *Cirsium arvense* was attacked by leaf herbivores, especially introduced species as a biocontrol, e.g. *Cassida rubiginosa*. Flower heads were attacked by Curculionidae (*Larinus* spp.) but this was more profound for native *Cirsium undulatum*, studied as a native dominant species, which had only a few flower heads compared to its IAS counterpart. Due to this, its abundance probably fell during the second year of study. The most often recorded specialist herbivore with the highest attack rates was *Microrhopala vittata* found on native *Solidago* spp. (especially *S. gigantea* and *S. canadensis*). In general, IAS were less attacked than their native counterparts, and that might increase their competitive ability. In addition, it is important to mention that herbivores usually occur in clusters so this might also influence the results although we tried to choose studied specimens randomly.

**Phenotypic Plasticity in invasive *Bromus inermis* and native *Elymus canadensis* in response to moisture variation**

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*Bromus inermis* (smooth brome) is a model invasive for mixed and tall grass prairie ecosystems. In a 2002-2006 study this cool-season perennial was found to comprise 45-49% of plant cover in some areas of tall and mixed grass prairie. According to the invasion triangle, biotic characteristics, site environmental conditions, and external influences interact to allow a successful invasion. Phenotypic plasticity is an invader attribute that is considered a trait of an ideal weed, as it provides the opportunity to expand its ecological niche breadth. This can affect not only the ability to make an initial establishment in a new environment, but also the ability to outperform the existing vegetation over time. In this study, we observe the responses of *B. inermis* under three levels of drought stress, in three different soil types. We create varied drought stresses by watering at 3 frequencies throughout the week to the same amount of total water input. *Elymus canadensis* (Canadian Wild Rye) and *Pascopyrum smithii* (Western Wheat) are two cool season native perennials included in this experiment to compare the strength of phenotypic plasticity between invasive species and native species. By comparing root and shoot biomass of each species between treatments, we discern the ability of each species to adapt to environmental variation. We hypothesize that *B. inermis* will display more phenotypic plasticity than the native grasses. With a better understanding of B. inermis invader attributes, we enable ourselves to form better risk assessments for mixed and tallgrass prairies and selectively manage for plants that are likely to be invasive, and protect prairies from further degradation.

**Snowpack, fire, and forest disturbance: interactions affect montane invasions by non-native plants**

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Montane regions worldwide have experienced relatively low plant invasion rates, a trend attributed to increased climatic severity, low rates of disturbance and reduced propagule pressure relative to lowlands. Manipulative experiments at elevations above the invasive range of non-native species can clarify the relative contributions of these mechanisms to montane invasion resistance, yet such experiments are rare. Furthermore, global climate change and land use changes are expected to cause decreases in snowpack and increases in disturbance by fire and forest thinning in montane forests. We examined the importance of these factors in limiting montane invasions, using a field transplant experiment above the invasive range of two non-native lowland shrubs, Scotch broom (*Cytisus scoparius*) and Spanish broom (*Spartium junceum*), in the rain-snow transition zone of the Sierra Nevada of California. We tested the effects of canopy closure, prescribed fire, and winter snow depth on demographic transitions of each species. Establishment of both species was most likely at intermediate levels of canopy disturbance, but at this intermediate canopy level, snow depth had negative effects on winter survival of seedlings. We used matrix population models to show that an 86% reduction in winter snowfall would cause a 2.8-fold increase in population growth rates in Scotch broom, and a 3.5-fold increase in Spanish broom. Fall prescribed fire increased germination rates, but decreased overall population growth rates by reducing plant survival. However, at longer fire return-intervals, population recovery between fires is likely to keep growth rates high, especially under low snowpack conditions. Many treatment combinations had positive growth rates despite being above the current invasive range, indicating that propagule pressure, disturbance and climate can all strongly affect plant invasions in montane regions. We conclude that projected reductions in winter snowpack and increases in forest disturbance are likely to increase the risk of invasion from lower elevations.

**Australian Acacia seed banks: Wattle lot they got!**

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Australian Acacia are invasive in many parts of the world. These plants change ecosystem structure and functioning, impacting species richness and ecosystem services in their invaded areas. Consequently, significant management efforts have been made to control their invasion. A large obstacle to their effective management, even in the presence of biological control agents, is their ability to accumulate persistent seed banks (28–46355seeds/m2). However, little is known about the seed banks of Australian Acacia, including how seed banks relate to stand characteristics. In an effort to fill this gap, the seed banks of *Acacia longifolia, A. mearnsii, A. pycnantha* and *A. saligna* were investigated in the Western Cape of South Africa where these plants have impacted on a vast area of land. Seed bank size was estimated from 30 surface litter and soil samples at 6-7 sites for each studied species. At each sampling location, stand diameter and density was measured and the presence and effects of biological control agents on seed input determined. Many seeds were located in the litter and soil with an average estimated seed bank size of 85–62000 seeds/m2 for the studied species. Current seed banks of Australian Acacia in South Africa are not residual i.e. they are not the legacy of seed input from before biological control agents were released. Furthermore, released biological control agents did not appear to have a marked effect on the seed banks of their Australian Acacia hosts. Lastly, a statistically significant relationship was observed between the seed bank and stand diameter of these species, providing predictive understanding for managing seed banks in the context of long-term mechanical clearing.

