

Department of Entomology and Entomology & Insect Science Graduate Interdisciplinary Program



Academic Program Review Self-Study Report 2023

**Department of Entomology
and
Entomology & Insect Science Graduate Interdisciplinary Program
Self-Study Report
2023**

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SECTION A: INTRODUCTION AND OVERVIEW

Welcome to the self-study report for the first joint Academic Program Review of the Department of Entomology (ENTO) and the Entomology & Insect Science (EIS) Graduate Interdisciplinary Program (GIDP) at the University of Arizona!

1. Administrative Homes and Unit Leaders

The Department of Entomology is one of 10 academic units in the College of Agriculture, Life & Environmental Sciences (CALES, formerly CALS: College of Agriculture & Life Sciences (Appendix A1). Dr. Bruce Tabashnik has led the Department as Head since 1996.

The EIS GIDP is one of the approximately 20 Graduate Interdisciplinary Programs in the Graduate College (GC, Appendix A2). In 2009, the graduate program of the Department of Entomology merged with the GIDP in Insect Science to create the EIS GIDP. Dr. Martha (“Molly”) Hunter has led the EIS GIDP as Chair since its founding. Dr. Hunter is a Professor in ENTO, which facilitates close collaboration between the Department and the EIS GIDP.

2. Productivity and Impact

Of the 52 students who earned degrees (24 PhD and 28 MS) in the EIS GIDP from 2014 to September 2023, 100% are employed and 98% are employed in areas related to their graduate education (Section I).

UA Entomology faculty ranked in the top three nationally among 36 entomology departments and programs in the percentage of faculty with articles, awards, and citations, as well as in awards and federal grant dollars per faculty member based on the most recent Academic Analytics data (through 2021, Section D).

The Arizona Insect Festival hosted by the Department of Entomology and over 100 volunteers delights thousands of children and their families annually by getting them up close and personal with insects and the scientists who study them (Section J).

Extramural funding awarded to the Department of Entomology reached an all-time high of \$8.6 million in Fiscal Year 2023 (ended June 30, 2023), equivalent to over \$600,000 per core Entomology faculty member who had research as part of their assigned duty (Section D).

The 26 current EIS students have won over 70 awards and honors and given 64 presentations, including 39 at national or international conferences and 15 for Extension and outreach (Sections D and I).

Since 2018, the Public Health Integrated Pest Management (IPM) Team led by Entomology faculty has partnered with 15 of Arizona’s federally recognized Native American Nations to benefit over 240,000 residents with programs that reduce the risk of diseases vectored by insects and ticks.

On a scale from 0 to 100% (best), courses taught by Entomology faculty from Spring 2020 to Spring 2023 were rated 92% by undergraduate students and 95% by graduate students (Section E).

Entomology publications include 275 journal articles and 9 book chapters listed by Scopus for 2016 to July 2023, with 27% of the journal articles and 22% of the book chapters coauthored by EIS students (Section D).

The three most recent faculty hires by Entomology identify as female and the two most recent tenure-track faculty hires identify as female and Hispanic.

Increased enrollment in Entomology courses raised Entomology teaching revenue 113% in FY2022 relative to FY2016, despite the 9% college-wide decrease in teaching revenue over the same period (Section G).

Entomology faculty and staff were instrumental in a collaborative effort that eradicated the invasive pest pink bollworm from the U.S., which helped to reduce insecticide use 82% overall in cotton in Arizona and saved U.S. growers \$192 million from 2014 to 2019 (Section E).

3. Overview of Faculty

We refer to faculty appointed in the Department of Entomology with at least 0.75 full-time equivalent (FTE) as core ENTO faculty. No faculty have a portion of their appointment in ENTO and a portion in another unit. We currently have 17 core faculty. Dr. Paulina Maldonado-Ruiz will join us in January 2024, bringing us to 18 core faculty with a total of 17.7 FTE including two Assistant Professors of Practice at 0.83 FTE each (Table A1, Figs. A1 and A2). Sixteen core ENTO faculty are also members of EIS. In addition, 12 additional faculty from seven departments and three colleges across UA are active members of EIS (Fig. A3).

Table A1. Department of Entomology core faculty: rank and mission areas

Core faculty member	First year	Rank	% FTE in each mission area*					Total FTE
			Res	Instr	Ext	Serv	Cur Admin	
Carrière, Yves	1998	Full	75	15		10		1.0
Davidowitz, Goggy	2009	Full	75	15		10		1.0
Ellsworth, Peter	1991	Full	10		80	10		1.0
Fournier, Al	2007	Assoc.	10		80	10		1.0
Gouge, Dawn	2000	Full	20		70	10		1.0
Hunter, Martha	1996	Full	75	15		10		1.0
Lanan, Michele	2022	Asst.		90		10		0.83
Li, Xianchun	2005	Full	75	15		10		1.0
Maldonado-Ruiz, Paulina	2024	Asst.	75	15		10		1.0
Matzkin, Luciano	2017	Assoc.**	75	15		10		1.0
McKnight, Tristan	2019	Asst.		90		10		0.83
Moore, Wendy	2010	Assoc.**	50	15		15	20	1.0
Palumbo, John	1990	Full	25	5	60	10		1.0
Riehle, Michael	2005	Full	75	15		10		1.0
Schlenke, Todd	2016	Assoc.	75	15		10		1.0
Tabashnik, Bruce	1996	Full	60			10	30	1.0
Tigres, Natasha	2023	Asst.	75	15		10		1.0
Walker, Kathleen	2011	Assoc.	50	25	15	10		1.0

*Full-time equivalent (FTE) in Research, Instruction, Extension, Service, Curation of the UA Insect Collection (UAIC), and Administration; **Promotion review in progress

Figure A1. Entomology core faculty: titles and areas of interest



Yves Carrière
 Professor
 Insect ecology, resistance
 management for transgenic crops
 Integrated Pest Management (IPM)



Goggy Davidowitz
 Professor &
 University Distinguished Scholar
 Ecological and evolutionary
 physiology, edible insects



Peter Ellsworth
 Specialist (Extension) & Professor
 IPM Coordinator, IPM
 Industrial & field crops pest management
 Maricopa Agricultural Center (MAC)



Alfred Fournier
 Assoc. Specialist & Assoc. Professor
 Evaluation of IPM adoption,
 implementation, and impact
 MAC



Dawn Gouge
 Specialist and Professor
 Public health entomology
 IPM
 MAC



Martha Hunter
 Professor & Chair, Entomology &
 Insect Science GDP
 Insect symbionts



Michele Lanan
 Assistant Professor of Practice
 Evolution of diet and gut morphology,
 ant collective foraging



Xianchun Li
 Professor
 Insect-plant interactions, molecular
 biology, resistance mechanisms &
 management, transposable elements



Paulina Maldonado-Ruiz
 Assistant Professor
 Medical entomology
 Understanding and managing ticks
 that vector diseases



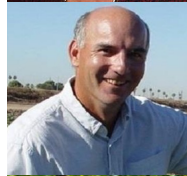
Luciano Matzkin
 Associate Professor
 Ecological genomics
 Cactophilic *Drosophila*



Tristan McKnight
 Assistant Professor of Practice
 Robber fly ecology and evolution



Wendy Moore
 Associate Professor
 Curator, UA Insect Collection
 Insect systematics



John Palumbo
 Specialist and Professor
 Endowed Chair
 Vegetable IPM
 Yuma Agricultural Center (YAC)



