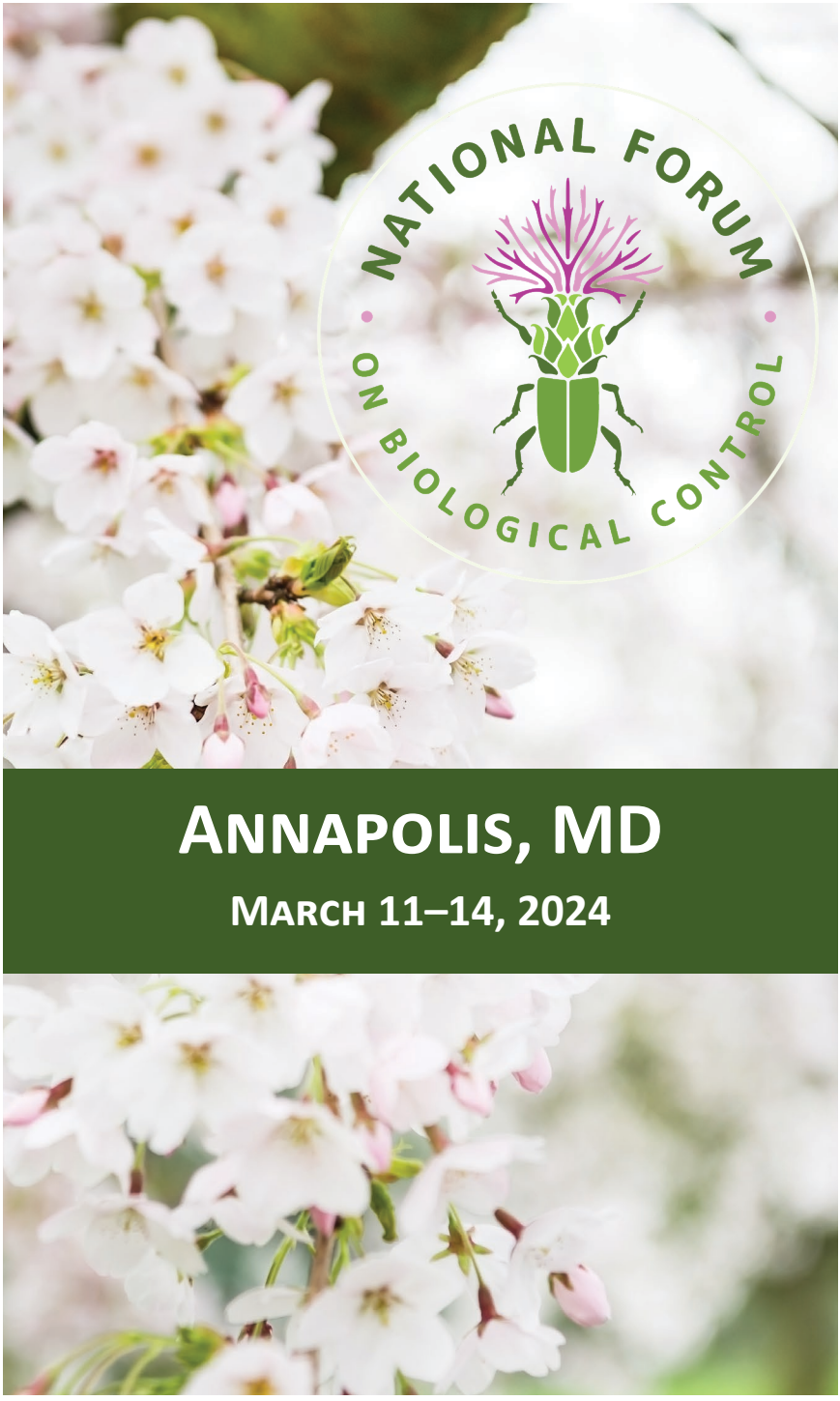

Annapolis, MD

March 11–14, 2024

Welcome

to the Inaugural Bi-Annual
National Forum on Biological Control Conference!

The goal of this conference is to build relationships and synergy amongst leaders in the biocontrol community. It was developed by joint agencies/organizations working on biocontrol (USDA Forest Service, Animal and Plant Health Inspection Service, Agricultural Research Service, DOI Bureau of Land Management, and University of Florida) and is hosted by the USDA Forest Service in partnership with the North American Invasive Species Management Association (NAISMA) and the National Association of State Foresters (NASF).

We're glad you're here!

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AGENDA

All times in EST. All talks in the Grand Ballroom.

Monday, March 11			
	4:00 PM		**Registration (Atrium)**
	5:00 PM		**Welcome Mixer 5:00 – 7:00 (Atrium)**

Tuesday, March 12: Research			
	8:00 AM	Vanessa Lopez	**Welcome and Coffee**
Keynote	8:20 AM	Mark Hoddle	Stepping up to the challenge: proactive biological control of invasive pests
Molecular and Microbial Innovations in Biocontrol	9:00 AM	Paul Rugman-Jones	The utility of DNA for defining the native ranges of pests and focusing natural enemy surveys
	9:20 AM	Marianna Szucs	Using hybridization to increase fitness, climate and host suitability of weed biocontrol agents
	9:40 AM	Matthew Tancos	Incorporating plant pathosystem omics for novel weed management strategies
	10:00 AM		**Networking Break**
Innovations in Biocontrol	10:30 AM	Michael Fulcher	Developing microbiome-based approaches to the discovery and release of microbial weed biocontrol agents
	10:50 AM	Phillip Weyl	Innovative classical biological control research—the big picture
	11:10 AM	Brian Rector	Mites as weed biocontrol agents: challenges and promise
	11:30 AM	Ian Pearse	Comparative and geographic analysis of biocontrol against weeds
	11:50 AM		Panel Discussion: Q & A
	12:10 PM		**Lunch**
Biocontrol Delivery	1:40 PM	Christopher Hayes	Detection and biological control of mile-a-minute weed using *Rhinoncomimus latipes* (Coleoptera: Curculionidae) and drones
	2:00 PM	Carey Minteer	Using drones to assess natural enemy impacts in aquatic systems
	2:20 PM	Jennifer Andreas	Considerations in developing new biocontrol research and development programs
	2:40 PM	Dan Bean	The role of a state facility in biocontrol implementation
	3:00 PM		**Networking Break**

Biocontrol Delivery	3:30 PM	Nicole Sawallich	The EAB biocontrol rearing facility
Chemical Ecology	3:50 PM	Sharlene Sing	Biological control of hybrid toadflax
	4:10 PM	Ikju Park	Unveiling plant signals: challenges and pathways in invasive plant management for sustainable forests
	4:30 PM	Alexander Gaffke	Application of chemical ecology to improve weed biological control
	4:50 PM		**Panel Discussion: Q & A**
	5:15 PM		**Adjourn**

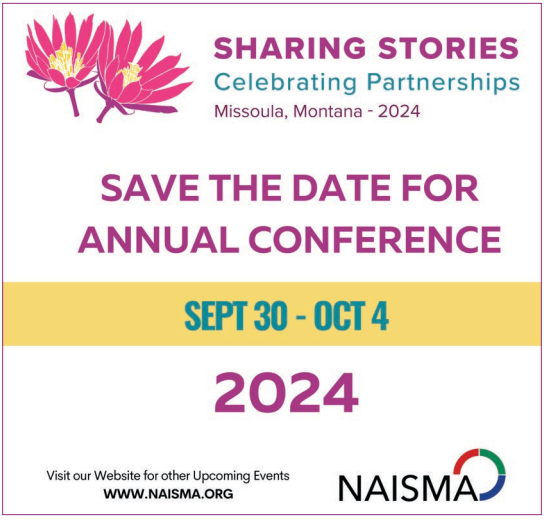
Wednesday, March 13: Management			
	8:00 AM	**Vanessa Lopez**	**Welcome and Coffee**
Keynote	**8:15 AM**	**Dean Brookes**	**Perspectives, opportunities, and challenges for native range research in Asia and Australasia**
Integration: Biocontrol & IPM	8:40 AM	Dave Mausel	Biological control of hemlock woolly adelgid in North America: history, status, and outlook
	9:00 AM	Lyn Gettys	Waterhyacinth herbicides & biocontrol
	9:20 AM	Timothy Morris	Managing emerald ash borer in urban forests via integration of biocontrol and insecticide treatments
	9:40 AM	Carol Randall	Biocontrol and IPM
	10:00 AM		**Networking Break**
	10:30 AM	Andy Sheppard	Integration of grazing management and classical biological control of pasture and rangeland weeds
	10:50 AM	Tim Shively	Doubling up: expanding the benefits of a bioherbicide to mitigate the meltdown of tree-of-heaven and spotted lanternfly
	11:10 AM	Stephen Enloe	Perspectives on weed science, entomology, and biological control, twenty-seven years in the making
	11:30 AM	Aaron David	Fire, herbicide, and biological control: integrative weed management of Old World climbing fern (*Lygodium microphyllum*) in Florida
	11:50 AM		**Panel Discussion: Q & A**
	12:10 PM		**Lunch**
Tools & Techniques for Management	1:40 PM	Michael Stastny	Regional adaptation of integrated pest management to control invasive forest insects
	2:00 PM	Amber Mendenhall	The Utah dashboard for biocontrol mapping and management
	2:20 PM	Ellen Lake	Biological control of mile-a-minute weed and integrating management techniques to restore invaded sites

	2:40 PM		**Networking Break**
Citizen Science & Outreach	3:10 PM	Christy Martin	Dispelling myths and a bad rap: telling the modern biological control story
	3:30 PM	Chuck Bargeron	EDDMapS & iBiocontrol
	3:50 PM	Carla Hoopes	Kids In Action for biocontrol
	4:10 PM	Christie Trifone Millhouse	Empowering invasive species managers with biocontrol tools and education
	4:30 PM		Panel Discussion: Q & A
	4:50 PM		**Adjourn**
	6:00 PM		**Poster Session & Mixer (Atrium)**

Thursday, March 14: Policy & Impacts

	8:00 AM	Vanessa Lopez	**Welcome and Coffee**
Keynote	8:10 AM	Stanley Burgiel	Advancing a biocontrol national agenda
Agency Biocontrol Program Updates	8:30 AM	Robert Simpson	Boots on the ground: state forestry agency perspectives
	8:40 AM	Vanessa Lopez	USDA Forest Service biological control: priorities, challenges, and next steps
	8:50 AM	Michael Grodowitz	ARS perspective
	9:00 AM	Joseph Milan	The DOI biocontrol program
	9:10 AM	Nathan Harms	Weed biological control—an Army Corps of Engineers perspective
	9:20 AM	Ronald Weeks	Overview of APHIS-PPQ biological control program
	9:30 AM	Shiroma Sathyapala	Implementation of biological control for the management of invasive species in developing economies—opportunities and challenges
	9:40 AM		**Networking Break**
	10:10 AM	Ricky Lara	Strengthening the legacy of biological control in California through capacity building
	10:30 AM	Sheri Trent	Fostering communication and collaboration with Native American communities, specifically with the Seminole Tribe of Florida
	10:50 AM	Robert Pfannenstiel	Regulation of biological control in the U.S. by USDA-APHIS: policy and process
	11:10 AM		Panel Discussion: Agency Perspectives
NISC FY24 Work Plan	11: 30 AM	Angela McMellen Brannigan & Bryan Falk	Biocontrol discussion—challenges, opportunities, needs, and next steps

	12:30 PM		**Lunch**
Impacts of Biocontrol Across the Landscape	2:00 PM	Juli Gould	The impact of hymenopteran parasitoids on populations of emerald ash borer and survival of ash trees
	2:20 PM	Kristen Bowers	Economic perspectives on biological control past, present and future
	2:40 PM	Dan Bean	Russian knapweed biological control success with host-specific wasps and midges
	3:00 PM	Jian Duan	Factors affecting the success of classical biocontrol of invasive insect pests: critical insights from Dr. Juli Gould's work
	3:20 PM		**Networking Break**
	3:50 PM	Natalie West	Evaluating the large-scale impacts of biological control on leafy spurge (*Euphorbia virgata*)
	4:10 PM	Michelle Rafter	An Australian perspective on harnessing biological control to manage invasive plants: impacts and future directions
	4:30 PM	Chandra Moffat	Understanding variable biological control of invasive spotted knapweed (*Centaurea stoebe* ssp. *micranthos*)
	4:50 PM		Panel Discussion: Q & A
	5:15 PM		**Closing Remarks & Adjourn**



GENERAL INFORMATION

LOCATION

All conference events are being held at:
The Graduate Hotel
126 West St
Annapolis, Maryland 21401
(410) 263-7777

PARKING

Self-parking at the Graduate Hotel is $28 per night. Valet service with unlimited in and out privileges is $32 per night or $16 for the first four hours and $20 for any additional hours.

Off-site parking is available at parking meters and garages around downtown Annapolis.

An electric car charging station is available adjacent to the hotel.

REGISTRATION

The registration desk will be open in the Atrium:

March 11	4:00PM – 7:00PM
March 12–14	7:30AM – 5:00PM

MEALS

BREAKFAST

A light breakfast will be provided each day in the Atrium 7:45AM – 8:20AM.

LUNCH

Lunches are on your own each day.

COFFEE & NETWORKING BREAKS

Morning and afternoon breaks will include coffee, tea and light snacks.

DINNER

Dinner is on your own each night. Annapolis boasts an eclectic variety of eating options from casual to fine dining and with flavors from around the world.

WELCOME MIXER & POSTER SESSION

Both events will include light refreshments (with vegan options available) and a cash bar.

NATIONAL FORUM ON BIOLOGICAL CONTROL CONFERENCE COMMITTEE

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Special thanks to the National Forum on Biological Control Conference Committee members for their hard work, time, and thoughtfulness in developing this conference. Jodi Hougan (NAISMA) was instrumental in organization and planning, Rachel Winston (MIA Consulting) brilliantly compiled and designed the program, and April Thorne (USDA-FS FHP) joyfully helped with registration planning. Thanks to Christie Trifone Millhouse (NAISMA) for support and guidance, Bob Simpson and NASF for their excellent partnership, and Rick Cooksey and USDA Forest Service, State, Private, and Tribal Forestry, Forest Health Protection for supporting the opportunity to bring together the experts and leaders in this important land management field.

SESSION TALKS

Tuesday, March 12

KEYNOTE

Mark Hoddle

University of California Riverside

Stepping up to the Challenge: Proactive Biological Control of Invasive Pests

Invasive pests represent a perennial threat to agricultural, wilderness, and urban areas. The need to manage invasive pest populations is a considerable long term challenge. A potential management opportunity is introduction biological control, the importation, release, and establishment of host specific efficacious natural enemies. A key strength of this management tool is that introduction biological control can permanently suppress invasive pest populations to levels that no longer cause economic or environmental damage. Introduction biological control programs are initiated after an invasive pest has established, spread, and is causing damage. Host specificity and host range testing of natural enemies for use in an introduction biological control program can take years to complete. This standard response is "reactive" and during this time the target pest population continues to increase, spread, and cause damage. An innovative step forward for introduction biological control is to take a proactive approach to an identified threat. Prior to establishment, "proactive" biological control projects identify pest species that have high invasion potential and are likely to cause economic or environmental damage following successful establishment. In response to this identified threat, host specific natural enemies are identified and approved for release prior to the anticipated establishment of the target pest. Following detection of the target pest and determination that incipient populations cannot be eradicated, natural enemies pre-approved for release are liberated into infested areas. Proactive biological control of invasive pests may significantly reduce post-invasion project development times thereby minimizing opportunities for pest populations to increase, disperse, and inflict damage.