**Researching the Use of Unmanned Aerial Vehicles to Assist Ground-Detection Efforts for Invasive Plant Targets**

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The Big Island Invasive Species Committee (BIISC) focuses on the early detection and removal of a select list of high-risk invasive plant species. Traditionally early detection has been a ground-based effort, and this remains the most complete--albeit labor intensive--practice. However, some landscapes may be too dense for a ground-perspective to capture all surrounding vegetation. BIISC has purchased and modified a consumer U.A.V. (Unmanned Aerial Vehicle) platform in order to research how an aerial-perspective may aid early detection and control efforts. Beginning in October of 2014, BIISC aerially-surveyed for a number of invasive plant targets, including: *Ilex cassine, Morella cerifera, Cryptostegia madagascariensis, Rubus sieboldii, Miconia calvescens*, and *Ulex europaeus*. Generally, these surveys were conducted in northern-southern transects, ranging from 80-500 meters in length and with altitudes ranging from 80-120 feet. Transects were captured with a bottom-mounted camera, recording in 1080p video. Potential targets were detected from these recordings by eye, geo-tagged through inference of the flight time and transect position, and finally ground-truthed in the field. Of the six target species, *I. cassine, M. calvescens*, and *U. europaeus* appear to be the most detectable and have represented our greatest success. Multiple individuals missed by previous ground actions were accurately detected, geo-tagged and controlled. This success may be attributed to both the open-canopy vegetation and comparatively distinct color of these species within their surveyed landscape. Future goals for this research will focus on increasing both the amount of area and target species surveyed, and implementing new technologies to enhance our detection capabilities such as higher resolution cameras, spectral filters, and in-field monitors.

**Protecting endangered and threatened species through invasive plant management at a remote Army installation on Hawaii Island: a 3-pronged approach**

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Pohakuloa Training Area (PTA) on Hawaii Island is a 132,800-acre military training facility, the largest in the Pacific. PTA is classified as a sub-alpine, tropical, dryland forest, one of the rarest ecosystems in the world and home to 20 federally-listed plant and animal species. The management of natural resources at PTA requires an Invasive Plants Program (IPP) to provide support for rare species programs (Botanical and Wildlife) of the PTA Natural Resources Office (NRO). Primary functions of the IPP are to protect federally-listed endangered and threatened species and their habitats from habitat modification and degradation due to competition from invasive plants, wildfires, and changes in fire regime. The IPP Manager and staff develop and implement management actions to address established and incipient invasive plant species and fuels to meet conservation compliance requirements described in Biological Opinions issued for PTA from the US Fish and Wildlife Service. Invasive plant species compete directly with listed plant species for resources, and can modify and degrade their habitats. Invasive plant species also add to fuels loads within the vicinity of listed species, increasing fire risks.  The IPP at PTA NRO is comprised of 3 sections: Vegetation Control; Invasive Plants Survey and Monitoring (IPSM); and Fuelbreak. The Vegetation Control Section strives to create areas around listed plant species free from invasive plant competition with the goal of increasing listed species distribution and abundance. Objectives of the IPSM Section are to detect new introductions of invasive plants before they become established, to eradicate these when possible, and to limit the ecological impacts of certain well-established, highly invasive plant species. The goal of the Fuelbreak Section is to mitigate risks to listed species and their habitats from wildland fire by implementing fuels control in specific firebreaks and fuelbreaks, and by assessing fuel monitoring corridors.

**Accounting for density dependence in weed-biocontol systems**

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Invasive plants often occupy large ranges in the introduced region and consequently, local population dynamics can vary in ways that affect the potential for biological control. Working with the highly invasive annual thistle *Centaurea solstitialis* (yellow starthistle, Asteraceae), we used matrix models to describe how density-dependent survival and population growth rate vary in time and space, and simulations to estimate the impact of biocontrol agents. Age-structured matrix models were parameterized with data collected over four years from invasions at the coast, interior valleys and Sierra Nevada Mountains of California (USA). Asymptotic growth rates across all populations and years varied dramatically with every population experiencing both steep declines and explosive growth. Plant density varied by an order of magnitude across the state and this had a measurable effect on each population's response to biocontrol. We used simulations to estimate the degree to which a biocontrol agent would need to reduce plant survival to control this invader. Strong density-dependent survival in the highest density populations meant that the plant was able to compensate for heavy losses ($\geq 90\%$) to the agent. Weak or non-existent density effects in the low density populations meant that those populations were more susceptible to control by biocontrol agents. In other words, by releasing surviving plants from strong density dependence, the biocontrol agent was least successful where the weed was most problematic. Matrix models coupled with simulations are powerful tools that can improve our ability to select effective biocontrol agents because this approach can estimate the degree to which the agent would need to reduce performance to achieve control, thus establishing a target level of attack against which prospective agents ought to be measured.

**Advanced control practices in the chemical eradication of invasive plants in Hungarian National Parks and Protected Areas (2009 – 2014)**

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Most of the protected areas of Hungary are affected by alien plant invasion which threatens the natural ecosystems, although the level of infection can vary considerably by locality . The sources of invasion are usually the neighbouring mismanaged agricultural lands, forests, abandoned agricultural fields or ruderal weed communities near the protected area.
A large-scale conservation program for the eradication and management of invasive alien plants including habitat restoration began in 2009. This program totals 17 projects covering 8.656 hectares in a number of National Parks and State forests with a budget of 8.5M USD. A considerable number of the most important invasive plants (e. g. *Ailanthus altissima, Robinia pseudoacacia, Asclepias syriaca*) have intensive resprouting characteristics and regenerative capacity, which makes the exclusive use of mechanical control in the case of these species technically unsuccessful. After technical development and large-scale field tests, productive application techniques (such as tree-injection and bark/leaf painting technologies) were developed and applied on large areas for several invasive species. More than 50 herbicides were tested for primary efficacy and resprouting inhibition, with analysis of their impact on the environment and floral rehabilitation after treatment. Subsequently, proper combinations of active ingredients (in most cases including glyphosate-ammonium and metsulfuron-metil base) with appropriate formulations (setting visible colour, surface tension, viscosity of mix and stability of the emulsion) were developed and applied. The resprouting activity of invasive plants was quantified in the first year after the treatments, then if required follow-up treatments were applied. Field studies and monitoring were also carried out to decrease the dosage of herbicides and analyse the environmental impact of leaf-painting and spot spraying techniques. At the end of each of the project terms (usually 3 or 5 years) most of the target species were completely eradicated, the size of survivor patches was insignificant (<0,1% ), and visible environmental damage was not detectable.