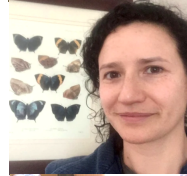
Michael Riehle
 Professor
 Physiology & medical entomology
 Controlling mosquitoes and
 reducing the diseases they vector



Todd Schlenke
 Associate Professor
 Evolutionary genetics of
 host-parasite interactions



Bruce Tabashnik
 Regents Professor &
 Department Head
 Understanding and managing
 pest resistance to transgenic crops

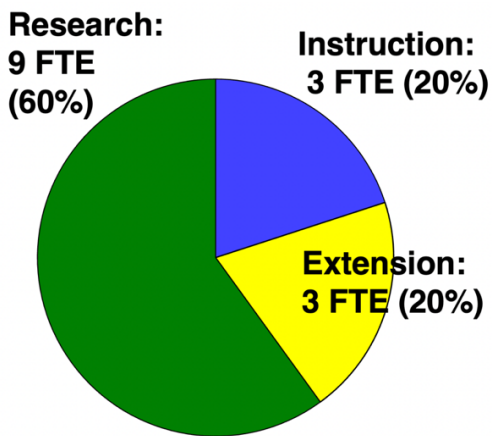
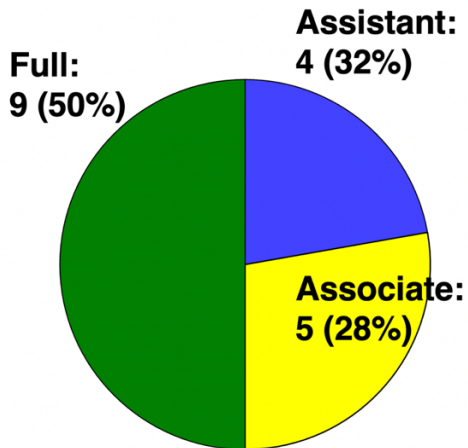


Natasha Tigreros
 Assistant Professor
 Insect nutritional ecology and
 life history



Kathleen Walker
 Assoc. Specialist & Assoc. Professor
 Ecology of arthropod vectors
 of human diseases
 Insect Discovery Outreach Program

Fig A2. Distribution of ranks and mission areas for Entomology core faculty. Two of the five Associate Professors are under evaluation now for promotion in 2024.



Additional Faculty FTE :
Service: 1.8, Administration 0.3, Curation 0.2

Of the 18 core faculty, 14 are stationed at the main UA campus in Tucson, whereas four with Extension appointments are at the Maricopa Agricultural Center near Phoenix (Ellsworth, Fournier, and Gouge) or the Yuma Agricultural Center (Palumbo). ENTO has two postdoctoral fellows and no lecturers or adjunct instructors. Academic programs for undergraduates in ENTO are the Minor in Entomology established in 2022 with current enrollment of 10 and the Certificate in Entomology and Insect Science, established in 2021 with four certificates earned and one in progress.

Fig. A3. Active EIS GIDP faculty members at UA (excluding ENTO core faculty) and USDA associates who are active in the EIS GIDP. Active participants have participated in events, served on EIS committees, taught EIS graduate courses, or mentored EIS students as either major advisor or committee member in the last three years.



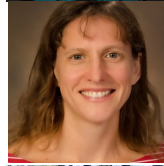
Kirk Anderson
Lead Scientist
USDA Agricultural Research Service
Social insect ecology and honey bee microbial ecology



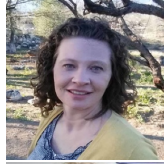
Michael Bogan
Associate Professor
Wildlife Conservation and Management
School of Natural Resources and the Environment
Freshwater and riparian ecology



Judith Bronstein
University Distinguished Professor
Ecology and Evolutionary Biology
Evolution and ecology of mutualisms



Heidi Brown
Associate Professor
Epidemiology and Biostatistics
Spatial epidemiology and climate change



Vanessa Corby-Harris
Research Physiologist
USDA Agricultural Research Service
Honey bee nutrition and physiology



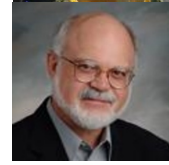
Anna Dornhaus
Professor
Ecology & Evolutionary Biology
Social insects, ants/honey bees



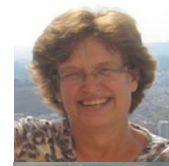
Kacey Ernst
Professor & Department Chair
Epidemiology and Bioscience
Epidemiology of infectious diseases



Wulfila Gronenberg
Professor
Neuroscience
Movement control, muscle biomechanics, learning and memory



John Hildebrand
Regents Professor Emeritus
Neuroscience
Olfaction and learning and memory



Lisa Nagy
Professor
Molecular and Cellular Biology
Development and evolution of pattern formation in arthropods



Daniel Papaj
Professor
Ecology & Evolutionary Biology
Learning and cognition in bees, fruit flies, butterflies; plant-insect interactions



Nicholas Strausfeld
Regents Professor
Neuroscience
Functional organization of arthropod central nervous systems, learning and memory

4. Overview of EIS Students

The academic program for graduate students is the Entomology & Insect Science Graduate Interdisciplinary Program (EIS GIDP) with current enrollment of 20 PhD and 6 MS students (as of August 22, 2023, Fig. A4).

Fig. A4. Students in the EIS MS and PhD programs.



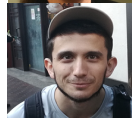
Nathan Allen
PhD student
Advisor: Kirk Anderson
Symbiosis and dysbiosis in honey bees



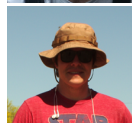
Joshua Ambrister
PhD student
Advisor: Kathleen Walker
Dengue in *Aedes aegypti*



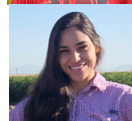
Meagan Ash
PhD student
Advisor: Todd Schlenke
Physiology of host-parasitoid interactions



Davide Bergamaschi
PhD student
Advisor: Wendy Moore
Systematics of ants



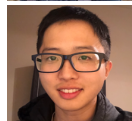
Charles Bradley
PhD student
Advisor: Wendy Moore
Microbiome of native bees and their parasites



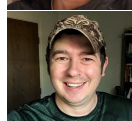
Isadora Bordini
PhD student
Advisor: Peter Ellsworth
Biological control of whiteflies in cotton



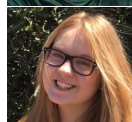
Emiliano Calvo
PhD student
Advisor: Anna Dornhaus
Behavior of social insects



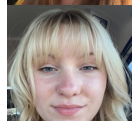
Xingsen Chen
PhD student
Advisor: Luciano Matzkin
Reproductive interactions among populations of cactophilic *Drosophila*



Hunter Clark
MS student
Advisor: Goggy Davidowitz
Insects for food and feed



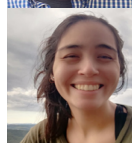
Megan Deeter
PhD student
Advisor: Vanessa Corby-Harris
Nutrition, lipid metabolism and honeybee health



Skyler Finucane
MS student
Advisor: Kathleen Walker
Knowledge, attitudes and practices survey about ticks for dog-adjacent professions



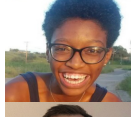
Kyle Harrington
PhD student
Advisor: Yves Carriere
Biology and pest management of a species complex of alfalfa weevil



Raine Ikagawa
PhD student
Advisor: Wendy Moore
Systematics and metagenomics of bombardier beetles



Zoe Jensen
PhD student
Advisor: Luciano Matzkin
Genetics of Bt resistance in *H. zea*