Mark Hoddle is an Extension Specialist in Biological Control, Department of Entomology, University of California Riverside. Hoddle received his B.Sc. (1989), M.Sc. (1991), and D.Sc. (2018) from the University of Auckland, New Zealand and his Ph.D. (1997) from the University of Massachusetts, Amherst. Currently, Hoddle's lab is working on the proactive biological control of spotted lantern fly and development of proactive IPM programs for avocado seed feeding weevils prior to the anticipated incursion of these pests into California. Other current projects on invasive insect pests include work on gold spotted oak borer, South American palm weevil, cotton seed bug, Asian citrus psyllid, and Argentine ant. Hoddle is the director of UCR's Center for Invasive Species Research.

The Utility of DNA for Defining the Native Ranges of Pests and Focusing Natural Enemy Surveys

Paul F. Rugman-Jones
University of California Riverside

The accurate identification of a target pest and subsequently, its natural enemies, is fundamental to the development of any biological control program. Thus, sound taxonomic knowledge is essential for success. In light of the so-called taxonomic impediment (i.e. shortage of taxonomic experts), the advent of DNA barcoding has made identification faster, and more-or-less accessible to anyone. However, the benefits of DNA don't stop there. It can also provide valuable tools for recognizing cryptic species and examining intraspecific variation. Used as a "fingerprint" for an invasive population, it can reveal the true native range of a pest species, and also accurately predict its most likely area of origin from within that native range, thus narrowing the geographic search for coevolved natural enemies. Furthermore, DNA can confirm or refute trophic relationships among pests and their associates.

Dr. Paul Rugman-Jones is a Project Scientist in the Department of Entomology, University of California Riverside. His research focuses on the development of molecular markers and PCR-based techniques for the identification and characterization of insect pests and their natural enemies, within the broader context of invasive species management and biological control. Beyond simple identification, Dr. Rugman-Jones employs these markers to investigate species boundaries, the genetics of populations, and to identify the source of invasive pests. He is currently involved with collaborative projects investigating the potential for classical biological control of diamondback moth and invasive ambrosia beetles in California.

Using Hybridization to Increase Fitness, Climate and Host Suitability of Weed Biocontrol Agents

Marianna Szucs[1], Brianna Foster[1], Andrew Yoshimoto[1], Ruth Hufbauer[2]
[1] Michigan State University, [2] Colorado State University

Incorporation of evolutionary principles into the science and practice of biological control could **strengthen** biocontrol programs by increasing establishment success, impact, and the resiliency of agents in the face of rapid environmental change. The use of intentional intraspecific hybridization to increase genetic diversity and create novel genotypes is an emerging new direction in biocontrol. It provides **opportunities** to enhance the fitness and adaptive ability of agents, however, this approach faces **challenges** because of concerns that it might lead to non-target effects. Two examples are presented of how hybridization may benefit biocontrol programs. For biological control of swallow-wort vines (*Vincetoxicum* spp.), we are releasing a defoliating moth, *Hypena opulenta* that spent over a decade in quarantine. To alleviate potential inbreeding in our laboratory colony and to increase chances of adaptation to the local climate we crossed our *H. opulenta* colony with individuals collected from a field-established population in Canada. Experiments indicate that the outbred colony created by these crosses has higher fitness than either the pure Canadian population or our laboratory colony. For biological control of knotweeds (*Fallopia* spp.), we are exploring how hybridization between two host races of *Aphalara itadori* alters preference and performance on different knotweed species and whether hybrids may be best suited for releases in lower Michigan. The **next steps** are to test how the positive effects of hybridization observed under laboratory conditions may translate to any improvements in biocontrol in the field. More studies are **needed** to better understand the effects of hybridization on host range.

Marianna Szucs received her Ph.D. in entomology from the University of Idaho and worked as a postdoctoral researcher at Colorado State University. She has been an assistant professor in the Department of Entomology at MSU since 2018. Her research focuses on developing, implementing, and monitoring biological control of invasive weed and insect pests. Research in the lab integrates contemporary ecological and evolutionary theory with the aim to increase the success and safety of biological control programs by better understanding how to collect, rear and release biological control agents to maximize their establishment success, population growth, and potential to adapt and spread in novel environments.

Incorporating Plant Pathosystem Omics for Novel Weed Management Strategies

Matthew A. Tancos
USDA-ARS FDWSRU

Leveraging advancements in molecular biology to augment classical biological control provides a unique opportunity to enhance modern weed management strategies through the incorporation of novel genetic tools. Scientific advancements in omics-based technologies, i.e., genomics, transcriptomics, proteomics, and metabolomics, can be utilized to develop innovative weed management methodologies, such as RNAi and gene drives. However, the successful incorporation and deployment of genetic biocontrol tools require greater omic resources for numerous, poorly studied weed pathosystems. Current research is utilizing whole genome sequencing and transcriptomics to identify gene drive targets against the invasive weed common tansy (*Tanacetum vulgare*) and evaluating the specificity and efficacy of topical double-stranded RNA (dsRNA) applications on the recently sequenced weed garlic mustard (*Alliaria petiolata*). Additionally, omics-based technologies are critical to characterizing the pathogens that exploit these invasive weeds for use in developing risk assessments, strain tracking, and the identification of novel agents and/or weed-specific toxins. For example, the genome of the fungal pathogen *Ramularia crupinae* was recently sequenced to improve diagnostic strategies following field releases and assess *R. crupinae* and common crupina (*Crupina vulgaris*) interactions. Moreover, insights into pathogen host range and genome plasticity can be inferred and used to assess host jump risks through comparative genomics. Risk assessments become critical when investigating promising biocontrol agents that are related to crop pathogens, such as the bacterial pathogen *Xanthomonas campestris*. Through the incorporation of weed pathosystem omics, new methods and tools can be leveraged to increase the efficacy of weed management strategies across diverse agroecosystems.

Matthew Tancos is a Research Plant Pathologist with United States Department of Agriculture – Agricultural Research Service (USDA-ARS) located at the Foreign Disease-Weed Science Research Unit (FDWSRU) in Fort Detrick, Maryland. He is originally from Northwest Indiana and received his B.S. in Biology, specializing in genetics and ecology, from Ball State University. He received his Ph.D. in Plant Pathology & Plant Microbe Biology from Cornell University in 2016. Matthew then researched the bacterial plant pathogen select agent, *Rathayibacter toxicus*, while a USDA-ARS postdoctoral researcher at the FDWSRU. Matthew's research program is investigating the use of plant pathogens as biological control agents to manage invasive weeds in the United States, characterizing pathogen emergence and evolution in our agroecosystems, and investigating novel molecular-based invasive weed management strategies.

Developing Microbiome-Based Approaches to the Discovery and Release of Microbial Weed Biocontrol Agents

Michael Fulcher
USDA-ARS FDWSRU

Invasive weeds associate with diverse microbes that may influence the success of plant pathogenic biocontrol agents. Weed biocontrol programs can be improved through additional microbiome research, and three ongoing projects highlight new opportunities for innovation in agent discovery and release. (1) The establishment and efficacy of the foreign fungal pathogen *Ramularia crupinae*, recently released for control of common crupina, is being modeled with a combination of environmental and microbiome data. Newly introduced biocontrol agents must integrate into resident microbial communities, and empirical models using microbiome features could reveal barriers to agent success. (2) Endophytic microbes from wavyleaf basketgrass are being evaluated for biocontrol potential based on genetic similarity to taxa identified as core members of the basketgrass microbiome. Focusing on conserved weed-microbe associations may lead to the identification of agents that perform consistently across host and environmental variation. (3) The genomes of microbes collected from garlic mustard are being screened for plant-antagonistic potential to determine whether endophytic communities found in healthy weeds should be considered as a source of biocontrol agents. Plant-associated microbes exist on a spectrum ranging from mutualist to parasite, and their interaction outcomes are highly context dependent, so this project aims to find apparently non-pathogenic microbes that might be manipulated into antagonizing their host. A lack of information about weed microbiomes in both invaded and native ranges impedes the development of microbiome-enhanced biocontrol approaches, and there is a need to record baseline microbiome measurements during surveys for and releases of microbial biocontrol agents.

Dr. Fulcher is a research plant pathologist working on the development of microbial weed biological control agents at the USDA-ARS Foreign Disease-Weed Science Research Unit on Fort Detrick in Frederick, Maryland. In addition to working on classical and inundative biocontrol projects using foreign and endemic plant pathogens, his research is aimed at developing new pipelines for microbial agent discovery and models for post-release monitoring.

Innovative Classical Biological Control Research–the Big Picture

Philip Weyl
CABI Switzerland

Classical biological control is a method of invasive weed or pest management that involves the introduction of specialist natural enemies from the native range of the pest to control it in its new environment. Classical biological control differs from other forms of biological control in that the goal is to introduce and establish a self-sustaining population of the natural enemy resulting in sustainable control. The aim is not to eradicate the invasive species but rather bring the population below a damage threshold to reduce negative impacts. In recent years, a greater emphasis on safety and efficacy coupled with a stringent regulatory process, has stimulated innovative research in the field improving the understanding of ecological relationships between the agent and the target. Advances in the field include adaptations to traditional host-specificity testing, such as the inclusion of chemical ecology; the use of global datasets to guide decisions on biological control agent selection; modeling to allow for better climatic and biogeographic matching; and the development of techniques to better augment existing processes such as pheromone based approaches and integrated management. Public awareness and education play a crucial role in gaining community support for classical biological control efforts. Innovations in communication strategies help convey the benefits of biological control and foster collaboration between researchers and the general public. Innovative research contributes to the success and sustainability of classical biological control programs, providing environmentally friendly solutions for invasive species management.

Dr. Philip Weyl is an entomologist with CABI where he currently leads a team of researchers in the weed biological control section at the Swiss center, working with existing biological control agents as well as developing new agents for release. This role involves managing approximately 20 projects, mainly for the USA and Canada, but also for Australia and South Africa. He remains active in student supervision, with MSc and PhD students at the University of Neuchatel, Switzerland, CBC, Rhodes University, South Africa and the University of Idaho, USA.

Mites as Weed Biocontrol Agents: Challenges and Promise

Brian G. Rector
USDA-ARS ISPHR

Eriophyidae are exclusively herbivorous, typically monophagous on their plant host species, and often cause important damage to the host. For these reasons, they are frequently sought as potential biocontrol agents for invasive weeds. The past few decades of research into utilizing eriophyid mites as weed biocontrol agents have increased the general knowledge of eriophyid biology and have revealed many challenges that exist in developing and petitioning them for release. This new knowledge has allowed researchers to more efficaciously evaluate eriophyid species as biocontrol candidates but there is still a great deal more to learn.

Dr. Brian G. Rector has worked as a Research Entomologist for USDA-ARS for 24 years, based at the Invasive Species and Pollinator Health Research Unit in Albany, CA since 2022. His current research is focused on classical biological control of invasive annual grasses in the western USA, including the discovery and identification of their natural enemies, followed by evaluation to assess their suitability for importation into the USA as biocontrol agents. Dr. Rector has published 70 peer-reviewed articles in the diverse fields of entomology, acarology, taxonomy, plant pathology, plant and arthropod physiology, apiculture, agronomy, ecology, evolution, molecular genetics, genetic pest management, and biological control. In addition to his working relationships in the USA, Dr. Rector has active collaborations with scientists from Bulgaria, France, Italy, Poland, and Serbia. Most evenings he can be found listening to Boston Red Sox or Bruins games on internet radio.

Comparative and Geographic Analysis of Biocontrol Against Weeds

Ian Pearse
USDOI-USGS FCSC

Biological control against weeds is a widely practiced and often effective method of controlling invasive plants. Enough instances of biological control against weeds have been implemented to allow comparisons among programs in order to understand predictors of successful invasive plant control. At the same time, there is a growing body of geographic information for both invasive plants and their biocontrol agents, which may allow better prediction of where biological control agents will be effective at weed control and where they will not be. Using comparisons of overall success of biological control programs against weeds, it appears that programs against invasive plants that lack close native relatives are more likely to result in some control of the weed, though the likelihood of an agent to establish does not depend on close relatives to the invasive plant. I highlight the growing geographic information on invasive plants and biocontrol agents as well as the major gaps in that knowledge. Niche models demonstrate varying niche overlap between biocontrol agent and target weeds. The INHABIT web tool for the geography of invasive plants in the United States may be extended to include geographic information on biocontrol agents.

Ian Pearse is a research ecologist with the U.S. Geological Survey at the Fort Collins Science Center in Fort Collins, Colorado. Ian works on a variety of topics involving plant-insect interactions including biocontrol, invasive plant geography, and endangered insects.

Detection and Biological Control of Mile-a-Minute Weed Using *Rhinoncomimus latipes* (Coleoptera: Curculionidae) and Drones

Christopher Hayes[1] and Yong-Lak Park[2]
[1]USDA-Forest Service FHP, [2]West Virginia University

Rhinoncomimus latipes Korotyaev is a specialist biocontrol agent of mile-a-minute weed, *Persicaria perfoliata* (L.) H. Gross (Caryophyllales: Polygonaceae). Release of *R. latipes* is challenging with the current visit-and-hand release approach because *P. perfoliata* shows a high degree of patchiness in the landscape, possesses recurved barbs on its stems, and often spreads into hard-to-access areas. We developed a spatially targeted biocontrol strategy by using drones for the detection of *P. perfoliata* and the aerial release of *R. latipes*. A ground survey was performed to locate *P. perfoliata* patches and then a drone was flown at 15 different altitudes to determine the detectability of *P. perfoliata* patches. We developed an insect-release system including a pod that housed *R. latipes* for aerial release. The pod was 3D printed with biodegradable polyvinyl alcohol (PVA), and field tests were conducted to determine the ability of *R. latipes* to escape the pod and assess their post-release mortality and feeding ability. The results of this study showed that *P. perfoliata* patches were readily detectable on the aerial images taken at ≤15 m above the ground. More than 98% of *R. latipes* (n = 118) successfully escaped from the pod within 24 hours after aerial deployment. There were no significant ($P > 0.05$) effects of PVA exposure on the mortality and feeding ability of *R. latipes*. These results indicate that aerial detection of *P. perfoliata* and deployment of *R. latipes* for spatially targeted biological control in hard-to-access areas can be accomplished using a rotary-wing UAS.

Chris Hayes has been working for the USDA Forest Service for 15 years with the last seven years as an Entomologist in Forest Health Protection in State, Private, and Tribal Forestry, Morgantown, West Virginia. Chris's interest in developing uses for unmanned aircraft (drones) for forest health applications has developed though his work in forest health monitoring and aviation. In collaboration with the Park Lab at West Virginia University, Chris has helped steer funding and collaborated on research projects that have included the development of protocols for the use of drone mounted sensors for detection of specific insect and disease-caused tree damage and invasive plants; development of artificial intelligence for mapping insect damage and invasive plant locations from imagery collected from drone mounted sensors; and release of biocontrol agents from drones. Chris is also a USFS drone pilot.