**IBIS: International Biosecurity Intelligence System for Early Warning, Better Planning and Rapid Response**

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The Australian Government Department of Agriculture plays the central role in facilitating the import and export of goods to and from Australia, whilst managing the risks to the environment, plant, animal and human health. Intelligence gathering and analysis on emerging and re-emerging pest and disease threats is critical to ensure that these risks are managed effectively. In the past, most of our intelligence gathering and analysis activities were resource intensive manual processes that required individuals to access and scan a vast volume of scientific, industry, and other sources including websites such as PestLens, ProMED and HealthMap. Although these approaches provide accurate information, timely information of greater depth and breadth, together with strategic intelligence analysis is required to effectively manage biosecurity risks. This presentation describes the results of a Centre of Excellence for Biosecurity Risk Analysis research project to develop the International Biosecurity Intelligence System (IBIS; www.biointel.org). IBIS is automated software that gathers near real-time open-source information to develop strategic intelligence on plant and terrestrial/aquatic animal pests and diseases from the World Wide Web. Emerging issues and trends are identified automatically by IBIS or by the user community and are analysed using both human and computer together. IBIS is open for anyone to join, and has attracted an international network of users to promote cross-sector intelligence analysis, crowd-sourced analysis and information sharing.

**The roles of multiple components of propagule pressure in predicting invasion success**

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An important issue in invasion ecologcy is understanding why certain colonization events are successful and why others fail. As invasions become more common due to increased globalization, it is critical to determine what drives this differential success. Currently, the only consistent predictor of invasion success is propagule pressure: the composite measure of the number of introduction events of a species at a specific location (propagule number) and the number of individuals introduced at each event (propagule size). Previous research suggests that increased propagule size and number positively influence invasion success, however the impacts of other aspects of propagule pressure such as the timing of introduction events, the duration of events, and the genetic diversity within colonizing populations remain largely unexplored. Using two model systems, *Tribolium castaneum* (red flour beetle) and *Carduus nutans* (musk thistle), we address how timing, duration and genetic variation, as components of propagule pressure, influence invasion success. For each model system, we used a factorial design of three propagule sizes (15, 30 and 60 seeds/eggs), two genetic treatments (low and high diversity), and six different timing schemes. After one generation, we measured the colonization success for each treatment. For *C. nutans*, we found significant differences among timing schemes and propagule sizes, but did not find that maternal genetics had an effect on colonization success. Colonization success will soon be analyzed for *T. castaneu*m. By comparing the impact of propagule pressure on invasion success in two different model systems with similar experimental approaches, we can better understand how consistently propagule pressure predicts invasion success and which specific components within propagule pressure most drive that success.

**Plant naturalization: from global patterns to regional and local drivers**

Mark van Kleunen

University of Konstanz, Germany

The search for drivers of plant naturalization can be done at global, regional and local scales. Through the Global Naturalized Alien Flora (GloNAF) database, we now have the first overview of the worldwide extent and patterns of plant naturalizations (see presentation by Petr Pyšek). So far, this has revealed that plant naturalizations are not happening at random with respect to geography and taxonomy, and that bilateral trade plays a pivotal role in the distribution of naturalized alien plants around the world.
A major pathway for introduction of alien plants into new regions is horticulture, which might result in the biased introduction of ornamental species with certain characteristics. We used path analysis of trait, introduction and naturalization data to unravel the direct and indirect effects of traits on naturalization success of ornamental plant species in Germany and Great Britain. Furthermore, using a data set of Asian woody species that have been introduced to Europe, we could show that climatic suitability is one of the major drivers of naturalization success. Given that many of the non-naturalized ornamental plants in Europe originate from warmer regions, they may have a head start under climate change (see presentation by Emily Haeuser). Using distribution modelling for almost 800 ornamental species, we have predicted the potential future invasion hotspots in Europe.
While analyses of global and regional databases provide important clues about the potential drivers of plant naturalizations, and could inform management, the actual naturalization process (population establishment) happens at the local community scale. Therefore, I will end my presentation with several examples of local introduction experiments that are currently underway in my group. These studies address the role of functional traits, phylogenetic relatedness and responses to climate change, and should provide insights into the mechanisms driving the local, and consequently regional and global naturalization success of plants.