Mamesha Jones
PhD student
Advisor: Goggy Davidowitz
Herbivory under drought stress



Oliver Kortenkamp
PhD student
Advisor: Kirk Anderson
Symbiosis in honey bees



Alex Lombard
MS student
Advisor: Wendy Moore
Symbiosis in bombardier beetles



Bailey Payne
MS student
Advisor: Kathleen Walker
Field survey for mosquito pesticide resistance in Arizo



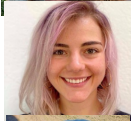
Brendan Riske
PhD student
Advisor: Mike Riehle
Physiology of insulin signaling in mosquitoes



Liam Roberts
PhD student
Advisor: Luciano Matzkin
Drought stress adaptation in cactophilic *Drosophila*



Shianna Rodriguez
MS student
Advisor: Yves Carriere
Pest management of an invasive thrips



Mara Short
PhD student
Advisor: Kathleen Walker, Wendy Moore
Systematics and biology of the brown dog tick



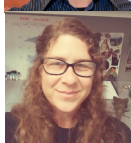
Ethan Stahura
MS student
Advisor: Yves Carriere
Mass rearing technique development



Liam Sullivan
PhD student
Advisor: Molly Hunter
Symbiosis in a leaf-footed bug



Edwin Umanzor
PhD student
Advisor: Molly Hunter
Symbiosis in a leaf-footed bug



Andrea Walton
PhD student
Advisor: Yves Carriere
Comparative fitness of mass-reared insects

SECTION B: GOALS

Entomology & Insect Science GIDP Mission Statement

EIS GIDP faculty members are an interdisciplinary and collaborative community of researchers and scholars engaged in providing an internationally recognized graduate program in research involving arthropods as models, pests, vectors, and critical components of biodiversity and ecosystem services. We are dedicated to providing a graduate program that is flexible to student goals, and blends innovative research training, coursework, dedicated mentoring, as well as trains students in science education and outreach to foster the next generation of insect scientists.

Department of Entomology and EIS GIDP

For details, please see our complete Strategic Plan (Appendix B1).

1. Purpose, Mission, Shared Values and Strategic Perspective, Vision, and Strategic Goals

a. Purpose: Improve the quality of life of the people of Arizona and the world by generating, disseminating, and applying information about insects.

b. Mission

- Conduct outstanding research to better understand insects and their impact on humanity
- Provide distinguished education in insect biology
- Provide innovative solutions to address critical issues such as food security and vector-borne diseases
- Facilitate capacity building of vector management programs in vulnerable communities
- Develop and deploy the most advanced technologies and progressive IPM programs in the world to minimize the negative impacts of insects and maximize their positive impacts
- Provide outstanding outreach programs about insects accessible to all community members

c. Shared Values and Strategic Perspectives

- Respect for all people
- Collaboration among department members
- Collaboration within and across disciplines with others in CALES, UA, and other institutions
- Put knowledge to work to improve lives
- Serve our profession and the people of Arizona and the world
- Excellence in all pursuits
- Passion for achieving positive outcomes
- Work hard and have fun doing what we love to do
- Provide value for resources invested in Entomology
- Develop programs with local and global relevance
- Take advantage of our desert environment and position in the front line of climate change

d. Vision (each Vision item is addressed in a specific strategic goal, see below)

1. The quality and impact of our research will be recognized in Arizona, nationally & globally.
2. Our Integrated Pest Management (IPM) programs will be implemented in Arizona and other regions worldwide and will promote better health, protect the environment, and boost the economy.
3. We will engage undergraduate students with active-learning courses and mentoring to help them succeed in the fourth industrial revolution (4IR).
4. The graduate program in Entomology & Insect Science (EIS) will attract the best students; students completing EIS degrees will be in high demand by employers.
5. Our outreach programs will educate, delight, and connect community members with Entomology, CALES, and the University of Arizona.
6. The UA Insect Collection will be the best source of specimens from the Sonoran Desert Region and a global center for specimen-based insect research.
7. Our programs will be well supported by private donors, as well as by governmental agencies.

e. Strategic Goals

1. Research: Increase Entomology research productivity 30% by 2025.
2. IPM: By FY25, greatly enhance the effectiveness of Integrated Pest Management (IPM) research, education, and Extension programs in Arizona for teaching students and stakeholders, and for addressing health, environmental, and economic problems caused by pests.
3. Undergraduate Engagement: Increase the yearly undergraduate student credit hours taught 30% by FY2025.
4. Graduate Program: Double the stable funding for EIS graduate students by FY25.
5. Outreach: Double the number of people served each year by FY25 through sustainable outreach programs to meet public demand for insect information, to support K-12 science education, and to connect underserved communities to UA Entomology and CALS.
6. Insect Collection: By FY25, double our holdings of expertly-identified insect pollinators and triple our holdings of expertly-identified DNA barcoded voucher specimens.
7. Development: Raise \$2M from private donors to support our programs by FY25

f. Relationship of Entomology Strategic Goals to the University of Arizona Strategic Plan
<https://strategicplan.arizona.edu/>

For details, please see Appendix B2.

Pillars of the University of Arizona Strategic Plan most relevant to ENTO Strategic Goals:

Pillar 1. “Wildcat Journey: Preparing students with the skills and mindsets to lead in the 4th industrial revolution”

Pillar 2. “Grand Challenges: Tackling society’s biggest challenges by enabling discoveries that will fundamentally shape the future”

Pillar 3. “Arizona Advantage: Advancing our land grant mission to drive social, cultural and economic impact”

Pillar 5. “Living our values and innovative culture to enable a high performing institution”

Entomology Goal	UA Strategic Plan Pillar
1	2, 5
2	2, 3, 5
3	1
4	1, 2,
5	1, 3
6	1, 2
7	1

C. CHANGES SINCE PREVIOUS REVIEWS

Department of Entomology

The most recent previous Academic Program Review (APR) of the Department of Entomology was completed in May 2009.

1. Major changes in instruction since 2009 include:

a) Development and teaching of two General Education courses (ENTO 160 & 170) in person and online via iCourses, Arizona Online, and Arizona International Direct (aka UA Global).

b) In 2021, we established a 12-unit Undergraduate Certificate in Entomology that offers a flexible course of study students can tailor to their own interests (Appendix C1)

<https://cals.arizona.edu/ento/content/undergraduate-certificate-entomology-and-insect-science>

c) In 2022, we established an 18-unit Undergraduate Minor in Entomology to provide students with advanced education and skills in insect-related fields to be competitive for employment in agricultural and biotech industries as well as for graduate programs in disciplines such as Entomology, Public Health, Environmental Sciences, Epidemiology, Biology, and Ecology (Appendix C1). <https://cals.arizona.edu/ento/content/undergraduate-certificate-entomology-and-insect-science/minor>

d) In November 2009, we merged the Entomology Graduate Program with the Insect Science Graduate Interdisciplinary Program to create the Entomology & Insect Science Graduate Interdisciplinary Program (EIS GIDP).

2. Response to recommendations from the 2009 APR of the Department of Entomology

The main recommendation of the 2009 APR of the Department of Entomology was to hire seven new faculty in the following areas: 1) Insect Systematics, 2) Insect Genomics, 3) Insect Ecology, 4) Crop Integrated Pest Management (IPM), 5) Urban IPM, 6) Biological Control, and 7) Economic Entomology.