Using Drones to Assess Natural Enemy Impacts in Aquatic Systems

Carey Minteer[1], Usman Mohammed[1], Aditya Singh[1], and Melissa Smith[2]
[1] University of Florida, [2] USDA-ARS IPRL

Waterhyacinth is a floating aquatic plant that invades freshwater systems globally. It impacts human health, navigation, aquaculture, and drastically degrades the health of the aquatic ecosystems it invades. A biocontrol program for this aquatic weed was established in the USA to control water hyacinth and mitigate its effect on freshwater ecosystems. Two weevils, *Neochetina* spp. (Coleoptera: Curculionidae), and a planthopper, *Megamelus scutellaris* (Hemiptera: Delphacidae) were released into the US to control waterhyacinth. Assessing the impact of biocontrol on waterhyacinth is essential in evaluating biocontrol agent efficacy and for making informed management decisions. Traditional methods of survey rely on ground-based visual surveys such as physical searches via transects, grids or points. These methods are subjective, often restrictive, challenging, and time consuming. Remote sensing tools can overcome most of these limitations. Unmanned Aerial System (UAS) based remote sensing can provide a safe, quick, and efficient survey in areas where access is difficult and dangerous for traditional survey methods. We are developing novel, plant-signature based remote sensing technologies to facilitate early detection, monitoring, and impact assessment of invasive pests and their biocontrol agents by collecting hyperspectral and LIDAR data using UAS. We use hyperspectral imagery to track changes in canopy chemistry and use lidar data to monitor changes in foliar biomass brought about by biocontrol agent pressure. We will develop algorithms that accurately assess the density and impact of biocontrol agents in the waterhyacinth system that will be used for making economically and environmentally sound control decisions.

Dr. Carey Minteer received her undergraduate degree in biology from the University of Central Arkansas. She received her master's degree in biology and her PhD in Entomology from the University of Arkansas. Dr. Minteer is now an assistant professor at University of Florida Indian River Research and Education Center where she leads a research program focusing on the classical biological control of invasive plants. Dr. Minteer has worked in the field of biological control for 15 years. Dr. Minteer has particular interests in developing sustainable control methods for invasive plant species, integrating classical biological control with other weed management techniques, and educating the public about invasive species.

Considerations in Developing New Biocontrol Research and Development Programs

Jennifer Andreas
Washington State University

Choosing appropriate invasive plant targets for future biocontrol development projects can be challenging and has been an important topic in recent years for biocontrol researchers and practitioners. Potential target weeds are often determined by assessing the weed's impact, distribution, and the likelihood for effective management using biocontrol. However, funding availability and public or agency interest also play a crucial role in initiating and sustaining a successful biocontrol development program. The flowering rush (*Butomus umbellatus*) biocontrol project has been quite successful with a large consortium, consistent funding from multiple sources, and strong support from the invasive plant community. Strategies that have led to the success of the project and may provide useful insights in planning for future projects will be discussed.

Jennifer received her Master of Science in Entomology from the University of Idaho in 2004 and has worked in biocontrol since 1998 in Canada, Switzerland, Idaho, and Washington. She joined Washington State University Extension in 2005 and leads the Integrated Weed Control Project (IWCP). The IWCP provides biocontrol education and biocontrol agents to land managers and landowners across Washington State. In addition to this work, Jennifer is chair for the Flowering Rush Biocontrol Consortium, co-chair of the Columbia Basin CWMA, member of NAISMA's Classical Biological Control Committee, and conducts research for several weed-biocontrol systems.

The Role of a State Facility in Biocontrol Implementation

Dan Bean, Sonya Daly, Nina Louden, and Kristi Gladem
Colorado Department of Agriculture

The Palisade Insectary was established in 1945 in western Colorado as part of a local effort to combat a peach pest using biological control. Project success resulted in support for biocontrol within the Colorado Department of Agriculture. The Insectary has worked with over 90 biological control agents since then with the mission of providing Colorado with safe and effective means of invasive species control. The ability of the Insectary to achieve these goals depends on cooperation with agricultural producers, municipalities, counties, state agencies, federal agencies, and overseas scientists. In this presentation we will discuss the strengths that cooperative projects bring to our ability to use biocontrol to suppress invasive species. We will point out the challenges of long-term cooperative projects that should be conducted in ecological time but may be restricted to shorter time frames. The availability of safe and effective biocontrol agents, and the generally positive public perception of biological control opens new opportunities for large scale integrated projects. We need to continue long term funding of biocontrol as well as enhance cooperation between groups practicing biocontrol. One major challenge is bringing advances in scientific disciplines such as genomics, remote sensing, chemical ecology, and ecological restoration to institutions doing applied work, such as the Palisade Insectary. The next step should be the inclusion of biocontrol practitioners, basic researchers, and end users of biocontrol within IPM frameworks. Examples discussed include biocontrol of tamarisk (*Tamarix* spp.), Russian knapweed (*Rhaponticum repens*) and yellow starthistle (*Centaurea solstitialis*).

I received a PhD in entomology from the University of Wisconsin, Madison, studying the physiology of an invasive pest, the European corn borer. My early work in insect physiology taught me the need to consider biological relationships in all elements of pest control. I began my career in biocontrol at the USDA-ARS facility in Albany, CA, where I investigated the physiological ecology of the tamarisk beetle and use of that knowledge for suppression of tamarisk. Since 2005 I have been director of Colorado's biological control program, which is part of the Colorado Department of Agriculture, and is headquartered at the Palisade Insectary. I have maintained my interest in using knowledge of insect physiology, behavior and ecology to improve our ability to utilize biological controls. I am also interested in developing better protocols for incorporating biological control into IPM-based weed and pest management strategies.

The EAB Biocontrol Rearing Facility

Nicole Sawallich
USDA-APHIS PPQ

The Emerald Ash Borer (EAB) Biocontrol Rearing Facility began mass producing the parasitoids *Oobius agrili, Spathius agrili* and *Tetrastichus planipennisi* in 2009 in effort to control Emerald Ash Borer (*Agrilus planipennis*) populations in North America. In addition, in 2015 the facility began rearing the parasitoid, *Spathius galinae*. The rearing facility is unique in that, it is the only facility that produces all four of the approved biological control agents for EAB on a mass scale. The parasitoid wasps are reared in EAB eggs or larvae that are produced by adult EAB beetles emerged from felled infested ash trees. Ongoing research is in progress for an artificial diet for EAB, but currently the facility is reliant upon fresh ash logs and leaf resources for parasitoid production. Utilizing EAB and the parasitoids natural life cycle, the rearing facility stockpiles the parasitoids throughout the year in preparation for the release season. The rearing facility continuously moves towards optimizing the production and release standards of the parasitoid wasps. The facility provides parasitoids each year to approved release cooperators and researchers. The rearing facility works in conjunction with state, federal, universities, tribal affiliations, and organizations with a stake in forest health to ensure the parasitoids are released at approved sites and that cooperators will perform concluding recovery work. The parasitoids have been released across 32 states and the District of Columbia, along with four Canadian provinces working towards the goal of maintaining ash as a viable part of North America's landscapes.

Nicole Sawallich is the acting supervisor at the Emerald Ash Borer (EAB) Biocontrol Rearing Facility. Sawallich received her B.Sc. (2019) from Eastern Michigan University in Environmental Science with an Interdisciplinary in Biology. Currently the EAB Biocontrol Rearing Facility mass produces four species of parasitoid wasps that are approved biological control agents for EAB. Sawallich began working at the Biocontrol Rearing Facility in 2019 as a biological science technician and has conducted both laboratory, greenhouse, and field work throughout her employment. Other projects directed through Sawallich at the rearing facility include the refinement of rearing standards to optimize biocontrol production, supporting and advising in EAB biocontrol research, and working towards facilitating release and recovery efforts to assess parasitoid establishment at prior release sites.

Biological Control of Hybrid Toadflax

Sharlene E. Sing[1], David K. Weaver[2], Sarah M. Ward[2], Robert K.D. Peterson[2], Eric Friesenhahn[2], Megan Hofland[2], and Carol B. Randall[3]

[1] USDA-Forest Service RMRS, [2] Montana State University, [3] USDA-Forest Service FHP

The basis of host specificity in weed biocontrol is the long-term shared evolutionary history of a plant species and natural enemy in their common native range. Hybrids of exotic plant species present a significant challenge to this paradigm because the plant targeted for biocontrol is a complex of species crosses and back-crosses, not a single well-defined species. Spontaneous hybridization of the exotic, invasive *Linaria* species Dalmatian toadflax (*L. dalmatica*) and yellow or common toadflax (*L. vulgaris*) has been molecularly confirmed in multiple western U.S. states. Known hybrid infestations have generally increased, often competitively displacing one or both parental species. Habitat suitability modeling has also forecasted that an increase in the occurrence of infestations in locations currently unaffected by hybrid toadflax is likely. Successful biocontrol of hybrid toadflax has thus far been complicated by the rigid fidelity of congeneric agents such as the stem mining weevils *Mecinus janthiniformis* and *M. janthinus* to their original (natural) native range host. Y-tube bioassays using the parental toadflax species, confirmed field-collected hybrids, and hand-pollinated reciprocal cross hybrids detected notable differences in host preference by agent species and sex. Volatile collections from the same array of plants have identified key differences in constituent semiochemical blends. Planned *Mecinus* spp. electroantennography and behavioral bioassays will confirm individual attractant and repellent components in host plant volatile blends. This approach could be adapted to evaluate the potential efficacy of additional current and candidate agents against hybrid toadflax and other targets.

Dr. Sharlene E. Sing is a Research Entomologist based at the Bozeman Forestry Sciences Laboratory, USDA Forest Service - Rocky Mountain Research Station. Her research focuses on developing, evaluating, optimizing, and increasing the use of classical biological control of weeds. Her primary targets include invasive toadflaxes, Russian olive, and saltcedar. This work is influenced by an overarching interest in ecological risk assessment. She also serves as the Chair of the Technical Advisory Group for Biological Control Agents of Weeds (TAG-BCAW).

Unveiling Plant Signals: Challenges and Pathways in Invasive Plant Management for Sustainable Forests

Ikju Park
University of California Riverside

Invasive plant removal is pivotal in managing forest ecosystems in the United States, impacting fuel reduction, pest control, and reforestation efforts. Understanding the intricate signals emitted by invasive plants is essential for effectively deploying biological control agents to reduce the invasive plant populations. However, decoding the signals presents two challenges. While the interconnectivity of biosynthetic pathways for floral scents and pigments is recognized, emphasis has predominantly been on the role of scents in weed biological control programs. Furthermore, the floral microbial community, responsible for transforming nectar contents and potentially enhancing the effectiveness of biological control agents, might not be fully present or understood in controlled settings like laboratories or greenhouses. A comprehensive investigation into such challenges contributes to suppressing invasive plant populations in fuel-reduction areas and bolsters reforestation efforts, which is crucial for sustainable forest management strategies.

Dr. Park is an assistant professor in biological control of invasive pests and weeds at the Department of Entomology, University of California Riverside. His research interest is classical biological control of invasive plants. He has conducted research projects on honey mesquite, houndstongue, musk thistle, and yellow starthistle. Insect Sensory and Behavioral Ecology Laboratory (ISABEL) studies the host recognition mechanisms of weed biological control agents in pre-release risk assessment and post-release monitoring under climate change. ISABEL is also collaboratively involved in mass-rearing and quality assurance of biological control agents such as *Ceratapion basicorne* for yellow starthistle.

Application of Chemical Ecology to Improve Weed Biological Control

Alexander Gaffke
USDA-ARS CMAVE

The use of semiochemicals in pest management programs has become widespread in agricultural systems, and has resulted in multiple success stories. However, few semiochemicals are being utilized to improve the performance of weed biological control agents. In this presentation, strategies to manipulate and modify the behavior of weed biocontrol agents with semiochemicals will be described. Specifically, studies successfully utilizing semiochemicals to establish agents, increase monitoring efficiency, and enhancing damage potential will be discussed. This presentation will highlight the application of semiochemicals in weed biological control and call for more widespread adoption and incorporation of chemical ecology into weed biological control programs.

Dr. Alexander Gaffke is a research entomologist at the Center of Medical, Agricultural, and Veterinary Entomology for the United State Department of Agriculture. His research focuses on the integration of chemical ecology, biological control, and integrated pest management. He has worked with multiple invasive weeds across the country and his research has resulted in the development of novel strategies to improve and enhance biological control programs.

KEYNOTE

Dean Brookes
USDA-ARS Australian Biological Control Laboratory

Perspectives, Opportunities, and Challenges for Native Range Research in Asia and Australasia

The Australian Biological Control Laboratory (ABCL) has conducted native range research on potential biological control agents throughout Oceania and Asia for nearly 40 years. The team has been involved in over 20 major invasive plant projects, and key successes highlight the crucial role that native range research plays in biological control programs. Drawing from the successful program targeting the paperbark tree (*Melaleuca quinquenervia*) in Florida, I will discuss the principles guiding effective agent surveys, prioritization, pre-screening evaluation for quarantine risk assessment, and their integration with other management strategies. I will then explore the opportunities and challenges that have arisen during the early stages of the cogongrass (*Imperata cylindrica*) exploration program and their broader relevance to biological control programs. The potential for fast tracking the discovery of effective agents is considerable, though realizing this potential requires greater integration of research across the native and invasive distributions of target weeds.

Dean Brookes' research background is in ecological genetics and insect-plant interactions in agriculture and biological control. For two years Dean has been working for the Australia Biological Control Laboratory (ABCL), a USDA-ARS overseas laboratory that is partnered with the Australian federal Commonwealth Scientific and Industrial Research Organisation (CSIRO). Dean is currently team leader within ABCL, overseeing the team's research projects, conducting surveys for potential agents throughout Asia and Australia, and building molecular capacity within the team. Dean's current research focus is the broader integration of molecular techniques into biological control to fast-track agent discovery and evaluation, and to better understand the host associations of potential biological control agents across the native and introduced distributions of invasive weeds.

Biological Control of Hemlock Woolly Adelgid in North America: History, Status, and Outlook

Dave Mausel[1] and Biff Thompson[2]
[1] USDA-Forest Service FHP, [2] Maryland Department of Agriculture, retired

Eastern hemlock (*Tsuga canadensis*) and Carolina hemlock (*Tsuga caroliniana*) in eastern North American forests are being severely impacted by the invasive hemlock woolly adelgid (HWA, *Adelges tsugae*, Hemiptera: Adelgidae). A classical biological control program for HWA was initiated in 1992, using insect predators from Asia and western North America where HWA is native. The goal is long-term suppression of HWA populations below damaging levels to prevent tree mortality and help restore damaged forests using IPM strategies (including chemical control, conservation genetics/resistance breeding, silvicultural practices, survey and monitoring). Five of seven predators permitted for release have been recovered in the East. Two species, *Laricobius nigrinus* and *La. osakensis* (Coleoptera: Derodontidae), exhibit large population growth and landscape-level dispersal allowing for a tactical shift from mass-rearing to field redistribution. *Laricobius* beetles significantly impact HWA from fall through spring, but because of high reproductive rates of the HWA progrediens generation in the early summer, populations rebound. Predation is needed on the progrediens, so recent efforts have focused on the silver flies *Leucotaraxis argenticollis* and *Le. piniperda* (Diptera: Chamaemyiidae). In addition, completion of host-range testing of *Scymnus camptodromus* (Coleoptera: Coccinellidae) is planned for potential future release. Challenges to HWA biological control includes the biotic potential of HWA, susceptibility of hemlock, lags in predator population growth, ecosystem complexities, and efforts rearing host-specific predators. Strengths of the HWA IPM program includes the long-term collaboration and dedication among 66 (and growing) federal, state, university, non-profit, and private entities, and sustained federal funding.