**Black locust in Central Europe – history, soil composition and vegetation**

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Black locust (BL; *Robinia pseudoacacia*) is able to tolerate extremely diverse soil physical-chemical conditions, from extremely acid to strongly alkaline, and from medium to highly base saturated soils with different subsurface stoniness. The most common soil types are shallow, genetically young soils, such as Cambisols, Leptosols, Arenosols, and coarsely textured Fluvisols; BL prefers well aerated and drained soils, tolerates desiccation but avoids compact and frequently waterlogged soils. On steep slopes, BL grows less vigorously, is stunted and less competitive than drought-adapted native shrubs. Once introduced, BL soon becomes a dominating species and creates specific, highly different stands due to the rapid growth and ability to fixate atmospheric nitrogen. In open biotopes, dense clones of BL create shaded islands, where heliophilous plants are disappearing. Including extremely acid soils, the contribution of nitrates to total nitrogen is much higher than that of ammonium. The key factors affecting the rate of N mineralization are soil reaction and concentrations of exchangeable cations. Excluding alkaline soils, acidification of top soils by nitrification was also documented. In Central Europe, the most invaded habitats include thermophilous grasslands, sandy soils, shrubbery and open azonal forests (natural habitats), and urban-industrial wastelands, fallow lands, disturbed traffic corridors and burnt sites (man-made habitats). There are four types of stands in different soil conditions: (1) species-rich nitrophilous stands on alkaline to acid bedrocks; (2) tall, species-poor grassy stands on strongly acid quaternary deposits; (3) open, mesic stands dominated by *Poa nemoralis* on upper and middle slopes of deep river valleys on siliceous bedrock; and (4) dwarf, shrubby stands on thermophilous rocky slopes. BL high flexibility in habitat conditions and absence of serious natural enemies in secondary range seem favorable for forestry, especially short-rotation energy plantations and soil reclamation, however it poses a danger to biodiversity, prevents restoration after plantation abandonment.

**Plant Invasions and Their Ecosystem-Level Consequences Along Environmental Gradients**

Peter Vitousek

Stanford University

Island ecosystems are widely recognized to be substantially altered by plant invasions, and so to provide useful systems for understanding invasions and their consequences. Many islands, including the Hawaiian Islands, also provide well-defined environmental matrices within which the invasibility of native communities and the potential consequences of invasion can be evaluated. The Hawaiian Islands support remarkable, orthogonal environmental gradients in climate (especially rainfall) and substrate age (and so in soil fertility); the resulting matrix can be used to demonstrate that low-rainfall ecosystems are particularly invasible and particularly subject to fundamental ecosystem-level alteration by invasion. While sites with high soil fertility are generally more invaded than low-fertility sites, invasions of a subset of low-fertility sites (those limited by N availability) have the potential to transform sites from low to high soil fertility. Finally, new remote-sensing technologies offer the potential of detecting not just the presence, but also the consequences, of plant invasions.

**How has theory influenced community restoration? A review of the experimental restoration ecology literature**

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Restoration practitioners often rely on personal experience and established empirical knowledge of their system to tailor cost-effective methods and maximize desired restoration outcomes. Community ecology theory has been increasingly suggested as a tool to supplement empirical knowledge in restoration situations. Much of community ecology theory is concerned with exploring the abiotic and biotic processes that shape and maintain natural communities, and the primary goal of restoration is often to reinstate these processes in degraded ecosystems. Specifically, theory can be used to explore the contingencies of returning communities to pre-disturbance conditions or a desired function once they have reached an alternate state.

Of the restoration ecologists who carry out experimental research, some ground their study design or hypothesis generation in community ecology theory, while other studies are not ostensibly motivated by theory but relate findings to theory *a posteriori*, while others do not make use of theory relative to other sources of knowledge. To date, however, there have been no quantitative descriptions or critical analyses of how community ecology theory has actually influenced experimental restoration ecology as a whole, despite the acknowledged complementarity of these two fields.

To describe the flow of information from ecological theory to experimental restoration ecology, we conducted a literature review of over 1,000 peer-reviewed ecological restoration experiments spanning 25 years. Our study was guided by two basic questions: 1) How often does experimental community restoration invoke community ecology theory? and 2) When theory is invoked, what is the nature and strength of its contribution? (e.g. Was it the conceptual basis? Was it used to justify the interpretation of findings?).

In addition to answering these questions, we gauged the prevalence of certain theories in experimental restoration ecology over time, and determined whether theory is more commonly applied in certain systems.

**Comparison of the vegetative reproductive ability of root fragments originating from seedlings versus root fragments from vegetative reproductive organs of *Solanum carolinense***

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*Solanum carolinense* is a very harmful invasive species in Japan. We aimed to investigate the difference in vegetative reproductive ability between root fragments originating from individuals germinated from seeds and vegetative reproductive organs. Seeds and artificial 3cm-length root fragments were cultivated in soil-filled 1/2,000a Wagner pots on May 22nd, 2013. The emergence of shoots was on June 7th for root fragments and on June 15th for seeds. On the 12th day after emergence, plants were harvested, and the length and diameter of roots were recorded every seven or ten days. The roots harvested were sliced into 3cm-length fragments according to the depth underground and cultivated in Petri dishes filled with soil. The root fragments were covered with 1cm-depth soil and then incubated under natural conditions to determine when the root fragments could reproduce vegetatively. The results indicated the roots of plants originating from root fragments could reproduce vegetatively from July 4th from depths of 1-15cm, while the roots originating from seedlings obtained vegetative reproductive ability from July 26th from depths of 0-12cm. Therefore, the root of *S. carolinense* could reproduce vegetatively ca. 4 weeks after the emergence. Based on the pot experiments, the priority for the removal of *S. carolinense* is to remove the seedlings within two-weeks after germination, when the seedlings did not develop firm thorns and vegetative reproductive ability from root fragments. Furthermore, the removal of roots of *S. carolinense* should be specially underlined due to their potential for fast vegetative reproduction.