Response: Since 2009, we have hired faculty in 1) Insect Systematics (Wendy Moore), 2) Insect Genomics (Luciano Matzkin and Todd Schlenke), 3) Insect Ecology/Physiological Ecology (Goggy Davidowitz and Natasha Tigreros), and 4) Crop IPM (Al Fournier). We are currently recruiting for another position in Crop IPM (Assistant Specialist in Extension). Although we have not received approval yet for a faculty position in Urban IPM, current grants support two Associates in Extension who address this area (Drs. Shaku Nair and Shujuan Li).

Entomology & Insect Science Graduate Interdisciplinary Program

The recommendations of the 2014 APR of EIS and changes made in response to the recommendations are summarized below.

Recommendations 1 & 2: The most recent previous APR of the EIS GIDP was completed in 2014. Note that EIS was reviewed alone at this time. The 2014 review team found the program “excellent overall” and made several recommendations. **As the most pressing concerns,** the review team noted the 1) “erosion of faculty expertise in critical research areas,” particularly in

sub-organismal disciplines, and the 2) “unpredictability and limited financial support available for students.”

Response 1: As noted above, the Department of Entomology has hired two faculty in genomics (Schlenke and Matzkin) and two ecological physiologists have or will join the faculty in 2023-24: Natasha Tigreros (plant-insect interactions and ecological physiology) and Paulina Maldonado Ruiz (medical entomology and the ecological physiology of ticks). Two of these critical hires (Schlenke and Maldonado) were facilitated by the GIDP-Shared Hiring Process (formerly known as the GIDP-Partnered Hire) contributions to the first two years of salary of these CALES hires.

Response 2: The unpredictability of financial support for students has not gone away, but the lines of communication among students, faculty mentors and the Chair have improved such that students are directed towards TA opportunities as they occur, the Chair takes an active role in finding TA opportunities, and funding has been found for all students who are making progress in the program. Very important for this increase in student confidence of being funded in the period from 2014-2022 has been the availability of one or two GIDP administration-supported TAs (for courses in Entomology or elsewhere on campus). We face challenges in funding our students because of a substantial increase in their stipends that has not been fully matched by increased funding from the Graduate College (GC) and CALES, which are dealing with budget constraints and uncertainty associated with a new budget model at UA. Please see Sections G and I for additional details on EIS funding.

Recommendation 3: The review team praised the EIS Graduate program coordinator at the time and recommended that she be moved closer on campus.

Response: We had a lot of turnover in coordinators (three in three years in one stretch) since this time, but our current coordinator Paula Nielsen, has now been in the position for three years and has restored stability and institutional knowledge to this position. She is also based in the Marley building where the greatest concentration of EIS faculty and students are housed and has an open-door policy so students can walk in (and do!)

Recommendation 4: The review team suggested a change in administrative structure, whereby the Executive Committee run admissions and oversee student progress reports without separate committees.

Response: We retained the ability to be flexible on committee membership and draw from the faculty at large but made the expectation of committee service more explicit when recruiting executive committee membership. In our generous and collaborative faculty community, we have not had trouble finding faculty willing to serve on these important committees.

Recommendation 5: The review team recommended that EIS devote more concerted effort to recruiting students of underrepresented groups.

Response: Concerted recruiting via advertisements on listservs over a few years following the review did not clearly yield greater diversity of US resident applicants in our pool. Our current

students are nonetheless diverse, balanced in gender identity (Figs. I1 and I2) and four recent students have been recipients of Graduate Access Fellowships that provide aid to matriculating students who are first generation or have surmounted financial or other obstacles to attend graduate school since 2014. We note that gender balance figures derived by the current university analytic software does not capture students identifying as non-binary, and so does not represent all of our current students as they would self-identify.

Recommendation 6: The review team evaluated several curriculum issues, including the value of a) research rotations, b) the EIS seminar series, c) a student-invited speakership, the two tracks currently in place for PhD students (Insect Science or Entomology), and program curricula requirements.

Response: Following a day-long retreat with EIS students and faculty in 2015 and several subsequent discussions, we:

- a) standardized required PhD student research rotations to two of eight weeks each.
- b) moved the joint EIS/ENTO seminar to Friday morning and attendance has improved.
- c) established the Hagedorn Speakership as an endowment through the GIDP Administration, which enables students to invite one outside speaker per year. It has been in place for several years, even in a pandemic year when the visit was virtual.
- d) ended PhD program tracks, a vestige of the previously separate, now defunct Entomology graduate program and Insect Science GIDP.
- e) selected three core courses of which students must complete at least two: Insect Systematics, Insect Ecology, and Insect Molecular Biology (which later became Insect Systems Biology). Because the third course had consistently low enrollment, it has not been offered in recent years. In effect, this means students must complete the first two core courses.

Recommendation 7: The Review team noted the accomplishments of the program faculty and students in outreach, with special recognition going to the annual Arizona Insect Festival, and Insect Discovery, an outreach program led by Dr. Kathleen Walker that reaches thousands of school children annually, while simultaneously providing training opportunities for graduate and undergraduate students. The team hoped that these activities could be continued to be supported at the College and University levels.

Response: Outreach remains central in its importance in our program. We are still looking for opportunities to secure permanent funding for these two programs and for dedicated EIS graduate assistantships in support of these programs. In recent years, a critical piece has been the availability of GIDP-supported TAs that the program can allocate to Insect Discovery. These experiences have had a large impact on our students, who often find them one of the most rewarding experiences of their program.

D. QUALITY AND PRODUCTIVITY

1. Publications and Citations. Based on the Scopus literature database, the UA Department of Entomology and EIS GIDP students published 275 journal articles and 9 book chapters from 2016 to July 7, 2023 (Appendix D1). These include many papers in prestigious journals, such as *Nature Biotechnology* (1), *Annual Review of Entomology* (2), *Science* (4), and *PNAS* (7), with a total of 21 publications in 11 journals that have an impact factor >10 (Table D1). EIS students coauthored 74 of the 275 journal articles (27%) and two of the nine book chapters (22%) (Appendix D1).

Scopus listed 4,717 citations of the total of 284 publications as of July 7, 2023, which yields a mean of 17.2 citations per publication. Because most citations occur a year or more after publication of the cited material, we also note that Scopus listed 4,650 citations of our 234 journal articles and book chapters published from 2016 to 2021, which yields a mean of 19.9 citations per publication. In addition, Associate Professor Wendy Moore co-edited the textbook *Invertebrates*, which is not tracked by Scopus and has been cited over 6,400 times according to Google Scholar.

Table D1. Twenty-one publications in 11 high-profile journals (impact factor >10) by the UA Department of Entomology and EIS GIDP students (2016-July 7, 2023)

Journal	Impact factor ^a	Number ^b
<i>BioScience</i>	10.1	1
<i>Environmental Health Perspectives</i>	10.4	1
<i>ISME Journal</i>	11.0	1
<i>PNAS</i>	11.1	7
<i>Science Advances</i>	13.6	1
<i>Plant Biotechnology Journal</i>	13.8	1
<i>Nature Communications</i>	16.6	1
<i>Trends in Biotechnology</i>	17.3	1
<i>Annual Review of Entomology</i>	23.8	2
<i>Nature Biotechnology</i>	46.9	1
<i>Science</i>	56.9	4

^a Impact factor from Journal Citation Reports 2022

^b Scopus search 7-7-23 based on affiliation with UA Department of Entomology or EIS

2. Extramural Funding. Extramural support of Entomology including grants, contracts, and gifts averaged \$3.7 million per year during the past seven fiscal years (starting FY2017: July 1, 2016 to June 30, 2017 and ending FY2023: July 1, 2022 to June 30, 2023, Fig. D1). Data provided by the CALES Data Solutions Team indicates that grants and contracts awarded to Entomology reached an all-time high of \$7.9 million in FY2023 (Appendix D2). Combined with gifts, a total of \$8.6 million in extramural funding was obtained during FY2023 (Fig. D1). The total extramural funding received by Entomology is nearly triple for FY2023 versus the mean for FY2017-FY2022 (\$2.9M). This increase was caused by a 2.4-fold increase in the percentage of requested dollars funded (46% in FY2023 vs. 19% in FY2017-FY2022) and a 1.2-fold increase in the proposed dollars. The number of proposals submitted was 13% higher in FY2023 (60) vs. FY2017-FY2022

(53). In an extremely competitive environment, this surge in extramural funding is resounding confirmation of the quality of our programs and bodes well for our future productivity.