Dave was trained in forestry at the Univ. of Massachusetts (BS), and forest entomology at the Univ. of Washington (MS) and Virginia Tech (PhD). He began his career in 2011 establishing a forest health program for a Native American reservation in WI and was hired as the regional forest entomologist for the USFS in 2020. Dave has 27 years of field experience with hemlock woolly adelgid starting with an internship at Harvard Forest in 1997, and he currently serves as the eastern region HWA program coordinator.

Waterhyacinth Herbicides & Biocontrol

Lyn Gettys[1], Melissa Smith[2], and Megan K. Reid[1]
[1] University of Florida, [2] USDA-ARS IPRL

Waterhyacinth [*Pontederia* (=*Eichhornia*) *crassipes*], a South American macrophyte, is considered one of the world's worst weeds and is the most aggressive floating invader in Florida. This floating perennial macrophyte can double its population in as little as 10 days, resulting in habitat degradation, reduced ecosystem services, and disruption of anthropocentric water usage. Waterhyacinth in Florida is managed using a variety of techniques, but the most common method relies on application of herbicides such as 2,4-D, diquat dibromide, penoxsulam, and others. Additionally, several host-specific biocontrol agents for waterhyacinth have been identified and released in Florida. These include the mottled and chevroned waterhyacinth weevils (*Neochetina eichhorniae* and *N. bruchi*, respectively), which were introduced to Florida in the 1970s, and the waterhyacinth planthopper *Megamelus scutellaris*, which was first released in 2010. When biocontrol weevils were released five decades ago, little research was conducted to determine how their presence affected herbicide treatments, but work conducted in the 2000s and 2010s revealed that herbicide rates could be halved with no loss in efficacy if the weevils were present. Current research is evaluating the effects of leaving small populations of waterhyacinth untreated to provide refugia for biocontrol agents. This strategy could be particularly important for the weevils, as they are "place-bound", unable to easily move to untreated plants, and risk drowning when trapped on treated, dying plants. Understanding the interaction between herbicides and biological control agents is important to improve integrated management of waterhyacinth and reduce costs and negative environmental impacts.

Dr. Lyn Gettys (Gettys rhymes with waterlettuce!) is an Associate Professor of Agronomy (Aquatic and Wetland Plant Science) and has been based at the University of Florida IFAS Fort Lauderdale Research and Education Center in Davie since 2012. She holds a bachelor's degree in horticulture from the University of Florida, a master's degree in plant breeding from North Carolina State University, and a Ph.D. in plant genetics from the University of Florida. Dr. Gettys' research focuses on the biology and ecology of native and introduced aquatic and wetland plants and evaluation of control methods for managing invasive species. She is the author or co-author of 70 refereed papers and lead editor of the 2nd, 3rd, and 4th editions of "Biology and control of aquatic plants: a best management practices handbook" published by the Aquatic Ecosystem Restoration Foundation.

Managing Emerald Ash Borer in Urban Forests via Integration of Biocontrol and Insecticide Treatments

Timothy D. Morris[1], Juli R. Gould[2], Theresa C. Murphy[2], Fredric D. Miller[3], John Kaltenbach[4], and Melissa K. Fierke[1]

[1] SUNY Environmental Science & Forestry, [2] USDA-APHIS PPQ S&T, [3] The Morton Arboretum/ Joliet Junior College, [4] Colorado Department of Agriculture

Ash trees (*Fraxinus* spp.) were commonly planted as urban street trees prior to arrival of emerald ash borer (EAB), *Agrilus planipennis* Fairmaire, in the 1990s. Insecticide treatments can provide consistent control of EAB and protect high-value trees; however, control only lasts a few years before reapplication is needed. Biological control of EAB seeks to provide long-term control and several parasitoids have been released, including larval parasitoids *Tetrastichus planipennisi* Yang (Eulophidae) and *Spathius galinae* Belokobylskij (Braconidae). In 2015, we released parasitoids in three cities (Syracuse NY, Naperville IL, and Boulder CO) while simultaneously treating high-value street trees with insecticides. We hypothesized parasitoids would establish on EAB in untreated trees and spread throughout the cities while treated trees remained healthy. We also hypothesized that as available ash was depleted and parasitism increased, EAB densities would fall and biocontrol populations would prevent EAB population growth as insecticide treatments were halted. Three-hundred trees were selected in each city: 100 untreated, 100 treated, and 100 temporarily treated. Untreated trees declined as expected. *T. planipennisi* successfully established in all cities, *S. galinae* established in Syracuse and Boulder. In 2018 a subset of trees was removed from the treatment cycle as EAB densities were low (≤ 10 larvae/m^2). Median crown class of these trees declined from 1 to 2 in 2021–2023. Most trees remained un-infested and retained healthy canopies, those that were infested had high apparent parasitism and low EAB densities.

Tim Morris is a postdoctoral researcher at SUNY Environmental Science and Forestry where he studies the biological control of emerald ash borer. He has previously studied biocontrol agent establishment and impacts and is currently studying their long-term dispersal.

Biocontrol and IPM

Carol B. Randall
USDA-Forest Service FHP

Weed biological control is one of the most economical tools in the integrated weed management tool box, yet it often is overlooked, underfunded, and undervalued. As invasive weeds become more abundant in their invaded range, the ability to adequately address them with chemical, cultural, or mechanical methods decreases and the need for biological control options increases. In this presentation I will discuss weed biological control within the context of the Invasion Curve and as a key component to addressing invasions which have progressed well beyond the Early Detection and Rapid Response phase into the integrated pest management (IPM) stage. I will discuss current challenges weed biological control practitioners face and explore opportunities for land managers to assume a leadership role in fostering weed biological control development and deployment.

Carol Randall is the pesticide use coordinator and weed biological control specialist for the Northern and Intermountain Regions of the US Forest Service. She works with federal, state, local, and private land managers to incorporate weed biological control into existing integrated weed management strategies. She has co-authored a series of technical manuals on the biology and biological control of weeds, most recently the NAISMA weed biocontrol factsheets, and works closely with other weed biocontrol practitioners to increase the availability of weed biological control agents to all land managers.

Integration of Grazing Management and Classical Biological Control of Pasture and Rangeland Weeds

Andy W. Sheppard
CSIRO Australia

Classical biological control of weeds has primarily focused on weeds of grazed rangelands and natural ecosystems many of which are naturally grazed. Grazing has also been widely used as a weed management approach and so it has been a natural step to combine classical biological control and grazing into an integrated management strategy. That pasture and rangeland weeds exist is because such weeds are resistant to grazing vertebrates through being physically (spines) or chemically (vertebrate toxins) protected, giving them an advantage that allows them to dominate such pastures and rangelands. As such using grazing as a management tool for such weeds can be challenging. Grazing management approaches include a) increasing the stocking rate when such weeds are still at relatively low density or during less toxic growth stages to force livestock to graze them to keep weed densities and seeding levels low (e.g. for herbaceous weeds), introducing less selective grazing animals (e.g. goats) at high densities especially for woody weeds like blackberry and spiny leguminous shrubs, or combining the use of herbicides and intensive grazing where this provides better control (so called "spray-grazing"). Grazing can also be used to reduce weed seed set during the flowering period, but this is more of a challenge for spiny over toxic weeds. Classical biological control where successful against pasture and rangeland weeds has introduced highly specialized insect herbivores that either reduce the survival, size or reproduction for the target weed. This talk will address the main ways in which classical biological control and grazing have been successfully used to improve weed management and has, together with judicious use of chemicals, frequently achieved integrated weed management.

Dr. Andy Sheppard is Chief Research Scientist in CSIRO having joined the organization in 1986 based in France. He is based in Australia working on biosecurity and invasive species management and is the non-residential Director of CSIRO's European Laboratory in Montpellier since 2002. Since 2006, Dr. Sheppard has been a CSIRO Research leader of three different programs on plant, animal and environmental biosecurity and terrestrial biodiversity management. He was Research Director in the CSIRO Health & Biosecurity business unit from 2015–2021. Currently, Dr. Sheppard's primary role is a secondment into the Commonwealth Department Agriculture Fisheries and Forestry as Co-Executive Director of DAFF-CSIRO Catalyzing Australia's Biosecurity Initiative after instigating this partnership across both agencies. This $50–$100M Mission is due to launch in mid-2023. He also serves on a number of boards/advisory committees for the Federal Government National Biosecurity Committee and the CSIRO Centre of Australian National Biodiversity Research.

Doubling Up: Expanding the Benefits of a Bioherbicide to Mitigate the Meltdown of Tree-of-Heaven and Spotted Lanternfly

Tim Shively[1], Jacob Barney[1], Leighton Reid[1], Anton Baudoin[1], Carrie Fearer[2], and Scott Salom[3]
[1] Virginia Tech, School of Plant and Environmental Sciences, [2] Virginia Tech, Department of Forest Resources and Environmental Conservation, [3] Virginia Tech, Department of Entomology

Tree-of-heaven (*Ailanthus altissima*), or TOH, is a widespread invasive tree that displaces native vegetation, reduces biodiversity, and is extremely difficult to remove. The tree is also primary host to spotted lanternfly (*Lycorma delicatula*), or SLF, so removal of TOH is a crucial strategy for slowing the spread of SLF. Current management options for TOH are limited, and treatment requires chemical applications to prevent reestablishment by sprouts and suckers. However, TOH is susceptible to a vascular wilt pathogen, *Verticillium nonalfalfae*, which is native to the U.S. and has been petitioned for approval as a commercially available bioherbicide. *V. nonalfalfae* has great potential as a safe and highly effective biocontrol agent, and while research has shown a consistent ability to kill its host, prevent recovery, and spread through a stand for several years, some trials have revealed isolate attenuation. Additionally, selective removal of TOH is likely insufficient to restore heavily invaded sites to a native plant dominated community. Co-located studies at ten sites across Virginia are investigating both the efficacy of a bioherbicide derived from a Pennsylvania isolate and restoration strategies to reduce pressure from other invasive species and bolster native plant communities. Future work will explore means of maintaining consistent and reliable virulence, identify a formulation that is stable, effective, and easy to use, and test the Pennsylvania isolate's efficacy across several states. Relatedly, the effect of TOH suppression on SLF populations as well as SLF's behavior in proximity to diseased and dying trees will need to be investigated.

Tim Shively is a Ph.D. candidate in Virginia Tech's School of Plant and Environmental Sciences. He received his M.S. in Natural Resources and Forestry from NC State after serving eight years as an officer in the U.S. Army. His current work involves large scale field inoculation trials for a bioherbicide to treat the invasive tree-of-heaven in addition to comparing approaches to restore invaded sites to a native plant community. His research interests include forest pathology, plant ecology, and invasion biology. He lives in Blacksburg, VA with his wife and two children.

Perspectives on Weed Science, Entomology, and Biological Control, Twenty-Seven Years in the Making

Stephen F. Enloe
University of Florida

Invasive plants comprise one of the greatest threats to natural ecosystems worldwide. Integrated pest management (IPM) concepts are foundational to successful invasive plant management, and the cultural, physical, biological and chemical tools of IPM are widely utilized. However, there has historically been some unease and even discord between the two key disciplines of invasive plant management, namely entomology and weed science. Although the author cannot point back to a singular event, the discord has been maintained through differences in several key areas. These include the philosophy of pest management practices, concepts of weed control, the maturity of the two disciplines, and limited funding for invasive plant IPM research. This discord has greatly hindered the advancement of IPM to the detriment of land managers, and considerable gaps still exist in our knowledge of IPM for many invasive plants. This talk will explore these dividing issues and propose common ground that can lead to improved collaboration and science to address the ever growing threat of invasive plants in natural ecosystems.

Dr. Enloe is a professor and extension specialist at the IFAS Center for Aquatic and Invasive Plants at the University of Florida. He has been involved with invasive plant research and extension for the past two decades and has worked throughout the western and southeastern United States on developing innovative management strategies for many of the worst invasive tree, shrub, vine, and herbaceous species in the US. Dr. Enloe earned his Ph.D at UC Davis in Plant Biology, a master's degree in weed science from Colorado State University, and an undergraduate degree in Agronomy from N.C. State.

Fire, Herbicide, and Biological Control: Integrative Weed Management of Old World Climbing Fern (*Lygodium microphyllum*) in Florida

Aaron S. David[1], Jessene Aquino-Thomas[2], Andrea Carmona Cortes[2], Logan Crees[2], Quentin D. Read[3], Melissa C. Smith[2], and Ellen C. Lake[4]

[1] Archbold Biological Station, [2] USDA-ARS IPRL, [3] USDA-ARS Southeast Area, [4] Mt. Cuba Center

Old World climbing fern (OWCF; *Lygodium microphyllum*) is a noxious invasive plant in Florida. The vine forms dense mats that smother native vegetation, alter fire behavior, and can climb into the tree canopy, killing mature trees. Two biological control agents have been introduced and established to help manage OWCF infestations: the moth *Neomusotima conspurcatalis* (Lepidoptera: Crambidae) and the mite *Floracarus perrepae* (Acariformes: Eriophyidae). Our research has focused on integrating biological control with other management tactics, particularly fire and herbicide. Specifically, we evaluated (1) biological control agent establishment on OWCF regrowth following management activities, and (2) synergistic effects between biological control agents and herbicide application. In a study of several burned OWCF infestations, post-burn OWCF was naturally colonized by both the mite and moth beginning 5–9 mo postburn. Similarly, in field experiments the mite readily colonized regrowth following herbicide treatment. In a multiyear experiment that manipulated biological control using a pesticide exclusion treatment and herbicide application, we found modest, interactive effects of herbicide and biological control with the mite on OWCF biomass, reproduction (i.e., development of fertile fronds), and vertical climbing. Overall, our findings suggest that biological control of OWCF is compatible with fire and herbicide treatment as part of a broader integrated management strategy. A key challenge that remains is integrating biological control agent dynamics and management plans to optimize control outcomes.

Dr. Aaron David is the Director of Plant Ecology at Archbold Biological Station, a non-profit research institution in south-central Florida. He earned his B.A. from Washington University in St. Louis, and his Ph.D. from the University of Minnesota. From 2018–2021 he was a postdoctoral researcher with USDA-ARS overseeing the mass-rearing, releasing, and monitoring of biological control agents of Old World Climbing Fern (*Lygodium microphyllum*) and conducting integrated weed management research, and, at his current position, he continues to research biological control on several invasive plant species in Florida.