**Crowdsourcing Invasive Weed Identification in Kauaʻi's Native Forests**

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1The Nature Conservancy, Hawaii Chapter, Honolulu, Hawaii

The Nature Conservancy (TNC) hosted the "Hawaii Challenge" campaign on TomNod, a crowdsourcing website for imagery analysis run by DigitalGlobe. More than 10,000 volunteers worldwide helped identify invasive Australian Tree Fern and African Tulip in Kauai's native forests. Participants scanned ultra-high resolution aerial photography from Resource Mapping Hawaiʻi (RMH) for suspect weeds, selected the weed from a menu, and clicked on the image to identify it. This innovative collaboration between TNC, DigitalGlobe and RHM brought crowdsourcing to conservation in Hawaiʻi. In just three months, this campaign generated spatial locations of 11,000 Australian Tree Ferns and 500 African Tulip Trees threatening Kauai's watershed. Achieving conservation and outreach/communications outcomes, this campaign successfully farmed out to the masses tedious conservation analysis usually conducted by a couple individuals. With social media and traditional media picking up the story, the campaign served as a successful outreach tool to raise awareness of the threat of invasive species to Hawaiian forests, generating over 2.7 million page views and 1.9 million clicks tagging suspected weeds. Efficacy results of the campaign will also be presented.

**Quantifying mechanical and chemical control methods for non-native *Poa annua* on a sub-Antarctic World Heritage island**

Laura K Williams1,2, Paul E Kristiansen1, Justine D Shaw2,3, Susan C Wilson1, Brian M Sindel1Laura K Williams1,2, Paul E Kristiansen1, Justine D Shaw2,3, Susan C Wilson1, Brian M Sindel1

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The islands of the sub-Antarctic are some of the most protected areas on the planet, however they have not escaped the impacts of humans and over 100 non-native vascular plants have become established in the region. *Poa annua* is the most widespread, invading native plant communities and competing with native species. With future climate change and increased human visitation to the region, invasive species are predicted to present a major threat to the region. Therefore it is essential to gain understanding of the ecology and management of invasive species in the sub-Antarctic. We quantified the efficacy of mechanical and chemical control methods on *Poa annua* on sub-Antarctic Macquarie Island. In situ mechanical disturbance (scalping surface material, hand weeding, hoeing and trimming surface biomass) had little impact on controlling *P. annua* over 2 years, instead promoting its growth at some sites, most likely due to the ability of *P. annua* to withstand heavy disturbance and grazing. The impact of mechanical trials on native species varied with treatment. *Ex situ* chemical control trials identified several herbicides that are effective on *P. annua* and selective against native grass species - glyphosate, rimsulfuron and trifloxysulfuron. Glyphosate was the most effective and selective herbicide and retained high efficacy and selectivity at a quarter of the recommended application rate. This indicates its potential suitability for use in these conservation areas. Ongoing ex situ work will quantify the persistence and mobility of glyphosate in a range of Macquarie Island soils under sub-Antarctic temperatures. Our research will inform management of invasive plants in the sub-Antarctic and Antarctic, and determine the impacts of management on these high conservation wilderness areas.

**Risk Analysis of Grain as a Pathway for Weed Seeds**

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The risk of introducing weeds to new areas through grain intended for processing or consumption is typically less than that from plants or seed for planting. However, within the range of end uses for grain, weed risk varies significantly and should not be ignored. For example, grains that are milled or crushed for human use present low risk whereas grains that undergo minimal or no processing for livestock feed or bird seed present greater risk. Furthermore, special consideration of screenings generated as a by-product of grain cleaning is necessary, as screenings represent a concentration of weed seeds and other foreign material in comparison to the original grain lots from which they are removed.

In this presentation, we discuss pathway risk analysis as a framework to examine the association of weed seeds with grain commodities throughout the production process, from field to final end use. In the field, weed seed contamination of grain is affected by factors such as weed density, height and maturity of weeds at harvest, harvest methods and combine settings. During transport and storage, issues may arise with respect to accidental spills or cross-contamination among conveyances. At the elevator or mill, the effectiveness and degree of grain cleaning are influenced by grain size, shape and density as well as by grade requirements. In cases where different grain lots are blended, uncertainty may be introduced with respect to the species and numbers of weed species found in grain. Finally, there are a variety of grain processing methods tailored to end use, which may also affect the presence and viability of weed seeds. Pathway risk analysis allows each of these stages to be evaluated in order to characterize the overall risk of introducing weeds with particular commodities, and guide regulatory decisions about trade and plant health.

**The theory and practice of incursion response**

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In many countries there has been an increase in efforts to control alien plants before they become widespread invaders. While this is often referred to as early detection and rapid response, it also involves a host of activities where detection is not "early" (e.g. revisiting historical records of naturalization) and where the duration and consistency of the response is as important as its speed (e.g. many eradication programs). We highlight key steps needed for proactive management: 1) predict, prevent, and prepare; 2) determine management options and take action; 3) evaluate management performance and revisit goals. We also discuss important facilitating mechanisms, specifically legislation; strategies and plans; organizational structure; partnership; and communication. This talk is based on the book we are writing entitled "Detecting and managing alien plant invasions: theory and practice" that will be published in 2016. We welcome input and practical examples from conference delegates.