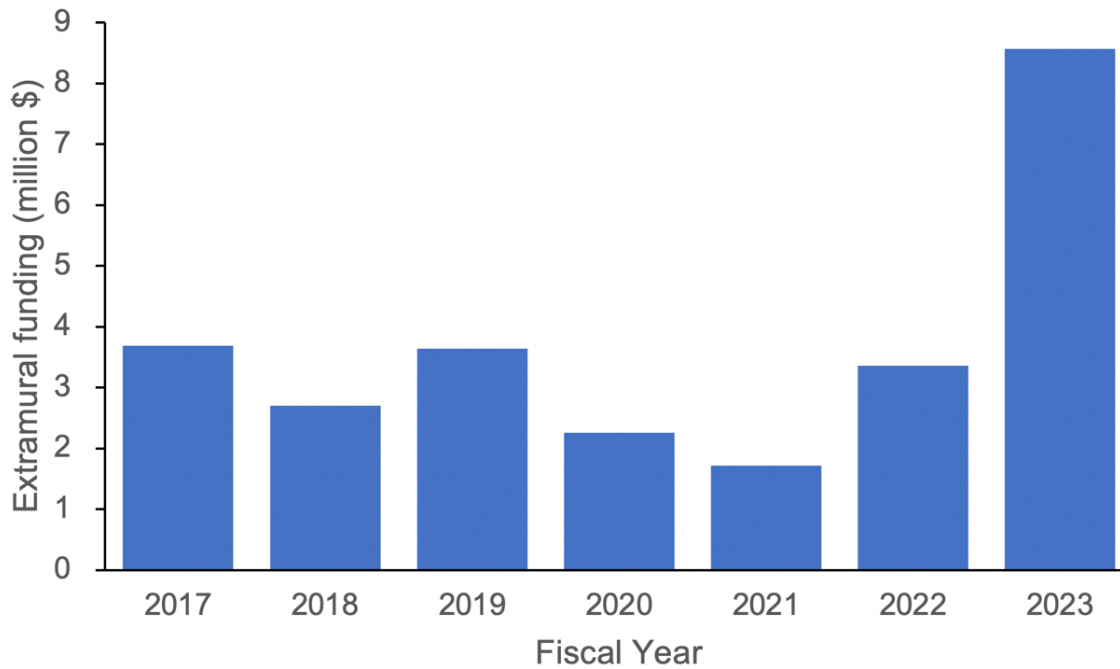


Fig. D1. Extramural funding (grants, contracts, and gifts) awarded to the Department of Entomology FY2017-FY2023.

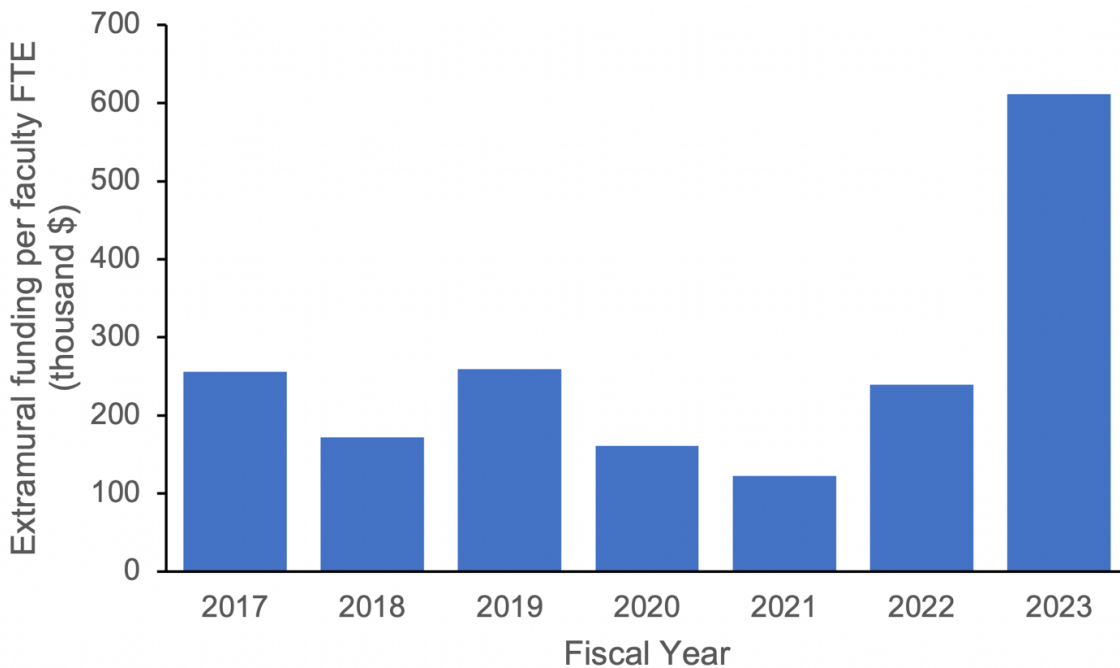


Fig. D2. Extramural funding awarded to the UA Department of Entomology per faculty full-time equivalent (FTE, excludes Professors of Practice -- they have no

Research or Extension FTE). Faculty FTE was 14.4 in FY2017, 15.7 in FY2018, and 14 in FY2019-2023.

Grants and contracts accounted for 86% of the total extramural funding for FY2017-2023. Federal agencies were the primary funding source, accounting for 96% of the grants and contracts awarded in FY23 (Appendix D2). Federal funding sources in FY2023 included the Centers for Disease Control and Prevention (CDC), NIH, NSF, U.S. Department of Housing and Urban Development (HUD), and USDA (Appendix D2). The remaining sources of grants and contracts in FY2023 were State agencies (2%) and industry (2%).

For faculty who have a portion of their FTE assigned to Research (including the Department Head and excluding Professors of Practice), we calculated the extramural funds awarded to the Department of Entomology per faculty member (Fig. D2) relative to the mean faculty salary. For FY2017-2023, the annual mean extramural funding awarded to ENTO per faculty member was \$260,400. The mean annual salary was approximately \$113,300 for FY2017-2023 (based on FY2023 and back-calculated for previous years, assuming a 3% increase had occurred each year). Thus, for FY2017-2023, the mean annual extramural funding awarded per faculty FTE was 2.3 times the mean annual FY2017-2023 salary. In FY2023, the mean extramural funding awarded to ENTO per faculty member was \$611,700 and the mean ENTO faculty salary was \$123,600 (n = 14 faculty with Research FTE). Thus, for FY2023, the mean extramural funding awarded to ENTO per faculty member with Research FTE was 4.9 times the mean salary per faculty member.