Regional Adaptation of Integrated Pest Management to Control Invasive Forest Insects

Michael Stastny[1], Juan C. Corley[2], and Jeremy D. Allison[3]

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Globalization is increasing the threat of invasive forest insects to ecosystems. Control efforts against the same pest species progressively take place across distant jurisdictions as biological control programs and other management tactics developed in one region are adopted by another. This knowledge exchange speeds up responses and collaboration; however, transplanted biocontrol programs often overlook pre-existing or emerging differences between regions that may explain their varying success. These differences include diverse sources of biological variation in the pest system, environmental conditions, issues of scale and capacity of the response, regulatory environments, and cultural context. We examine the role of these factors in the adoption and outcomes of biocontrol programs and integrated pest management more broadly, drawing from case studies and an online survey of experts on invasive forest insects. We propose an evaluation framework for regional adaptation of biocontrol programs in their adoption in new regions. We recommend strategies, such as an open repository of data that document both successes and setbacks in biocontrol program development and implementation, to reduce risks and to maximize program uptake, efficacy, and resilience in the face of global change.

Michael joined the Canadian Forest Service as a forest insect ecologist in 2016. Since then his research has focused on the management of native and invasive forest insects in eastern Canada, including implementation of the biological control of the hemlock woolly adelgid in Nova Scotia. Coming from a diversified background in community ecology as well as weed biocontrol (tansy ragwort, purple loosestrife), his current work also examines the broader ecological and ecosystem impacts of native pest outbreaks versus the prevention of these natural disturbances. Michael is also studying the responses of insects and their tree hosts to climate change, including in native insect pests whose geographic range expansion is leading to invasive-like consequences.

The Utah Dashboard for Biocontrol Mapping and Management

Amber Mendenhall
Utah Weed Supervisors Association

Biological control has entered a new phase. It is increasingly important to use mapping and strategic planning to implement successful biocontrol and track efficacy. The State of Utah has outlined four areas to focus biocontrol efforts: 1. The establishment of new biocontrol insectaries using an integrated management approach, 2. Tracking of historic biocontrol releases and continued insectary management, 3. Monitoring for efficacy using USFS SIMP protocol, 4. Knowledge transfer to coordinating agencies and land managers to improve biocontrol strategies in Utah and in the western region. Utah has developed a GIS based dashboard to help accomplish our goals. The dashboard uses data submitted by EDDMapS and EDDMapS Biocontrol to represent historic biocontrol efforts and track new projects. Cooperators are able to submit updates using EDDMapS. We plan to use the dashboard to improve insectary maintenance and strategically integrate biocontrol into more noxious weed projects. The Utah Biocontrol Dashboard allows us to visually represent biocontrol projects in a mapping format. We plan to use easy to find statistics and information to assist in the transfer of knowledge to granting agencies, local weed boards and cooperating noxious weed programs. This will help better communicate the success and challenges in our biocontrol program.

Amber Mendenhall has been the biocontrol specialist in Utah since 2005. She has built biocontrol programs for 12 noxious weeds in Utah. She currently works as a private contractor for the Utah Weed Supervisors Association. Amber works with cooperating agencies in several western states to share biocontrol agents and techniques across borders. She coordinates the implementation of new biocontrol strategies in Utah. Amber's priorities are to establish new biocontrol insectaries and assist in integrated pest management strategies that incorporate biocontrol to accomplish weed management goals. She focuses on mapping and monitoring field sites in all 29 counties with the use of EDDMapS and the new Utah Biocontrol Dashboard. Amber currently serves as the Vice President for the Utah Weed Control Association.

Biological Control of Mile-a-Minute Weed and Integrating Management Techniques to Restore Invaded Sites

Ellen Lake[1], Kiri Wallace[2], Kimberley Shropshire[3], and Judith Hough-Goldstein[3]
[1] Mt. Cuba Center, [2] University of Waikato, [3] University of Delaware

Mile-a-minute weed (*Persicaria perfoliata* (L.) H. Gross), is an aggressive annual vine of Asian origin that was introduced to the United States in the mid-1930s. It has invaded numerous mid-Atlantic and northeastern states and range expansion is ongoing. *Persicaria perfoliata* can be challenging to manage using traditional methods because it can develop dense monocultures that outcompete native species, produces large quantities of seeds, and forms a persistent seed bank. A biological control program was initiated in 1996 and releases of the host-specific weevil *Rhinoncomimus latipes* Korotyaev (Coleoptera: Curculionidae) began in 2004. The weevil can reduce mile-a-minute weed growth and seed production, but efficacy can vary based on abiotic conditions and habitat. In some cases, successful control of mile-a-minute weed with biological control alone resulted in replacement by other weed species, the invasive treadmill effect. Biological control of *P. perfoliata* was successfully integrated with native plantings in two small-scale field experiments to restore plant communities. One experiment combined biological control with plantings of a native seed mix that included warm and cool season grasses and an annual and a perennial forb. The second experiment integrated weevil releases with pre- and post-emergent herbicide applications and plantings of a native forb and tree. Integration of biological control with other management techniques can reduce the abundance of mile-a-minute weed, promote recruitment of additional native plant species, and prevent dominance by other invasive plants. An adaptive management approach may be needed to successfully manage *P. perfoliata,* especially in frequently disturbed areas.

Dr. Ellen Lake is the director of conservation and research at Mt. Cuba Center, a botanical garden focused on native plants, located in Hockessin, Delaware. She received her M.S. in Entomology and Ph.D. in Entomology and Wildlife Ecology from the University of Delaware, where she researched biological control of mile-a-minute weed and how to integrate weed management techniques to restore invaded sites. From 2012–2021, Ellen worked as a research entomologist at the USDA Agricultural Research Service Invasive Plant Research Laboratory in Fort Lauderdale, Florida. Her research focused on biological control of invasive weeds in the Greater Everglades ecosystem. Ellen served on the board of directors and biocontrol committee of the North American Invasive Species Management Association. She also served on the boards of the Florida Invasive Species Council and Brandywine Valley Association. Her research interests include restoration ecology, integrated weed management, biological control, and plant-insect interactions.

Dispelling Myths and a Bad Rap: Telling the Modern Biological Control Story

Christy Martin
University of Hawai'i at Mānoa

Invasive species are the greatest driver of native biodiversity loss on islands. Invasive weeds, pests, and diseases can alter the composition of forests, increase fire susceptibility, and reduce a forest's ability to buffer severe weather, keep soil moist, accelerate water infiltration, hold topsoil, and store carbon. Through these direct and indirect impacts, invasive species degrade the resilience of forests which are critical natural infrastructure. Protecting native biodiversity and ecosystem functions, and meeting Hawaii's climate resilience strategy will require managing the impacts of invasive species and classical biological control is one of the few cost-effective, available methods that can be used to mitigate the impacts of established weeds and pests. However, classical biological control has a bad reputation despite modern techniques and regulations, and a much-improved track record worldwide. In Hawai'i, the focus is on dispelling myths and reframing the narrative from old stories and techniques to modern ones.

Christy Martin has worked on terrestrial and marine invasive species issues in Hawai'i and the Pacific region for more than twenty years. She is the program manager and spokesperson for the Coordinating Group on Alien Pest Species (CGAPS), a partnership of agencies and organizations working to protect Hawaii from the impacts of invasive species. Christy is also one of the co-founders of the Pacific Regional Invasive Species and Climate Change (Pacific RISCC), whose aim is to focus research and communications on the confluence of invasive species and climate change in the Pacific Island region. Social science and communications are integral parts of her work. CGAPS is a project of the Pacific Cooperative Studies Unit of the University of Hawai'i at Mānoa.

EDDMapS & iBiocontrol

Chuck Bargeron
University of Georgia

The biocontrol web portal (iBiocontol) provides access to the World Catalogue of Biological Control Agents and Their Target Weeds, the Proceedings of International Symposia on Biological Control of Weeds, Biocontrol in Your Backyard – a Youth Biocontrol Education Program, and various publications focused on the biological control of weeds. The website also provides access to information, images, and known distribution of biological control agents. It also provides access to the SIMP (Standardized Impact Monitoring Protocol) Survey 123 smartphone app and access via ArcGIS to the SIMP data. The EDDMapS Biocontrol smartphone app provides a field guide to common biological control. The web portal was redesigned and modernized in 2023. This presentation will highlight the new iBiocontrol website as well as how to register in Connect, the new expert's database and collaboration building tool that links Bugwood Images, EDDMapS, and the IPM Centers Resource Database. Connect is your hub for all content, data, collaborations, and impact. iBiocontrol is a collaborative effort of the University of Georgia, MIA Consulting, University of Idaho, and the USDA Forest Service.

Chuck is the Director of the Center for Invasive Species & Ecosystem Health at the University of Georgia. Chuck has been with UGA for 24 years where his work focuses on invasive species and information technology. Websites he designed received awards for content and design, and received over 3 billion. Chuck developed the infrastructure behind Bugwood Images, which runs the Forestryimages.org and Invasive.org websites and archives over 300,000 images. Recently, Chuck has focused on mapping invasive species and tools for Early Detection and Rapid Response using EDDMapS and smartphone applications. He has led the development of 73 smartphone applications. Chuck has been an invited speaker at over 350 regional and national conferences and co-authored over 67 journal articles and outreach publications. He was initially appointed to the National Invasive Species Advisory Council in 2013, elected as Chair in 2017, and reappointed in 2022.

Kids In Action for Biocontrol

Carla Hoopes
Intermedia Productions PLLC

Kids In Action for Biological Control is an action model for America's youth engaged in and returning often to natural areas — experiencing biocontrol events and activities with foresters and scientists in the Intermountain West. One common objective of land management and biological control research in natural areas is to create an environment that inspires youth and communities to care for and about natural areas and return often. A consortium of agencies, state foresters, and youth educators worked with outdoor science schools, biocontrol scientists, and land managers to develop fun activities based on biocontrol to get kids (of any age) out in nature...understanding what a weed is, how weeds become competitive, and the benefits of natural enemies that reduce negative impacts of noxious weeds. The Kids In Action for Biocontrol program emerged in 2011 after extensive workshops collaborating with communication professionals, agencies, communities, tribal councils and outdoor science school program managers. Pilot testing brought kids and parents together to refine a program of curriculum called What's In Your World? Youth Naturalist - Weed Scientist. Piloted in Gallatin National Forest (Montana) in 2008 and improved engaging Tribal educators and sharing methods for Native American students in 2010, we integrated Kids In Action curriculum online within The Bugwood Wiki as an online portal called BIOCONTROL IN YOUR BACKYARD. Our partnering agencies, foresters and educators created a Kids In Action Initiative Steering Committee and Technical Team to guide how we advance to new regions of the USA and North America. Our expectation is to work with biocontrol scientists and foresters in natural areas to continue and increase engagements with kids in fun activities focused on biocontrol — hoping to inspire kids to care about natural areas and return often.

Carla Hoopes has been collaborating with foresters and biocontrol scientists since 1996, bringing youth activities and events to natural areas. Her work with steering committees and technical teams, as a wildlife biologist and facilitator of grass roots biocontrol of invasive plant awareness and education programs have put her at the heart of helping partnering entities get kids out in nature, inspiring them to return again and again.

Empowering Invasive Species Managers with Biocontrol Tools and Education

Christie Trifone Millhouse
NAISMA

Having the tools and technology to get the job done is sometimes the most difficult hurdle when managing with classical biological control methods. NAISMA empowers invasive species management in North America by providing a place and space for professionals and experts to find the information and connections needed to prevent and control biological invasions. This session is designed to highlight all that NAISMA offers to the growing field of biological control with a focus on programming and resources.

Christie Trifone Millhouse has been in the natural resources sector for over 20 years. She has a seasoned background that includes work with federal, state, tribal nations, and local partners in addition to a lengthy tenure in the non-profit land trust community. Christie has worked in research, habitat restoration, fundraising, community engagement, strategic initiatives, for-profit endeavors, and non-profit management. Invasive species management has always been woven in the framework of every element of her career. Christie joined the North American Invasive Species Management Association (NAISMA) in 2022. Since then, her deep vested commitment to the mission of NAISMA has been the driving force for growth and the sustainability of the organization.

KEYNOTE

Stanley W. Burgiel
National Invasive Species Council

Advancing a Biocontrol National Agenda

The National Invasive Species Council works across the Federal Government to facilitate high-level dialogue and outputs related to invasive species. In the development of its FY2024 Work Plan, biocontrol arose as a recurring issue and was ultimately included as an item for further interagency dialogue. This presentation will focus on some of the issues and challenges that percolated up to the Council and how to identify potential opportunities that can be advanced through interagency cooperation. Along with the Federal agency biocontrol updates, this will help frame the session on Harvesting Challenges, Opportunities, Needs, and Next Steps.

Stanley W. Burgiel ("Stas") serves as the Executive Director of the National Invasive Species Council (NISC), where he facilitates high-level policy dialogue across federal departments and White House offices on invasive species. He is responsible for overseeing the development and implementation of NISC work plan activities in areas such as wildland fire, climate change, and early detection and rapid response. Stas has worked and consulted for a range of nongovernmental, governmental, and intergovernmental organizations, including the Global Invasive Species Programme, the Nature Conservancy, the UNEP/World Conservation Monitoring Centre, and the International Institute for Sustainable Development. He received his Ph.D. in international service from the American University and a B.A. in political science from Swarthmore College.

Boots on the Ground: State Forestry Agency Perspectives

Robert S. Simpson
National Association of State Foresters, Forest Science & Health Committee

Providing boots-on-the-ground support for US private forest owners, State forestry agencies often find themselves in the role of frontline invasive species detectors, providers of information and treatment implementation. In his presentation, Bob Simpson will offer viewpoints he has garnered through surveys and personal interviews with current State Foresters, offering macro-views on their invasive species programs' challenges, management priorities, state agency key strengths and weaknesses. He will close with a summary of state forestry agency needs, both policy and budgetary, and what next steps might be taken to meet future strategic outcomes addressing invasive species.

Bob Simpson is President and CEO of GreenWoodGlobal Consulting, Ltd. His firm specializes in working with forest products companies, natural resource and other governmental agencies and natural resource NGOs, helping them meet their strategic directives involving forest sustainability, with focus on family forest owners, cooperatives and communities owning and managing forest land.

USDA-Forest Service Biological Control: Priorities, Challenges, and Next Steps

Vanessa M. Lopez
USDA-Forest Service FHP

The USDA Forest Service focuses on biocontrol research and implementation through the National Biological Control Program administered by Forest Health Protection (FHP) within State, Private, and Tribal Forestry and from work conducted by National Forest System land managers and Research and Development scientists. The National FHP Biological Control Program provides support for the development and use of biocontrol technologies and methodologies used to manage invasive species across the landscape. Some examples of the work we support includes investments in biocontrol technologies/applications such as iBiocontrol and EDDMapS, the production of publications such as factsheets on the biocontrol of invasive plants, and engagement in outreach activities. Research and Development scientists have focused on developing tools, techniques, and collecting data to manage invasive plants and insects such as toadflax, emerald ash borer, and hemlock woolly adelgid. The key strengths of Forest Service biocontrol efforts include financial support, technical expertise from our scientists and land managers, and our ability to partner with federal, state, tribal, NGO, and other entities to utilize this important tool across landscape boundaries. These strengths bring opportunities for increased scientific capacity and extended partnerships. While the Forest Service provides funding to support biocontrol activities that help manage invasive species impacts across the nation, we are continuously challenged to prioritize work based on the limited funds available. To further prioritize the use of biocontrol in IPM, we need to better understand the return on investment and comparative risk of using biocontrol as compared to other management tools.