**The status and impact of *Opuntia stricta* in East Africa and its control**

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More then 15 cactus (Family Cactaceae) species are known to have been introduced to East Africa. Of these at least nine species are naturalized and/or invasive. *Opuntia ficus-indica, O. stricta, O. monacantha, O. elatior, O. engelmannii* and *Austrocylindropuntia subalata* are considered to be the most widespread and/or problematic. Opuntia ficus-indica is widely used and cherished for its edible fruit while *A. subalata* is used as a living fence. Biological control agents (*Dactylopius* spp.) have been introduced for the control of *O. monacantha*, and most recently *O. stricta*, while *D. opuntiae* was probably accidentally introduced and is now widely established on *O. ficus-indica. Dactylopius opuntiae* "stricta" biotype was introduced after requests for control from a pastoralist community and wildlife conservancies in Laikipia, Kenya. A socio-economic survey amongst affected communities revealed that, amongst others, *O. stricta* was reducing access to available forage for their livestock and that after prolonged consumption of cactus fruit some livestock would fall ill and eventually die. Similar impacts have been recorded for *O. stricta* in Madagascar. It was also claimed that young elephants died as a result of consuming cactus fruit during a past drought. Other recorded impacts have included increased reproduction rates amongst baboons who readily consume the cactus fruit. Field surveys have also shown that a significant amount of forage is inaccessible to livestock, especially in dense infestations. This presentation reviews the results of the socio-economic surveys and field trials and the impacts of the recently introduced biocontrol agent *D. opuntiae*. We also discuss the attitudes of the public in general towards the biocontrol of cactus in Kenya and the potential for further management interventions.

**The exceptional success achieved with biological control of *Cylindropuntia fulgida* var. *mamillata* using *Dactylopius tomentosa* in South Africa.**

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*Cylindropuntia fulgida* var. *mamillata,* also known as the boxing glove cactus, is a garden escapee which has invaded large areas in the Northern Cape, Western Cape and Limpopo provinces of South Africa and also in parts of Australia.  It is a monstrose form of the chain-fruit cholla (*C. fulgida* var. *fulgida*) and is native to south-western USA and north-western Mexico.  A biotype of the cochineal, *Dactylopis tomentosus* was collected from a closely related cholla, known as *C. cholla* in Baja California Sur which was subsequently introduced into quarantine in South Africa for host-specificity studies. This cochineal biotype, also known as the Cholla biotype, is highly host-specific and shows a high preference for both *C. fulgida* varieties. The first releases were made on *C. fulgida* var. fulgida in 2008 followed by further releases on the boxing glove cactus in 2012.  The results are spectacular and invasions are usually brought under biological control within three years.  Best results are achieved in hot and dry areas.  Several boxing glove infestations are now being monitored to demonstrate population declines.  Two institutions and private landowners are involved in the manual dispersal of the insect to all infestations. The dramatic outcome of this project could be the result of a new association effect which is based on the avoidance of evolved interspecific homeostasis typical of old associations.

**Invasive pioneer plants in China are unlikely to persist during later stages of succession**

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Most invasive plants are pioneer species in China and they appear to only invade areas already disturbed by human activities, such as abandoned croplands, roadsides and forest edges. We used surveys and experiments to assess the ability of  several invasive plants to spread into less disturbed vegetation.  We showed that (1)  invasive plants only occurred within 5 m along forest edges with forest canopy closure of 65%; (2) the seeds of invasive plants, such as *Thysanolaena maxima*, *Chromolaena odorata*, *Crassocephalum crepidioide*s etc, did not germinate under the canopy of forest ecosystems; (3) the population growth of an invasive plant, *Ambrosia artemisiifolia,* was inhibited by grassland plant biodiversity; (4) reproduction and population growth of two invasive plants, *Sonneratia apetala* and *Chromolaena odorata*, were limited by local natural vegetation. Our results imply that invasive plants, which are often pioneer plants in vegetation succession, can not survive through the whole  successional process, and thus, their populations are expected to decline as  succession continues.

**Trait-based design of communities resistant to invasive alien plants: The role of limiting similarity in ecological restoration**

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The invasion of alien species (IAS) contributes to ecosystem degradation and complicates efforts to restore degraded systems. The question arising is whether we can prevent the successful establishment of IAS by designing resistant plant communities. Biotic resistance of the target community can be predicted by means of the limiting similarity theory, which states that IAS will be unlikely to establish if native species with similar traits are present in the resident community.
We tested this theory by creating synthetic plant communities with a design based on single traits or functional groups using specific functional traits related to competitive strength and obtained from trait databases. Hence, we present results from a greenhouse experiment with seed size as plant trait for designing communities resistant to two IAS (large-seeded *Ambrosia artemisiifolia* vs. small-seeded *Solidago gigantea*) that are a challenge for roadside re-vegetation. Here more effective suppression was observed when the natives and the IAS were small-seeded. With large-seeded IAS the suppression was density-dependent and not explained by seed size similarity.
In the second experiment we clustered the native grassland species in three functional groups according to eight traits and introduced the same two IAS. When IAS and native species were sown at the same time, functional group identity was not a significant factor for IAS suppression. In contrast, the suppression could be explained by the presence of particular highly competitive species, among them *Achillea millefolium*.
Together these findings suggest a partial support to the limiting similarity theory. One single trait alone or a cluster of traits may not be the most successful approach for designing communities resistant to IAS. This could be a consequence of failing to include some other meaningful traits, which can also lead to the discussion if we have the right traits available in current trait databases.