3. Awards and Honors.

Entomology faculty and EIS students have earned many awards and honors (**Tables D2 and D3**). For example, 6 of 17 (35%) of current Entomology core faculty are Fellows of the American Association for the Advancement of Science (AAAS). Excluding our department, 50 of 698 (7.2%) of entomology faculty nationally were AAAS Fellows in 2021 according to Academic Analytics. Thus, the percentage of faculty earning this honor is about five times higher for UA Entomology relative to the pooled percentage for other entomology faculty in the U.S (Table D2). Current EIS students include six who have received external fellowships for one or more semesters of funding, four who have won awards for presentations, and many who have been awarded scholarships and prizes for their excellence (Table D3).

Table D2. Entomology faculty: selected career awards and honors (72 listed of >100 total)

National and International Awards and Honors (34)

Fellow, Association for the Advancement of Science (AAAS)

Yves Carrière, Goggy Davidowitz, Molly Hunter, Mike Riehle, Todd Schlenke, Bruce Tabashnik

Fellow, Entomological Society of America (ESA)

Yves Carrière, Molly Hunter, Bruce Tabashnik

Lifetime Achievement Award, Plant-Insect Ecosystems Section, ESA

Yves Carrière, Bruce Tabashnik

Integrated Pest Management (IPM) Team Award, Plant-Insect Ecosystems Section, ESA
Yves Carrière, Peter Ellsworth, Xianchun Li, Bruce Tabashnik

NSF CAREER Award
Goggy Davidowitz

Award for Excellence in IPM, ESA
Peter Ellsworth, John Palumbo, Bruce Tabashnik

Pesticide Environmental Stewardship Program Gold Tier Shining Star Award, U.S. EPA
Peter Ellsworth, Al Fournier, Dawn Gouge et al., Arizona Pest Management Center (team award)

Recognition Award for Excellence in Cotton IPM, National Cotton Council
Peter Ellsworth

Outstanding Contributions to National IPM in Schools, U.S. EPA
Al Fournier

International IPM Award of Excellence, International IPM Symposium
IPM Recognition Award, IPM Institute of North America
Childcare and School IPM Recognition Award, IPM Institute of North America
Dawn Gouge

Fellow, Japan Society for the Promotion of Science
Molly Hunter

Henry and Sylvia Richardson Research Grant, ESA
Early Career Professional Award, ESA
Paulina Maldonado-Ruiz

Invited participant, National Academies of Science, Engineering and Medicine:
Next Steps for Functional Genomics
Luciano Matzkin

Rosemary Grant Award, Society for the Study of Evolution
Tristan McKnight

Distinguished Achievement Award in Extension, ESA
John Palumbo

Time magazine's 50 best inventions (2010): Malaria-proof mosquito (#1 Health & Medicine)
New Scholar Award in Aging, Ellison Medical Foundation
Michael Riehle

Member, National Academy of Sciences

Louis Malassis International Scientific Prize for Agriculture and Food, Agropolis Fondation

Researcher of the Year Award, International Cotton Advisory Committee

Fellow, Royal Entomological Society, United Kingdom

Nan-Yao Su Award for Innovation and Creativity in Entomology, ESA

Bruce Tabashnik

Award for Eradication of Pink Bollworm from the United States, USDA

Bruce Tabashnik on behalf of the University of Arizona

Regional and State Awards and Honors (13)

Distinguished Achievement Award in Extension, Pacific Branch, ESA

Peter Ellsworth

Industry Appreciation Award, Arizona Cotton Growers Association

Peter Ellsworth, Bruce Tabashnik

Outstanding Work & Dedication to Crop Protection Industry, Arizona Crop Protection Association

Al Fournier

Environmental Achievement Award, Pacific Southwest (Region 9), US EPA

Dawn Gouge

Award for Distinction in Student Mentoring, Pacific Branch, ESA

Molly Hunter

Editor's Choice Award, *Diversity and Distributions*

Southwest Book of the Year Award, Pima County Public Library, Arizona

Wendy Moore

Outstanding Contribution to Agriculture Award, Yuma County Farm Bureau

Distinguished Service Award, Yuma Fresh Vegetables Association

Outstanding Contribution to Agriculture Award, California Assoc. of Pest Control Advisors

John Palumbo

Recognition Award in Medical, Urban and Veterinary Entomology, Pacific Branch, ESA

Michael Riehle

Environmental Protection and Technology Award, Arizona Farm Bureau

Bruce Tabashnik

Honorary Lectures & Awards from Universities other than University of Arizona (13)
Distinguished Alumnus Speaker, Simon Fraser University
Yves Carrière

Visiting Eminent Ecologist, Kellogg Biological Station, Michigan State University
Goggy Davidowitz

H. Gunderson Memorial Lecture in Entomology, Iowa State University
P. L. Adkisson Distinguished Speaker Award, Texas A&M University
Peter Ellsworth

A. M. Boyce Lecturer, University of California, Riverside
H. R. MacCarthy Lecturer, University of British Columbia and Simon Fraser University
Molly Hunter, Bruce Tabashnik

C. P. Alexander Speaker, University of Massachusetts
Molly Hunter

Chutian Scholar Award, Huazhong Agricultural University, China
HouJin Scholar Award, Northwest A. & F. University, China
Xianchun Li

C. C. Doane Lecturer, University of Wisconsin
C. V. Riley Lecturer, University of Missouri
Bruce Tabashnik

UA and College of Agriculture & Life Sciences (CALs*) Awards and Honors (12)
Research Faculty of the Year Award, CALS
Yves Carrière

Distinguished Scholar Award, UA
Goggy Davidowitz

Honored Faculty, Graduate Interdisciplinary Programs, UA
D. E. Cox Faculty Teaching Award, CALS
Eminent Researcher Award, ALVSCE**
Molly Hunter

Endowed Chair in Integrated Pest Management, CALS
John Palumbo

Cooperative Extension Faculty of the Year, CALS
Peter Ellsworth, John Palumbo

Faculty Member of the Year, 'Ag' 100 Council of CALS Alumni

Peter Ellsworth, John Palumbo, Bruce Tabashnik

Regents Professor, UA

Koffler Prize for Research/Scholarship/Creative Activity, UA

Bruce Tabashnik

*name recently changed to College of Agriculture, Life & Environmental Sciences (CALES)

**Division of Agriculture, Life, and Veterinary Sciences and Cooperative Extension, which includes CALS/CALES

Table D3. EIS current students: selected awards and honors (70 listed).