Vanessa Lopez is an entomologist who specializes in invasive species research and management. She completed her PhD at the University of California, Riverside, and her dissertation focused on the development of a biological control program for the invasive goldspotted oak borer (*Agrilus auroguttatus*) in southern California. In 2014, Vanessa moved to Cincinnati, OH, where she was a postdoc at Xavier University working on Asian longhorned beetle (*Anoplophora glabripennis*) and emerald ash borer (*Agrilus planipennis*) biology and management including studies on the dispersal and trapping of these invasive woodborers. Vanessa currently serves as the National Program Manager for Invasive Plants and Biological Control with USDA Forest Service State and Private Forestry, Forest Health Protection in Washington, DC.

ARS Perspective

Michael J. Grodowitz
USDA-ARS National Biological Control Laboratory

This presentation will provide a broad overview of the large number and diversity of biological control research projects currently being undertaken by USDA-ARS scientists. A short history will be presented followed by an examination of not only traditional biocontrol projects but those on the periphery of what is typically considered as classical biocontrol. Such a broad and encompassing nationwide and international research program demonstrates USDA-ARS commitment to the use and application of biological control.

Dr. Grodowitz is a leading national and international authority on the use of insect biological control primarily for the management of aquatic and wetland plants. He was the lead principle investigator and biological control Focus Area Lead for the U. S. Army Engineer Research and Development Aquatic Plant Control Research Program directing, developing and implementing independent basic and applied research nationwide on the use of biological control technologies. He has 29 years of experience as a research entomologist for the USDA, ARS and the U.S. Army Corps of Engineers (USACE) with 27 years' experience researching and implementing exploration, release, establishment, and mass-rearing of insect biocontrol agents. He is an advocate for more active use of biological control aiding in the development of insect mass-rearing facilities and monitoring programs for state and local agencies across the nation and at several overseas locations. Dr. Grodowitz has developed physiological age-grading systems that allow for the evaluation of female reproductive status and past reproductive history; useful for evaluating agents during host testing and establishment. He also served for 2.5 years as the Director of the USDA-ARS European Biological Control Laboratory in Montpellier, France. While in France, working with local scientists, he made advances in understanding the trypanosomatid symbionts associated with the invasive stink bug *Bragada hilaris*.

The DOI Biocontrol Program

Joseph Milan
USDOI-BLM

The Department of the Interior (DOI) collectively manages more than 500 million acres of public lands with 70,000 employees, 280,000 volunteers, 2,400 operating locations and one overarching mission: "The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, Native Hawaiians, and affiliated Island Communities." Within this umbrella mission statement, there are 11 bureaus with more focused approaches to accomplishing their respective missions and directives. This presentation will include briefs on key strengths within DOI such as our strong overall invasive species programs, a standardized biocontrol monitoring program, and potential access to funding mechanisms (among other topics). This presentation will also identify challenges (NEPA constraints, variable receptiveness to utilizing biocontrol, etc.), opportunities (increasing implementation efforts throughout participating bureaus), needs (consistent funding for target species, infrastructure to be able to address those needs, etc.) and projections of future goals for DOI bureaus as next steps forward to optimize biocontrol as an integral part of an Integrated Pest Management (IPM) strategy.

Joseph "Joey" Milan is the Bureau of Land Management's Biological Control Specialist and he regularly consults with Department of Interior (DOI) bureaus as the only Biological Control Specialist within the DOI. Joey did his graduate work at the University of Idaho where he studied the effects of established biocontrol agents on the invasive rush skeletonweed (*Chondrilla juncea*). At his present post, he serves as the BLM's interagency coordinator for biological control, assisting weed control practitioners in their Integrated Weed Management approach by providing technical assistance and monitoring of past releases as well as organizing new collections and additional potential release sites. In addition to these duties, he is the co-chair of NAISMA's Classical Biological Control Committee.

Weed Biological Control—an Army Corps of Engineers Perspective

Nathan Harms
USDOD-USACE ERDC EL (TX)

The US Army Corps of Engineers manages more than 25,000 miles of inland and intracoastal waterways and 400 lake and river projects in 43 states for navigation and recreation. Invasive species control is an important component of habitat management that costs the Corps more than $200M annually in prevention, early detection and rapid response, habitat restoration, R&D, and control. A majority of Corps' invasive species management occurs in freshwater habitats with focus on animals such as zebra and quagga mussels (*Dreissena* spp.), and plants such as water hyacinth (*Pontederia* (=*Eichhornia*) *crassipes*), hydrilla (*Hydrilla verticillata*), and common reed (*Phragmites australis*). Although herbicide application is the primary approach to manage invasive plants, biological control plays a significant role in sustainable and long-term invasive plant control success. Beginning with a program to control the aquatic plant alligator weed in the 1950s, through modern programs aimed at hydrilla and Brazilian peppertree (*Schinus terebinthifolia*), the Corps continues to use biological control as a component of its invasive species control toolbox. A recent research direction within the Corps is the identification and development of thermally-adapted agents for weeds that have spread beyond their original climate distributions. Although the majority of current target species are aquatic, riparian and terrestrial weeds are managed as well. After more than 70 years of development and implementation, the Corps continues to invest in biological control to manage both new and historical target plant species.

Dr. Nathan Harms is a Senior Research Biologist in the Aquatic Ecology and Invasive Species Branch, Environmental Laboratory, US Army Engineer Research and Development Center, Lewisville, TX. He leads a team of scientists to study the ecology and management of invasive plants. Since 2019, he is the Corps' representative to the USDA Technical Advisory Group (TAG) for Biological Control of Weeds. Dr. Harms is involved with identifying suitable targets of biological control for the Corps and the development and implementation of new control programs, from overseas exploration for new agents to rearing, release and monitoring of control agents. His research projects have centered on freshwater and terrestrial weeds in USACE water control and ecosystem restoration projects. Currently, his focus is on the importance of genetic variability within and between introduced weed populations for management success and local adaptation of weeds and their control agents to climate.

Overview of APHIS-PPQ Biological Control Program

Ronald D. Weeks, Jr.
USDA-APHIS PPQ

The Animal Plant Health and Inspection Service (APHIS), Plant Protection and Quarantine (PPQ) Biological Control program promotes, facilitates, develops, and delivers safe and effective biological control to help reduce the economic losses and negative impacts of non-indigenous, invasive pests to America's agricultural production and natural areas. The program does this by investing in the discovery, development, and deployment of new, non-native agents (e.g., parasitoids, predators, herbivores, or pathogens). Limited resources and the continued pressure of invasive pests on American agriculture and natural resources make it impractical for PPQ alone to maintain the necessary resources, infrastructure, space, and scientific expertise to effectively sustain the overall biological control program. PPQ's Biological Control program actively seeks and maintains partnerships with tribal governments, state agencies, federal agencies, and universities to be better prepared, equipped, and more efficient in carrying out the agency's biological control mission. In FY23, the program provided national program oversight for both insect and weed biological control activities. Field Operations provided funding and oversight for 31 cooperative agreements with organizations in 22 different states that will rear, release, and monitor the establishment and impact of 16 agents attacking 3 invasive arthropods and 14 exotic weeds. Our Science and Technology unit supported the coordination of research projects against 33 targets. Scientific research is currently focused on advancing research and data collection towards future evaluation for US permitting of 19 potential agents as well as advancing methods development for rearing and release of 24 agents.

Ron began his federal career in 2002 with Animal Plant Health and Inspection Service (APHIS), Plant Protection and Quarantine (PPQ), Science and Technology (S&T), Imported Fire Ant (IFA) Laboratory in Gulfport, Mississippi. Ron helped develop methods for release and monitoring of biological agents against IFA. In 2008, Ron moved to Field Operations in Raleigh, North Carolina as National Operations Manager overseeing the implementation of a diverse portfolio of biological control projects. In 2016, Ron moved back to S&T and served as National Program Coordinator for PPQ's Biological Control Program. Ron has served on APHIS's Technical Advisory Group and North America Plant Protection Organization as an agency representative and subject matter expert. Ron currently serves as National Policy Manager for Biological Control in APHIS, PPQ, Emergency and Domestic Programs. Ron received a Bachelor of Science in Biology from the University of Nevada-Reno, Master of Science in Entomology from Colorado State University, and Doctor of Philosophy in Entomology from Texas A&M University.

Implementation of Biological Control for the Management of Invasive Species in Developing Economies—Opportunities and Challenges

Shiroma Sathyapala
Food and Agriculture Organization of the United Nations, Italy

Biological control plays a crucial role in the integrated pest management of forest invasive species, (insect pests, pathogens, and invasive plants). While biological control is an excellent management tool for many invasive species, the process of developing and implementing a biocontrol program can be complex, with numerous obstacles in implementation. Recognizing this gap in 2017, the Food and Agriculture Organization of the United Nations (FAO) developed a practical guide titled "Classical Biological Control of Insect Pests in Forestry." This guide offers information from both theoretical and practical perspectives, allowing forest pest managers worldwide to gain the practical understanding needed to implement successful classical biological control programs against key forest pests within their countries. Additionally, FAO has utilized biological control as the main integrated pest management (IPM) method for managing forest invasive species in many countries. The recent projects include biological control of chestnut gall wasp (*Dryocosmus kuriphilus*) in Turkey, Albania, and Kosovo, chestnut blight (*Cryphonectria parasitica*) in Azerbaijan and Georgia, and *Eucalyptus* pests in Zimbabwe. Drawing from these experiences, the presentation discusses the challenges and opportunities in the implementation of biological control in the management of forest invasive species.

Dr. Shiroma Sathyapala, Forestry Officer FAO has been leading the Forest Health and Protection Program in FAO, Rome, Italy since 2014. Through this program, FAO assists, advises and supports countries and regions to safeguard the health and vitality of forests, forest ecosystems and trees outside forests, with special reference to insect pests, diseases and other harmful biotic and abiotic agents. She is actively involved in facilitating capacity-building activities for five regional forest invasive species networks, covering more than 100 countries. Before joining FAO, Shiroma led Pest Risk Analysis and forest biosecurity activities at the Ministry for Primary Industries in New Zealand. She has also worked as a biologist in Japan and Sri Lanka.

Strengthening the Legacy of Biological Control in California through Capacity Building

Ricky Lara
California Department of Food and Agriculture

Invasive arthropod species are a major threat to California's agricultural and natural resources. The California Department of Food & Agriculture with support from partner agencies is constantly on alert to improve management programs for current/emerging insect pests while also preventing the arrival of new ones. Biological control remains a key component of sustainable pest management programs for urban, natural, and agricultural ecosystems. This presentation will highlight (1) current classical biological control research projects targeting stink bugs, wood-boring beetles, and moths, (2) challenges with delivering timely biological control solutions against the backdrop of rising pressure from invasive species, (3) the need for comprehensive proactive biological control, (4) opportunities for dynamic stakeholder partnerships to bolster pest management, and (5) recommendations to strengthen California's biological control programs through various types of capacity building (e.g., human, organizational, and material).

Dr. Ricky Lara is a Senior Environmental Scientist – Specialist with California Department of Food and Agriculture. He is a research entomologist by training. He specializes in the development of classical biological control programs targeting invasive arthropod species that pose a threat to specialty crop production in agricultural systems. Part of his research responsibilities include conducting foreign exploration for co-evolved natural enemies of invasive target pests and studying the host-specificity of candidate natural enemies in quarantine lab space to determine their environmental safety in future release areas. Some of his pest control projects have involved working with ambrosia beetles, stink bugs, and spider mites. His work is driven by a desire to better understand the ecological relationships in the natural world and a commitment to share these findings with the public, research scientists, and farming communities through a variety of publications, extension/outreach events, and conference presentations.

Fostering Communication and Collaboration with Native American Communities, Specifically with the Seminole Tribe of Florida

Sheri L. Trent
University of Florida

While exploring the complexities of engaging with Native American communities, emphasis must be focused on patience, understanding, and respect. Grounded in the historical context of colonization and ongoing challenges faced by Native Americans, this session seeks to provide insights for individuals, organizations, and agencies seeking to work collaboratively with tribes while honoring their rich history and culture. Active listening, respectful engagement, and cultural sensitivity must be utilized to foster a deeper appreciation for the rich tapestry of Native American cultures, emphasizing the importance of traditional communication methods. Strategies for cultivating patience and empathy, particularly in the face of systemic challenges, are discussed to guide individuals and organizations in their collaborative efforts. The successful relationship with the Seminole Tribe of Florida is examined to extract best practices and lessons learned, providing practical insights for those navigating partnerships with Native American communities. The implications of these conclusions extend beyond academia, providing valuable insights for policymakers and community leaders seeking to engage with Native American tribes in a respectful and culturally sensitive manner. By combining an awareness of historical trauma with a genuine respect for cultural diversity, stakeholders can contribute to the empowerment and self-determination of Native American tribes. This session aims to inspire a paradigm shift in how collaborations are approached, fostering enduring relationships based on patience, understanding, and a profound respect for the unique history and culture of Native American communities.

Sheri Trent is a seasoned educator with a master's degree in Educational Leadership and a bachelor's degree in Agriculture Education, who has dedicated 18 years to the field of teaching. For the past two years, she has served as the UF/IFAS Extension Federally Recognized Tribal Extension Program Agent for the Seminole Tribe of Florida, focusing on agricultural and 4-H programming on the reservations of Brighton, Big Cypress, Immokalee and Hollywood. She is an active member of the South Florida Beef Forages Group, who provide educational programs related to cattle nutrition, reproduction, and health throughout the counties of south Florida. She is a member of the Florida Seminole Cattlewomen's Association and an established volunteer for the Okeechobee county 4-H program. Sheri's dedication to the Seminole Tribe's agricultural and 4-H programs fosters a connection between cultural heritage, positive youth development and modern agricultural practices.

Regulation of Biological Control in the U.S. by USDA-APHIS: Policy and Process

Robert S. Pfannenstiel
USDA-APHIS PPQ

The current policy and processes for approval of movement and release of commercial and classical biological control agents in (and into) the United States will be presented. This includes both permitting for importation and release as well as the environmental compliance process for the approval for release of novel biological control agents for invasive insects and weeds. Additional discussion will address jurisdictional issues, biological control of plant pathogens, and permitting challenges.

Bob Pfannenstiel is a Senior Entomologist and the Biological Control Specialist with the U. S. Department of Agriculture, Animal Plant Health Inspection Service (USDA-APHIS) Pest, Pathogen and Biological Control Permitting Unit. Bob coordinates the environmental compliance and risk assessment for petitions proposing the release of novel biological control agents of insect pests and weeds in the U.S. Additionally, Bob is in charge of permitting functions within USDA-APHIS for importation and interstate movement of biological control agents in the U.S. Before coming to USDA-APHIS in 2017, Bob was a Research Entomologist for 17 years with the Agricultural Research Service (USDA) and studied the ecology and behavior of biological control agents of insect pests in annual and perennial crops.