**Alien tree invasion into grassland ecosystems: impacts on rangeland condition and livestock carrying capacity**

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Many of South Africa's natural ecosystems have been invaded by invasive alien plants, which typically results in a decline of these ecosystem goods and services. Australian wattle species have been described as the most problematic of all invasive aliens in this regard. We examined the impacts of *Acacia mearnsii* (De Wild) invasion on ecological functioning and productivity of rangelands in South Africa, and the subsequent condition following clearing activities. We located uninvaded, lightly invaded, densely invaded and cleared sites in a grassland ecosystem in the Eastern Cape, South Africa, and examined the impacts of these treatments on forage production. Both light and dense *A. mearnsii* invasions reduced grazing capacity by 56% and 72%, respectively. The clearing of this species was found to improve grazing capacity by 66%, within 5 years. The reduction in grazing capacity following invasion was largely due to reduced basal cover and herbaceous biomass. The clearing of invaded sites was found to increase both basal cover and herbaceous biomass to pre-invasion levels. *A. mearnsii* invasion was found to affect certain soil properties. Under *A. mearnsii* canopy, plant litter, carbon content of the soil and nitrogen concentrations were all found to be elevated. Soil moisture content was found to be significantly lower on densely invaded sites compared with lightly invaded and cleared sites. Overall, this study demonstrates that Acacia invasions have a significant effect on grazing resources, with grazing capacity reduced from 2 to 8 ha required to support one large livestock stock unit on uninvaded and densely invaded sites, respectively. This is likely to have important financial and human well-being repercussions. However, clearing and restoration programs are clearly able to reverse or mitigate these effects. This study therefore supports other ecosystem service provision arguments for clearing alien invasive species.

**Positive invader/soil feedbacks versus community change: insights from California and Hawaii**

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Many invasive species have dramatic impacts on ecosystem processes. It is often hypothesized that these impacts can positively feedback to perpetuate invader dominance leading to seemingly alternate stable states. While positive feedbacks have been shown to occur, questions remain as to their ecological relevance and whether they persist over longer timescales. First, reviews and meta-analyses have shown that negative feedbacks—which favor rarer competitors and lead to community change—are more prevalent than positive feedbacks. Community change may also be the prevailing dynamic if positive feedbacks are not strong enough to overcome non-frequency dependent ecological factors such as population growth rates. Finally, feedbacks may exist early in invasion but fail to be important over time due to fluctuations in the strength of other important drivers of invader abundance. We explore case studies from exotic grass-invaded sites in California and Hawaii that illustrate these points. The introduction of exotic grasses and grazing to Santa Cruz Island, California, converted native shrublands into exotic-dominated grasslands, altering nutrient-cycling regimes. Results from field-based soil transplant experiments showed that plant-soil feedbacks quantified under natural climate and competitive conditions did not match native plant recovery patterns, suggesting that feedback influence is small relative to competition. We also examined plant-soil interactions in Hawaiian woodlands that have been converted to exotic grasslands due to invasion and fire. These grasslands showed feedbacks with soil nutrient cycling that were consistent with ongoing invader persistence. Re-survey of the sites two decades later, however, suggested that plant-soil feedbacks and grass dominance deteriorated over time. In this case, only long-term data were able to correlate feedbacks to community change. We explore how to better predict long-term outcomes of feedbacks generated by invader impacts.

**Consequences of novel plant-insect interactions: a meta-analysis of Lepidoptera and exotic host plants.**

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Investigating the effects of invasive species on native biodiversity is one of the most pressing challenges in ecology. Our goal in this study was to quantify the effects of invasive plants on butterfly and moth communities. In addition, we sought to elucidate the fitness consequences of non-native hosts on lepidopterans. We conducted a meta-analysis on a total of 32 papers representing 81 experiments: 34 lepidopteran performance studies, 14 oviposition preference studies, 13 survival studies, 12 community abundance studies, and 8 community richness studies. Overwhelmingly, we found that performance and survival were reduced for larvae developing on exotic relative to native hosts. At the community level, alien plant invasion reduced the overall abundance and richness of lepidopteran communities. We did not find a relationship between oviposition preference and host origin. Our results suggest that non-native plant species are a threat to native insect biodiversity due to their role as ecological traps.

**Rapid evolution of an invasive pine consistently results in increased invasiveness across six replicated and independent invasions**

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BrazilIt is becoming increasingly evident that rapid evolution is a common phenomenon in biological invasions. For instance, rapid evolution can allow organisms to adapt to novel environments faster than Allee and stochastic effects drive local extinction of introduced populations. A previous study of six naturalized populations of *Pinus taeda* showed that they rapidly evolved and became invasive due to positive genetic provenance-climate interactions. Specifically, certain adapted provenances were able to spread and invade, whereas maladapted provenances tended not to contribute offspring and genes along the naturalization-invasion continuum. Owing to strong selection pressures, we expect that plants at the leading edge of the invasion front will have better fitness than plants nearer or in the original introduction pool. Here, we present preliminary results of a follow-up study showing that the rapid genetic changes these six populations are experiencing during the invasion processes are consistently producing plants with higher mean annual growth rates and/or higher constitutive chemical defenses (e.g., non-volative resin and total phenolics). So far, out of the four analyzed invasive populations, three are evolving higher mean annual growth rates with up to twofold increases from the rear to the leading edges; one population is increasing allocation in constitute defenses, whereas three populations are not changing; two populations are decreasing in specific leaf area, whereas the other two are not changing.

Overall, the observed trend suggests that, in the 40 years since introduction, the invasive populations are successfully adapting to their new habitats, although in different ways. In conclusion, positive genetic provenance-climate interactions have resulted in the evolution of plants with increased invasive potential when compared to past generations. The notion that invasive plants may rapidly evolve greater invasive potential stresses the importance of early detection and rapid responses in invasion management.