Fellowships with stipend

UA One Health Initiative Graduate Research Assistantship (1 year)

Josh Arnbrister

National Science Foundation Graduate Research Fellowship (3 years)

Charles Bradley, Mara Short

UA/Sloan Partnership Indigenous Graduate Scholarship (2 years)

Charles Bradley

UA NSF Research Traineeship (NRT) Building Resources for an InterDisciplinary training in Genomics and Ecosystem Sciences (BRIDGES) (2 years)

Zoe Jensen

Pacific Southwest Center for Excellence, Vector-Borne Disease Training Grant (1 semester)

Josh Arnbrister (twice)

UA University Fellows Award (20 incoming PhD students chosen annually across campus, 1 year)

Raine Ikagawa

EIS First year recruiting assistantship (1 year)

Nate Allen, Davide Bergamaschi, Xingsen Chen, Emiliano Calvo, Hunter Clark, Megan Deeter, Skyler Finucane, Raine Ikagawa, Bailey Payne, Liam Sullivan, Edwin Umanzor

Student excellence awards

EIS Carruth award for outstanding student

Isadora Bordini, Meg Deeter

Center for Insect Science Chapman Award for outstanding student studying insects

Isadora Bordini

UA Graduate Access Fellowship

Skyler Finucane, Edwin Umanzor

Western IPM Center Student Fellowship

Isadora Bordini (twice)

UA Department of Entomology Jack Root Graduate Fellowship for Integrated Pest Management & Urban Entomology

Isadora Bordini (twice), Skyler Finucane, Kyle Harrington, Bailey Payne, Mara Short

North America Alfalfa Improvement Conference Student Award

Kyle Harrington

Center for Insect Science Research Award

Davide Bergamaschi, Isadora Bordini, Megan Deeter

Outstanding Master's Student in Biological Control, International Organization for Biological Control (IOBC)

Isadora Bordini

Ford Foundation Fellowship Honorable Mention

Ford Foundation Fellowship Alternate

NSF Graduate Research Fellowship Program Honorable Mention

Edwin Umanzor

Coleopterists Society Graduate Student Research Enhancement Award

Raine Ikagawa

UA CALES Stanley M. Alcorn Memorial Scholarship

Davide Bergamaschi, Megan Deeter

UA CALES Lee S. Stith Scholarship

Isadora Bordini (twice), Edwin Umanzor

UA CALES General Scholarship

Raine Ikagawa

UA CALES Lynham Student Support Scholarship

Skyler Finucane

UA CALES Impact Leader Professional Development Program

Isadora Bordini, Brendan Riske

**UA CALES Kingston J. Smallhouse Scholarship
EIS Leadership award**
Liam Sullivan

EIS Education award (for teaching, mentorship and/or outreach)
Davide Bergamaschi, Raine Ikagawa

UA CALES Online Course Design Bootcamp Award
Davide Bergamaschi, Raine Ikagawa et al.

Scholarship to attend “Trees in the Desert” workshop, Tucson, AZ
Davide Bergamaschi

Research awards

Research grant from T&E, Inc.
Raine Ikagawa

UA BRIDGES Summer Research Experience Award
Zoe Jensen

Presentation awards

Entomological Society of America

Meagan Ash, 2nd place oral presentation, Genetics; Raine Ikagawa, 1st place oral presentation, Systematics and Evolutionary Biology; Mara Short, 1st place poster, Medical, Urban and Vector Entomology; Liam Sullivan, 2nd place oral presentation Award, Systematics and Evolutionary Biology

Travel Awards

UA Graduate Interdisciplinary Programs Herbert E. Carter Travel Award

Davide Bergamaschi (twice), Isadora Bordini, Megan Deeter, Raine Ikagawa, Liam Sullivan, Edwin Umanzor

UA Graduate and Professional Student Council Travel Award

Davide Bergamaschi, Edwin Umanzor

Gordon Research Conference in Animal Microbe Symbiosis, Carl Storm Travel Fellowship

Edwin Umanzor

4. National Rankings from Academic Analytics. Fig. D3 shows the percentile for UA Entomology relative to 36 U.S. entomology departments and programs for 22 metrics reported by Academic Analytics. We highlight eight of these metrics that indicate per capita productivity rather than department size (i.e., number of faculty). The focal eight metrics (with years covered by Academic Analytics) are the percentage of faculty that contributed and the output per faculty for each of four categories: articles published (2018-2021), awards (years not specified), citations and federal grants (both 2017-2021; Table D4).

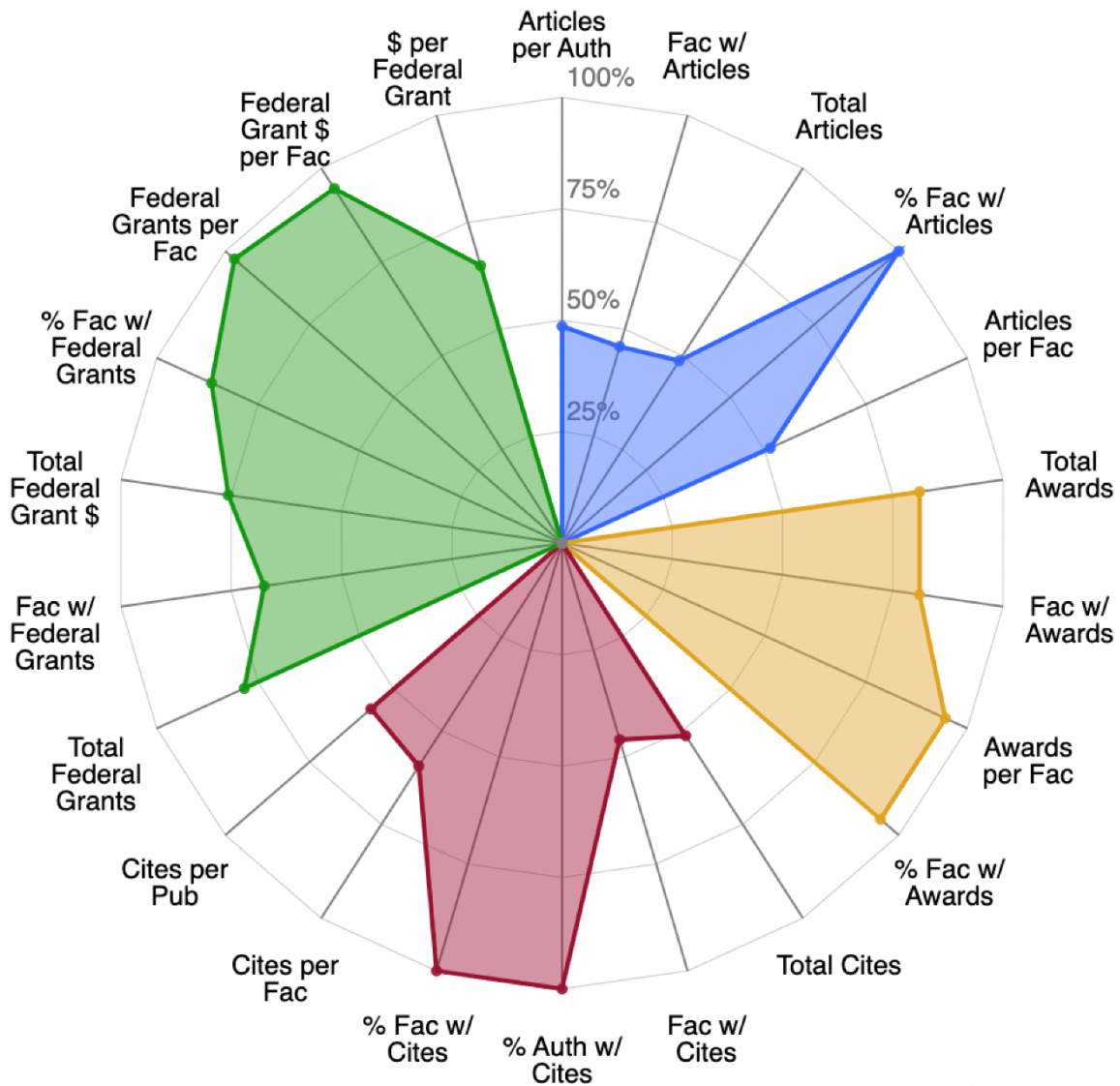


Fig. D3. Academic Analytics percentile for 22 metrics for UA Entomology relative to 36 entomology departments and programs in the U.S. (50% is the median, 100% indicates #1 ranking).