Biocontrol Discussion—Challenges, Opportunities, Needs, and Next Steps

Angela McMellen Brannigan and Bryan Falk
National Invasive Species Council

The National Invasive Species Council (NISC) recently identified biological control of invasive species as a thematic priority in its Fiscal Year 2024 work plan. As the initial steps, NISC staff have begun facilitating dialogue across relevant federal agencies by assembling a federal interagency team with expertise in the regulation, research, and management application of biological control. This team will identify the priority areas of engagement and any outputs. The purpose of this working session is to help inform how these efforts might be useful by seeking a range of ideas and perspectives from individuals working on biological control. What are the challenges, opportunities, and needs? What are the potential next steps? NISC staff will bring this information back to their interagency team as they consider how their work can best improve biological control of invasive species.

Angela McMellen Brannigan is the NISC Technical Adviser. She has the lead role in scientific and technical invasive species issues identified in the NISC Work Plan and by member agencies. Angela has invasive species expertise as a researcher and policy maker. With much of her career spent at the USDA Animal Plant Health Inspection Service, Angela has extensive regulatory experience. She has developed regulatory policy to prevent the spread of invasive species through both domestic and international agricultural trade in plants and plant products, engaging with a wide variety of trading partners, industry groups, state departments of agriculture, domestic producers, and scientists. Additionally, Angela has worked for state government and in academia and managed a large grant program. Angela holds a B.A. in French and Biology from Austin College, a M.S. in Zoology from Michigan State University, and a Ph.D. in Forest Resources/Wildlife Ecology from the University of Georgia.

As the NISC Program Analyst, Bryan Falk leads and supports efforts to achieve NISC priorities and core functions. Much of his current work is at the intersection of climate change and invasive species. Bryan's previous experience with invasive species was focused on developing and managing control programs and on research to improve efficacy of detection and control. He was most recently the supervisory invasive species biologist for Everglades National Park, and before that, he was a post-doctoral research fellow for the US Geological Survey and based in the Everglades. His dissertation work centered on diversification of parasites in wildlife, and he has held various education-related positions, having taught students from elementary through university levels, other educators, and the public. Bryan received a Ph.D. in Comparative Biology from the American Museum of Natural History and a B.S. in Biology from Portland State University.

The Impact of Hymenopteran Parasitoids on Populations of Emerald Ash Borer and Survival of Ash Trees

Juli R. Gould[1], Jian Duan[2], Timothy D. Morris[3], and Theresa C. Murphy[1]
[1] USDA-APHIS PPQ S&T, [2] USDA-ARS BIIRU, [3] SUNY Environmental Science & Forestry

Biological control of emerald ash borer (*Agrilus planipennis*, EAB) is a mature program, having been initiated more than 20 years ago. During that time, a dedicated cadre of federal, university, and state scientists have done all the steps necessary for a successful classical biocontrol project. They conducted host specificity testing, applied for and received release permits, developed methods for mass rearing, optimized release methodology, and most importantly have been tracking the success of the program. Scientists developed methods for determining parasitoid presence and impact, and a nationwide consortium of cooperators have collected data showing where the various species of parasitoids have established. Scientists have been studying the impact of EAB parasitoids on EAB population density since 2014. They have documented an increase in parasitism following release while densities of EAB declined. *Tetrastichus planipennisi* has been shown in multiple studies to play a considerable role in reducing the net reproductive rate of EAB, especially in small, regenerating trees. The braconid *S. galinae* was permitted and released beginning in 2015, and recent studies show that it too is having a considerable impact on EAB populations. In these studies, the combination of parasitoids and woodpecker predation leads to the net reproductive rate of EAB falling below one. Recent assessments of ash regeneration at long term study sites in New York demonstrate that the density of seedling ash at biocontrol release sites did not significantly decline between 2014 and 2021, and the density of larger saplings (>1m) significantly increased.

Juli Gould has been working on biological control of insect pests since conducting doctorate research on *Lymantria dispar* at the University of Massachusetts in the 1980s. As a post-doc she was a member of the team that successfully controlled the ash whitefly with biocontrol. She has also worked on biocontrol of other insect pests (Russian wheat aphid, eucalyptus longhorned borer, silverleaf whitefly) and the weedy saltcedar plant. In 2001, Dr. Gould moved to APHIS Science and Technology Laboratory in Massachusetts. Currently she is part of a team that researches biological control of the emerald ash borer, spotted lanternfly, Asian longhorned beetle, polyphagous shot hole borer, and Roseau cane scale. She plays an active role in all aspects of these biocontrol programs including foreign exploration for natural enemies, host specificity testing, development of rearing technologies, release, and post-release evaluation.

Economic Perspectives on Biological Control Past, Present and Future

Kristen Bowers
New Mexico State University

Historically, the economic impacts of biological control programs have not been evaluated when considering overall biological control impacts. There are several possible explanations for this, including the difficulty in valuing ecosystem services, a lack of expertise in social sciences among biocontrol practitioners, the perception that biological control is a "last resort" strategy, the cost of economic analysis, and the role of the public sector in biological control, especially in classical weed biological control projects. The economic impact evaluations of biological control programs that do exist vary in scale and scope but offer insights into the methods available and considerations for future analyses. As part of the biological control program against Brazilian peppertree (*Schinus terebinthifolia* Raddi), we began collecting economic data about weeds and weed control in 2020 shortly after the Brazilian peppertree thrips, (*Pseudophilothrips ichini* (Hood)), was released in Florida. We surveyed both cattle ranchers and homeowners about their knowledge and perceptions of weeds on their properties, their attitudes about biological control, and their willingness-to-pay (WTP) for biological control of Brazilian peppertree. In addition to providing insight into factors that influenced respondents' attitudes and WTP, these surveys exemplify the challenges and pitfalls of collecting economic impact data on biological control projects. These data will be used as a baseline to evaluate the economic benefits of Brazilian peppertree biological control efforts and as a model for other biological control programs. Future efforts to collect economic impact data can be used to target biocontrol programs and specific management interventions.

Kristen Bowers has 10 years of experience in classical biological control of weeds, including managing grants and research teams. In addition to weed biocontrol projects, she has an additional 10 years' experience in entomology, working on insect pests in agroecosystems. Dr. Bowers holds an undergraduate degree in economics from the University of Virginia and a master's in ecology and PhD in entomology, both from the University of Florida. She is currently a research scientist at New Mexico State University in the Department of Entomology, Plant Pathology and Weed Science.

Russian Knapweed Biological Control Success with Host-Specific Wasps and Midges

Sonya Daly and **Dan Bean**
Colorado Department of Agriculture

Russian knapweed (*Rhaponticum repens*) is a List B noxious weed in Colorado invading grazing land, rangeland, croplands, roadsides, and riparian areas across the western United States. The Colorado Department of Agriculture (CDA) Biological Control Program, Palisade Insectary offers two host-specific biocontrol agents to naturally control Russian knapweed. Russian knapweed gall midge (*Jaapiella ivannikovi*) and stem gall wasp (*Aulacidea acroptilonica*) are well established across Colorado. The Palisade Insectary developed collection sites for both agents to serve high number of releases to the people of Colorado and out-of-state users. In 2019, a stem gall wasp distribution program was developed with county weed coordinators, municipalities and other government agencies. The USDA-APHIS expressed a concern about midge gall parasitoids imported to out-of-state users. The CDA collaborated with the U.S. Forest Service on a midge gall parasitoid study to evaluate Russian knapweed gall midge (*Jaapiella ivannikovi*) likelihood of parasitism. The Palisade Insectary monitored both agents at sites across Colorado for gall establishment, gall impact, and recovery of native vegetation. A monitoring site outside Gateway, CO has shown major suppression due to the gall midges and stem gall wasps. The CDA will continue to develop more distribution programs, research studies, monitoring efforts and educational outreach in Colorado.

Sonya Daly is a biocontrol specialist with the Colorado Department of Agriculture (CDA) Biological Control Program at the Palisade Insectary for 17 years and led the Russian knapweed biocontrol program from 2018 to 2023. The Colorado Weed Management Association awarded Sonya the Weed Manager of the Year in 2021. Sonya is honored to have served Russian knapweed biocontrol agents to the people of Colorado. She has recently resigned with the CDA to join the Department of Energy (DOE) Legacy Management Support (LMS) Ecosystem Management Team as a biocontrol specialist in 2023. Sonya is very grateful to Dr. Dan Bean, CDA Biological Control Program Director, for his mentorship and leadership in biocontrol implementation and looking forward to continuing the mission with implementing biocontrol at DOE Legacy Management sites.

Factors Affecting the Success of Classical Biocontrol of Invasive Insect Pests: Critical Insights from Dr. Juli Gould's Work

Jian Duan
USDA-ARS BIIRU

I will first discuss the principle and steps of classical biocontrol in the context of invasion biology and then go over successful biocontrol programs developed by Dr. Juli Gould by highlighting some critical factors that have the potential to affect the successes and failures of classical biocontrol introduction. These factors include science-based policy, good target selection, effective corporations, dedicated people (like Dr. Gould and others), and knowledge base of the target system, pests and natural enemies.

Dr. Jian Duan is a research entomologist and lead scientist with the U.S. Department of Agriculture, Agricultural Research Service (ARS), Beneficial Insects Introduction Research Unit (BIIRU, Newark, DE). His current research focus is on biological control of invasive wood-boring pests such as emerald ash borers and Asian longhorned beetle, which involves natural enemy introduction, quarantine safety testing, and non-target risk assessment as well as evaluation of the establishment and impact of introduced natural enemies on the target pest.

Evaluating the Large-Scale Impacts of Biological Control on Leafy Spurge (*Euphorbia virgata*)

Natalie West, Tatyana A. Rand, and Joshua W. Campbell
USDA-ARS PMRU

Leafy spurge (*Euphorbia virgata*) infests millions of acres in the central and western US and remains a priority weed for stakeholders. Although biocontrol is critical to viable and cost-effective integrated leafy spurge management, what drives variation in biocontrol efficacy remains unclear. Few post-establishment large-scale data are available to assess long-term biological control impacts, though such evaluations are necessary to identify gaps in biocontrol management and ensure the long-term reliability of the biocontrol program. We surveyed leafy spurge and biological control agent communities for four years in 60 sites across Idaho, Montana, and North Dakota, and evaluated how different leafy spurge taxa and genotypes are distributed and correlated with agent efficacy across ecological gradients. Initial findings suggest biocontrol agents are ubiquitous. The agents present vary across space but agent community composition varies less across time, suggesting some degree of ecological partitioning. Associations between agent impacts and leafy spurge populations are nuanced, though the highest leafy spurge densities often occur where agent abundance is low. The dataset and collections from this survey provide multiple avenues for quantifying weed biological control efficacy across a wide region, and a baseline for considering how agent communities may establish and change over time and may in turn change the invasion dynamics of their target weed. Such information can inform how management may need to evolve over the life a weed biological control program.

Dr. West is a Research Ecologist at the Pest Management Research Unit in Sidney, MT, studying applied weed ecology and classical biological control of weeds. Her research focuses on quantifying interactions between weed populations, introduced biological control agents, and their associated plant and insect communities, with the goal of increasing the efficacy of weed management and improving health and sustainability of wild and rangeland systems.

An Australian Perspective on Harnessing Biological Control to Manage Invasive Plants: Impacts and Future Directions

Michelle Rafter and Ben Gooden
CSIRO Australia

Classical biological control (biocontrol) has been used in Australia to successfully control invasive weed species for over 120 years, beginning with the visible success of *Cactoblastis cactorum* on prickly pear in the 1920's. Biological control has proved to be a valuable and effective approach to weed management in Australia with 39% of all programs considered to produce complete or near complete control, 30.5% partial control and an average benefit-cost ratio of 23:1. These solutions do not come about quickly and require sustained investment that has at times been lacking. Recent strategic investments in biological control are encouraging and will ensure that the discipline maintains momentum in its contribution toward addressing Australia's annual $5 billion invasive weed problem. Since 2014–15, off the back of recent successful programs, the Australian government has invested approximately $20 million in weed biocontrol projects, but most of these programs concluded in 2023. The recently developed National Weed Biocontrol Pipeline Strategy will sustain a pipeline of prioritizing weed candidates for research, native range exploration, risk assessment, biocontrol agent release, impact monitoring and evaluation.

Dr. Michelle Rafter is a Senior Research Scientist who manages CSIRO's weed biocontrol program with insect candidate biocontrol agents, based in Brisbane, Australia. Dr. Rafter has extensive experience in delivering risk analysis under containment for multiple biocontrol agents and weed targets in Australia, South Africa, and South America (e.g., for tropical soda apple, Passiflora, African boxthorn, Brazilian pepper, Parkinsonia and fleabane, both flaxleaf and tall). More recently, Dr. Rafter has assumed responsibility for liaising with various government agencies on behalf of CSIRO on weed management and biocontrol strategies. Dr. Rafter is an entomologist with specialist skills in evolutionary ecology. Her research is focused on developing novel, safe and effective pest management solutions for problematic weeds and insects. Key areas of her research include plant-insect interactions, behavioral ecology, gene flow, species delimitation, dispersal ecology, chemical ecology and weed biological control.

Understanding Variable Biological Control of Invasive Spotted Knapweed (*Centaurea stoebe* ssp. *micranthos*)

Chandra Moffat[1], Robert Bourchier[1], Rosemarie De Clerck-Floate[1], Val Miller[2], Emma Bacon[3], Chris Eckert[4], and David Ensing[1]

[1] Agriculture & Agri-Food Canada, [2] British Columbia Ministry of Forests, [3] Concordia University, [4] Queen's University

Recent reviews have identified that variable control of widespread invaders is a common pattern. One such species is spotted knapweed (*Centaurea stoebe* ssp. *micranthos*), a widespread and problematic invader of rural and urban areas worldwide, including much of southern Canada. Together with diffuse knapweed (*C. diffusa*), spotted knapweed has been the subject of a North American biocontrol program since the 1970s, resulting in the release of 13 insect agents. Despite effective biocontrol of diffuse knapweed in British Columbia, and widespread reductions in the density and fecundity of spotted knapweed across the province, pockets of abundant spotted knapweed remain with considerable costs to rangeland tenure holders. Integrating various long term datasets on spotted knapweed density, we found, on average, a long term decline under biological control. However, control is highly variable among study sites. Here we report on ongoing work exploring potential mechanisms for this variability. We find that short-growing season sites may act as refugia from a key control agent species, which may influence knapweed success. Taken together, the longer term successful control of spotted knapweed in BC will require an integration of biological control efforts and revised land use practices to reduce this species' abundance to non-problematic levels.

Chandra is a Research Scientist in Entomology, specializing in the biological control of invasive insects and invasive weeds, with Agriculture Canada in Summerland, British Columbia. Her team focuses on generating new knowledge of the evolutionary ecology of invasive species, their natural enemies, and the habitats they invade, across agricultural, rangeland and riparian ecosystems. They draw on approaches from natural history, taxonomy, ecology and molecular biology, to accelerate biological control based pest management tools and systems.