**Seed bank and reproductive capacity of *Cenchrus spinifex* Benth., a noxious invasive grass in China, under different farming practices**

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We investigated the seed bank dynamics of *Cenchrus spinifex*, a native of North America, in natural grassland and upland farmland, which are two typical habitats where the plant is found in China. An in-depth study was also conducted on the impact of fertilization, irrigation, mowing and alternative planting on population expansion by *Cenchrus spinifex*. The results showed that: in the two habitats 25 plant species were identified belonging to 12 families, 24 genera were found in the soil seed bank, and the total seed reserves of *Cenchrus spinifex* in natural grassland and upland farmland were respectively, 12,923/ m2 and 8,960 /m2 accounting for 67.7% and 79.7% of the total of each seed bank. The vertical distribution of *Cenchrus spinifex* seeds in the soil in degraded grassland indicated that seeds are concentrated in the topsoil (0～2cm), accounting for 45.7%, while in upland farmland, the soil surface (0～2cm), middle (2～5cm), and lower (5～10cm) depths did not differ significantly t in seed distribution (p> 0.05). The experiments showed that low fertilizer treatment can significantly increase the amount of seeds per plant (p> 0.05), while high levels of fertilization can reduce the amount of seeds; With increased water, *Cenchrus spinifex* seeds were significantly increased (p> 0.05), the average number of seeds under the high level of watering was 2,563/plant, Increased mowing frequency can effectively suppress the growth of *Cenchrus spinifex*; mowing once a week resulted in an inhibition rate of 98%. Planting of sunflower and Jerusalem artichoke can significantly inhibit the growth and seed production of *Cenchrus spinifex* (p＜0.05).

**Effects of *Wedelia trilobata* and *Rhodomyrtus tomentosa* on soil characteristics and microbial biodiversity in South China**

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*Wedelia trilobata* and *Rhodomyrtus tomentosa* are invasive and native in South China, respectively. However, *R. tomentosa* is an invasive plant in Florida and Hawaii, USA. So a comparative study regarding the effects of W. trilobata and *R. tomentosa* on soil characteristics and microbial biodiversity was conducted in situ at Wenchang city, Hainan province, China. In the same landscape area, soil samples from three field plots were compared: invasive *W. trilobata* plot (IP), native *R. tomentosa* plot (NP) and the control plot composed of native *Urena lobata, Paspalum conjugatum, Setaria viridis* and *Setaria plicata* (CP). Results showed :
1) The soil pH decreased to around 4.9 in IP. The contents of soil organic matter, total nitrogen, available nitrogen in IP decreased by 52%, 57% and 61%, respectively; The soil urease activity was reduced whereas catalase activity was higher in IP; IP had significantly decreased microbial biomass-N by 69%. Compared with CP, McInotsh and richness diversity of microbial communities decreased in IP.
2) Compared with CP, NP had increased soil organic matter (about 1.2 times), available nitrogen (about 1.2 times) and available phosphorus (about 6.1 times); Meanwhile, NP had significantly increased activities of urease, protease, cellulose and catalase, as well as higher microbial biomass-C, -N and -P. In addition, NP had increased richness but had decreased Pielou diversity of soil microbial communities.
3) Contents of soil organic matter, total nitrogen and available N, P in IP were significantly lower than those in NP. The activities of urease, protease, cellulose, biomass-C, -N and –P, the McInotsh and richness diversity of microbial communities in IP were also less than those in NP.
The above findings suggested that the alien invasive *W. trilobata* is more aggressive in utilizing soil nutrients and degrading the soil microenvironment than native *R. tomentosa* in China.

**Impacts of *Eichhornia crassipes* (Mart.) Solms stress on the physiological characteristics, microcystin production and release of *Microcystis aeruginosa***

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*Eichhornia crassipes* (Mart.) Solms is effective in assimilating nutrients from eutrophic waters. However, it is an invasive plant, and it is not clear whether *E. crassipes* has an adverse impact on the waters in which heavy blooms of *Microcystis aeruginosa* occur. The objective of this study was to understand the interactions of *E. crassipes* with toxigenic *M. aeruginosa* and the consequences on environmental safety. Thus, the growth, physiological characteristics, microcystin production and release of *M. aeruginosa* influenced by *E. crassipes* were investigated using a co-existence experiment. The risk of microcystin-LR (MC-LR) accumulation in *E. crassipes* was also evaluated. Our results indicated that the cell death of M. aeruginosa occurred at a quicker pace due to the presence of E. crassipes. But the caspase-3 activity of *M. aeruginosa*, as the proxy for programmed cell death, was suppressed significantly by *E. crassipes*. Photosystem (PS) II-Hill reaction in *M. aeruginosa* was not significantly interrupted by *E. crassipes*, but a direct positive relationship between phycocyanin (PC) and algae biomass ($R^2=0.661$, $P<0.01$) and a consistent relationship between phycocyanin/allophycocyanin (PC/APC) ratio in *M. aeruginosa* and algae biomass ($R^2=0.598$, $P<0.01$) were found to be statistically significant. These results suggested that the energy harvest and electron transfer processes in the photosystem of *M. aeruginosa* might be disturbed by *E. crassipes* due to its damage of PC and a change in the PC/APC ratio. After this 12-day experiment, the level of extracellular MC-LR was significantly eliminated from $212.68\pm25.05$ µg·L-1 to $18.98\pm0.35$ µg·L-1and the MC-LR production in *M. aeruginosa* was not stimulated by the influence of *E. crassipes*. The MC-LR level in the whole plants of *E. crassipes* was $3.88\pm0.49$ ng·g-1 FW.