POSTERS

Gall Mites (Acari: Eriophyoidea) of Scotch broom (*Cytisus scoparius*) and Field Bindweed (*Convolvulus arvensis*): Updates from the USDA Biological Control Program

Jacqueline V. Sarratt and Paul D. Pratt
USDA-ARS ISPHR

Gall-forming mites (Acari: Eriophyoidea) are highly host-specific phytoparasites, with most species reported on only one host species. The USDA is investigating two gall mites, both adventive in California: *Aceria genistae*, a potential control agent of the invasive shrub Scotch broom (*Cytisus scoparius*), and *A. malherbae*, a well-studied agent of field bindweed (*Convolvulus arvensis*). We describe the phenology of *A. genistae* and show heavy infestations may reduce seed production of *C. scoparius* by up to 80%. We also report geographic range expansions of *A. genistae* as well as *A. malherbae*, a new record for the state. *Aceria malherbae* is permitted and used to suppress field bindweed in other states, but currently unpermitted in California due to potential risks to nontarget taxa endemic to the state. However, some studies suggest risks in natural conditions may be very low; we describe further host transfer studies that may help assess these risks and inform the permit reapplication process. We also discuss possible approaches to address the challenge of gall-resistant host genotypes, described from Scotch broom, field bindweed, and other systems. We report *A. malherbae* is a junior synonym of *Aculus convolvuli,* a species with a larger native geographic range than *A. malherbae*, and describe possible areas in the native ranges of both *A. genistae* and *A. malherbae* to collect novel genotypes that may improve efficacy and establishment rates of these mites as biological control agents.

Jacqueline Sarratt is a biological science technician specializing in eriophyoid mites at the USDA biological control lab in Albany, CA. In 2021 she received an M.S. from San Francisco State University focusing on the coevolution of eriophyoids and their host plants. Her thesis compares traditional morphology-based taxonomy with a molecular phylogeny of 33 taxa of eriophyoids collected across California and Nevada, inferred using ribosomal DNA. Other interests include the invasion of the plum and almond bud gall mite recently discovered in the SF bay area.

Biological Control of the Invasive Grass Cogongrass, *Imperata cylindrica*

Greg Wheeler[1] and Dean Brookes[2]
[1] USDA-ARS IPRL, [2] USDA-ARS Australian Biological Control Laboratory

Cogongrass, *Imperata cylindrica*, is one of the 10 worst weeds in the world impacting agriculture, forestry, and biodiversity. Options to control this invasive weed are limited to synthetic herbicidal compounds which provide only temporary relief requiring annual retreatments. We are developing ecologically safe, sustainable, and cost-effective control of cogongrass through the development of biological control agents. Our research seeks to identify the origin of the invasive lineages of *I. cylindrica* with molecular approaches and prioritize surveys for potential agents in the areas with the closest matches and where the weed originates. One of the invasive lineages invading the southeastern USA comes from Japan. Despite the traditional view that grasses have low herbivore diversity, we have recovered over 60 species of potential agents in Japan and Australia. These include a diverse assemblage of herbivores that feed on different plant tissues including flowers, stems, shoot tips, and rhizomes. Two agents have been prioritized, a stem borer *Emmalocera latilimbella* (Lepidoptera: Pyralidae) and a shoot tip borer *Atherigona* sp. (Diptera: Muscidae) which have been colonized and are currently undergoing host range testing in quarantine in the US. Preliminary tests indicate that both are specific and may provide significant control of the target weed. Further testing will determine if these species can be promoted for safe and effective biological control of *I. cylindrica.*

Greg Wheeler is a research entomologist who has been working for over 30 years on biological control of invasive weeds of Florida natural areas. Weed targets have been primarily Brazilian peppertree and Chinese tallow tree for which safe agents have been developed.

Biological Control of Hemlock Woolly Adelgid in North Carolina: Efforts of the NCDACS Beneficial Insects Laboratory

Greg Wiggins[1], Albert Mayfield III[2], and James Rhea[3]
[1] North Carolina Department of Agriculture and Consumer Services, [2] USDA-Forest Service SRS, [3] USDA-Forest Service FHP

Biological control is a crucial management strategy in the long-term management of hemlock woolly adelgid, *Adelges tsugae* (Hemiptera: Adelgidae) (HWA) in eastern North America. Since 2002, the Beneficial Insects Laboratory (BIL) of the North Carolina Department of Agriculture and Consumer Services has been involved in biological control programs targeting HWA. Initial efforts focused on rearing and releasing *Sasajiscymnus tsugae* (Coleoptera: Coccinellidae), a predator of the spring generation (progrediens) of HWA. Over 640,000 *S. tsugae* were reared at the BIL between 2002 and 2015, and recent surveys found *S. tsugae* in 17% of historic areas of release in North Carolina. Beginning 2015, rearing efforts shifted to beetles in the genus *Laricobius* (Coleoptera: Derodontidae), a predator of the winter generation (sistens) of HWA. All current rearing and release efforts are focused on *L. osakensis*. In addition to initiating a colony of *L. osakensis* in the laboratory, efforts are underway to increase field insectaries where *L. osakensis* can be collected and redistributed to areas of interest. We are also assessing the feasibility of conducting egg releases to establish *L. osakensis* in new areas to reduce the time beetles slated for release spend in laboratory conditions. To provide additional predation on HWA progrediens, predatory flies in the genus *Leucotaraxis* (Diptera: Chamaemyiidae) are being developed as biological control agents. We are using whole-tree cages to evaluate the potential for establishment of these predatory flies in the field to further suppress HWA populations. Highlights and findings from each of these efforts will be presented and discussed.

Greg Wiggins is Biological Control Program Administrator in the Beneficial Insects Laboratory at the Plant Industry Division of the North Carolina Department of Agriculture and Consumer Services, Raleigh, NC.

Developing New *Phragmites* Treatments Targeting Genetic Expression and Microbial Symbionts

Kurt P. Kowalski[1], James F. White[2], Ping Gong[3], Seung Ho Chung[3], Keith Clay[4], Wesley A. Bickford[1], Spenser L. Widin[1], Alexandra Bozimowski[1], Kathryn I. Kingsley[2], Meagan Froeba[1]
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Management of the non-native invasive grass *Phragmites australis* ssp. *australis* (common reed) is a priority for federal, state, provincial, and private land managers in the United States and Canada. This robust and proliferative plant can outcompete native plants, resulting in degraded fish and wildlife habitat, increased fire hazard, and reduced property values. Conventional approaches to managing invasive *Phragmites* (e.g., cutting, drowning, burning, herbicide) can be resource intensive and nonspecific in their effects. Therefore, advancements in biotechnology are being applied to the development of innovative new control measures in order to provide resource managers with additional management options. First, a species-specific RNA interference technique exploits a natural plant defense mechanism to inhibit gene expression necessary for critical metabolic functions. A second approach interrupts the mutualistic relationships between invasive *Phragmites* plants and their microbiome (e.g., bacteria, fungi) in order to inhibit plant growth. Additionally, while these techniques have been developed for use in *Phragmites*, they could also be adapted for management of other invasive plant species (e.g., *Hydrocharis morsus-ranae*, *Bromus tectorum*).

Dr. Kurt Kowalski is a research wetland ecologist at the U.S. Geological Survey Great Lakes Science Center based in Ann Arbor, MI USA. His research focuses on the restoration and management of Great Lakes coastal wetland habitats, including the development of novel management approaches for the invasive grass *Phragmites australis*. He has extensive involvement in the application of research results into practice and policy, including the development of adaptive management approaches and online decision support tools.

Biological Control of Pests at the Foundation for the Study of Invasive Species in Argentina: Past, Present and Future

Guillermo Cabrera Walsh and **Fernando Mc Kay**
Fundación para el Estudio de Especies Invasivas, Argentina

The Foundation for the Study of Invasive Species (FuEDEI) located in Buenos Aires, Argentina, was established in 2012 as a continuation of the USDA-ARS, South American Biological Control Laboratory. The South American lab has been active since 1962. FuEDEI operates through a cooperative agreement as an Overseas Biological Control Laboratories within the ARS Office of International Research Engagement and Cooperation (OBCL-OIREC). FuEDEI's main missions include: search for biological control agents against pests; study the biology, ecology and evaluate the specificity of those organisms; send selected agents to the United States and cooperating countries; provide logistical support to US researchers and other scientists conducting research in South America; and liaise with local and foreign universities and agricultural research agencies for possible cooperative work. Over its 62-year history, the lab has studied more than 40 targets, evaluated 110 biocontrol candidates, and released of 22 biocontrol agents in the US and other countries. Main past and present weed targets include: water hyachinth (*Pontederia crassipes*), alligator weed (*Alternanthera philoxeroides*), giant salvinia (*Salvinia molesta*), brazilian peppertree (*Schinus terebinthifolia*), water primrose (*Ludwigia grandiflora*), parkinsonia (*Parkinsonia aculeata*) and stinking passionflower (*Passiflora foetida*). Current insect biocontrol projects include: fire ants (*Solenopsis* spp.), cactus moth (*Cactoblastis cactorum*) and cactus mealybug (*Hypogeococcus* spp.). Current biocontrol research programs are funded primarily by the US Department of Agriculture, Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Centre for Agriculture and Bioscience International (CABI). Prospective biological control projects include: pampas grass (*Cortaderia* spp.), frogbit (*Limnobium laevigatum*) and parrot's-feather (*Myriophyllum aquaticum*).

Fernando Mc Kay is a research entomologist and doctor in Biological Sciences from the Faculty of Exact and Natural Sciences of the University of Buenos Aires, Argentina. Since 2002 he has worked at the Foundation for the Study of Invasive Species (FuEDEI), in Buenos Aires, Argentina, formerly known as USDA-ARS, South American Biological Control Laboratory. During his career he participated in several classical biological control (CBC) projects of weeds with native plants from South America. He is currently deputy director of FuEDEI.

Using Collaboration and Partner Engagement to Inform Siren: the National Early Detection and Rapid Response (EDRR) Information System

Nicole D. Hernandez[1], Aimee C. Agnew[1], Wesley M. Daniel[2], and Brian E. Reichert[1]
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Invasive species present a significant threat to ecosystems, the economy, and public health. Addressing the challenges posed by these species across the United States and its territories requires a concerted effort. Here, we highlight the role of Siren: the National Early Detection and Rapid Response (EDRR) Information System in fostering collaboration among existing and emerging EDRR projects. As the Information System of a National EDRR Framework, Siren aims to enhance collaboration among partners, streamline communications, and establish a centralized platform for tools, resources, and information related to invasive species management and control. However, the journey is not without its challenges, as Siren continues to navigate complexities in data integration, user needs, and technological advancements. It is essential that Siren engages with diverse groups of EDRR practitioners to learn what barriers exist and identify management needs. To address this, we will showcase how partner feedback related to biocontrol will be pivotal in informing decisions related to the creation of Siren and guide the integration of resources and tools that support biocontrol actions. Additionally, we invite participation to our Community of Practice Groups that focus on the Planning, Detecting, Responding, and Reporting of invasive species, and help us understand what future needs exist. Finally, we will review the next steps of Siren by highlighting how tools and resources to support biocontrol efforts nationwide may be integrated into the web application based on the feedback we receive.

Nicole is based out of the USGS Fort Collins Science Center in Colorado and serves as the National Outreach Coordinator for Siren: the National EDRR Information System. She is also the lead for Siren's four Community of Practice groups (Plan, Detect, Respond, Report) that assist with identifying user needs and inform the content and design of Siren.

Low Social Acceptability of Common Invasive Species Management Methods in the United States

Wade Simmons[1], Darragh Hare[2], Andrea Dávalos[3], and Bernd Blossey[1]
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Decisions to manage invasive species can be controversial. Despite the potential challenges of social controversy to public relations and conservation goals, attitudes of the public towards invasive species management (ISM) are poorly characterized, leaving decision makers with little information on the social acceptability of proposed plans. To evaluate social acceptability towards ISM in the US, we conducted an online vignette experiment using hypothetical but realistic management scenarios with a large (n=1,212) and stratified sample of respondents – a key project strength. We varied targeted taxa (insect or plant), control method (mechanical, chemical, biological), risk severity (low, high), and type of non-target risk (to humans or native species). We found low public acceptability for ISM, with tepid support for mechanical control and low support for chemical and biological control, particularly at high non-target risk levels. Of eight scenarios, respondents only supported biocontrol efforts in one, and biocontrol of plants was opposed more than biocontrol of insects. Regarding non-target risks, respondents were equally accepting of risks to human well-being as risks to native species, challenging calls for simply more human-centric justifications for conservation. Our results suggest that public support for invasive species management should not be assumed. Beyond low and selective support for ISM, our results highlight a disconnect between effectiveness of common management methods and their social acceptability, underscoring dual needs for greater outcome monitoring in management, and more research attention on social science approaches to better understand drivers of human attitudes.

Wade Simmons is an ecologist working on his PhD at Cornell University. Wade's work currently is focused on the aquatic plant water chestnut and the research assessing its potential for biological control using a specialist, leaf-feeding beetle. Beyond ecological interactions, Wade is also interested in the social context of conservation and environmental management, and has led projects documenting public attitudes towards invasive species control. Wade is enthusiastic about engaging others about ecology and biological control through teaching in formal and informal settings, and was excited to contribute to the recent development of the online course, Classical Weed Biological Control 101.

The Status of Integrating Brazilian Peppertree Thrips (*Pseudophilothrips ichini*) to Manage Brazilian Peppertree (*Schinus terebinthifolia*) in Federal Ecosystem Restoration Projects in South Texas

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A goal of many ecosystem restoration (ER) projects is to improve plant communities by increasing native species and reducing invasive species. Biocontrol has been used to support this effort but is generally underutilized in government-sponsored IPM or ER programs. Since 2017, the U.S. Army Corps of Engineers has studied AER methods on paleochannels of the Rio Grande River, TX. Termed "resacas", these rare ecosystems are home to endemic species, but have been degraded due to habitat fragmentation and invasive species—primarily Brazilian peppertree (*Schinus terebinthifolia*). In 2021, we initiated a biocontrol program of *S. terebinthifolia* using the recently USDA-permitted Brazilian peppertree thrips (*Pseudophilothrips ichini*) to support these efforts and research the application framework of the biocontrol technology in this context. After planning and design, releases of 88,000 thrips has reduced fruiting by 57% and apical growing tips by 60%, however, persistence has been tenuous. Low abundance during summer months suggests temperatures are a limiting factor. As such, we investigated and correlated thermal limits of the organism with weather data to spatially illustrate suitable release regions. Results indicate major differences in the predicted summer survival between south Texas (30%) and Florida (70%, other region of release). As a next step, we intend to further explore how heat influences population growth—releases farther up the Texas coast where survivorship may be improved are ongoing. This case study has also provided lessons-learned for integrating biocontrol into a publicly funded restoration framework—how to incorporate into project phases, regulatory issues, value-engineering, and cultural resources considerations.

Aaron Schad is a Research Biologist with the U.S. Army Engineer Research and Development Center. As a part of the Aquatic Ecology and Invasive Species Branch, his research and work focus include aquatic ecosystem restoration, habitat mitigation, and vegetation establishment and management.

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