For six of the eight Academic Analytics metrics indicating per capita productivity, UA Entomology was in the top 86th percentile or higher (% of faculty with articles, awards, citations, and grants; and awards and federal grant dollars per faculty). We were in the top 51st percentile for articles per faculty and 59th percentile for citations per faculty (Table D4). Based on these eight metrics, the median percentile for UA is the 95th percentile and the median rank is #3 nationally (Table D4).

Based on the Scholarly Research Index (SRI) derived from the private algorithm of Academic Analytics, UA Entomology was in the 76th percentile and ranked #10 nationally. Relative to peer departments at six other public universities, the UA SRI ranking was below University of Illinois (#1), University of California, Davis (#4), and Colorado State University (#6); and above University of California, Riverside (#15), Purdue University (#16), and Washington State University (#26) (Table D5).

Table D4. UA Entomology articles, awards, citations, and grants from Academic Analytics*

Productivity metric	Value	Percentile**	Rank**
Faculty with articles (%)	100%	100	1
Articles per faculty	12.4	51	19
Faculty with awards (%)	75%	95	3
Awards per faculty	1.8	95	3
Faculty with citations (%)	100%	100	1
Citations per faculty	217	59	16
Faculty with federal grants (%)	69%	86	6
Federal grant \$ per faculty	\$373,491	95	3
Median***	NA	95	3
Scholarly research index****	0.2 (Z-score)	76	10

*Data years: articles: 2018-2021, awards: varies, citations and grants: 2017-2021

**Among 36 entomology departments and programs in the U.S.

***Calculated from the eight metrics listed

****From Academic Analytics based on their private algorithm

Table D5. National ranks from Academic Analytics for UA & six peer entomology departments (U. Illinois, UC Davis, Colorado State U., UC Riverside, Purdue U., and Washington State U.)*

Productivity metric	U. Illinois	UCD	CSU	UA	UCR	Purdue	WSU
Faculty with articles (%)	1	1	1	1	1	22	24
Articles per faculty	2	1	11	19	16	17	28
Faculty with awards (%)	2	10	13	3	4	32	20
Awards per faculty	1	4	12	3	7	30	22
Faculty with citations (%)	1	1	1	1	1	24	25
Citations per faculty	5	1	4	16	12	20	30
Faculty with federal grants (%)	1	4	13	6	17	7	29
Federal grant \$ per faculty	7	9	18	3	19	11	12
Median rank**	1.5	2.5	11.5	3.0	9.5	21.0	24.5
Scholarly research index***	1	4	6	10	15	16	26

*Rank among 36 entomology departments and programs in the U.S. based on coverage of these years from Academic Analytics: articles: 2018-2021, awards: varies, citations and grants: 2017-2021

**Calculated from the eight metrics listed

***From Academic Analytics based on their private algorithm

SECTION E: FACULTY

1. Nature and Breadth of Research and Extension

Entomology faculty generate knowledge about insects that advances fundamental science and has applications that improve the quality of life of the people of Arizona and the world. Significant contributions that advance the discipline have been reported in hundreds of publications in leading journals, including 21 publications from 2016 to July 7, 2023 in journals that have an impact factor >10 (Table D1). Recognition of this excellence includes more than 100 awards received by faculty, including 34 national and international awards (Table D2). Areas of entomology where major advances have been made include integrated pest management, management of pest resistance to insecticides and transgenic pest-killing crops, biology and management of insect vectors of disease; insect behavior, ecology, evolution, genetics, genomics, microbiomes, physiology, symbioses, and systematics; as well as host-parasitoid interactions, insect-plant interactions, and insects as food.

As one example of our impact (see Section J for many others), a team of Entomology faculty and staff was instrumental in a collaborative program with farmers, industry, and government that eradicated the invasive cotton pest pink bollworm from the U.S. and Mexico. This innovative program used environmentally friendly tactics including a synergistic combination of mass releases of sterile moths and genetically engineered cotton that produces bacterial proteins lethal to some pests but safe for non-target organisms including people. Contributions of the Entomology team included computer simulation modeling to evaluate potential outcomes of different management strategies as well as discovery and tracking of pink bollworm mutations that confer resistance to the transgenic cotton. This landmark success helped to reduce insecticide use 82% overall in cotton in Arizona and saved U.S. growers \$192 million from 2014 to 2019, as reported in our multi-authored paper featured on the cover of *PNAS* in 2021 (Appendix D1).



2. Current Grants

Appendix D2 lists the principal investigator, title, source, and duration of 24 Entomology grants and contracts for \$7.9 million awarded in FY2023 (July 1, 2022 to June 30, 2023). Federal agencies are the primary funding source, accounting for 96% of the grants and contracts awarded in FY23 (Appendix D2). Federal funding sources in FY2023 include the Centers for Disease Control and Prevention (CDC), NIH, NSF, U.S. Department of Housing and Urban Development (HUD), and USDA (Appendix D2). The remaining sources of grants and contracts in FY2023 are State agencies (2%) and industry (2%).

3. Leadership in Professional Service

Many Entomology faculty serve in leadership roles in the profession of Entomology. Thirty-six examples of service on grant review panels and in journal editorial roles (2016-2023) are listed below (Table E1).

Table E1. Entomology faculty service on grant panels & journal editorial roles (2016-2023). *Grant Panels*

Yves Carrière: USDA Crop Protection and Quarantine (2020), USDA Biotechnology Risk Assessment Grants Program (2021)

Goggy Davidowitz: NSF Biology Integration Institute (2020)

Molly Hunter: NSF Population and Community Ecology (2016), USDA Pests and Beneficial Species (2017)

Luciano Matzkin: NSF Animal Behavior (2017), USDA Pests and Beneficial Species (2022), NSF Enabling Discovery through Genomics (2023)

Wendy Moore: NSF Phylogenetic Systematics (2017), NSF Advancing Digitization of Biological Research Collections (2019)

Michael Riehle: NIH panels (2016, 2018, 2020), NIH Tropical Medicine Research Centers (2021), NIH Co-Chair Special Emphasis Review Panel (2022)

Todd Schlenke: NSF Organismal Response to Climate Change (2023), NIH: Centers of Biomedical Research Excellence (2020), NIH Biological Materials Resource Centers (2018) NSF Symbiosis, Defense, and Self-recognition (2016).

Editorial Roles at Journals

Yves Carrière: Co-editor, special collection in *Journal of Economic Entomology*, Global perspectives on field-evolved resistance to transgenic Bt crops (2018-2023)

Goggy Davidowitz: Associate Editor, *Functional Ecology* (2009-2018), Guest editor, special issue in *Current Opinion in Insect Science* on Edible Insects for Food and Feed (2021)

Dawn Gouge: Editorial Board member, *Journal of Integrated Pest Management* (2011-present)

Xianchun Li: Editorial Board Member, *Insects* (2021-present), *Scientific Reports* (2012-present), *Journal of Insect Science* (2012-2021)

Luciano Matzkin: Associate Editor, *Ecology and Evolution* (2018-present), Editorial Board Member, *Communications Biology* (2018-present)

John Palumbo: *Arthropod Management Tests*, Editorial Board Member (2018-present)

Michael Riehle: Review editor, *Frontiers in Physiology* (2021-present), Editorial Board Member, *Insects* (2019-present), *Insect Biochemistry and Molecular Biology* (2017-present)

Todd Schlenke: Handling editor, *eLife* (2018)

Bruce Tabashnik: Lead editor, special collection in *Journal of Economic Entomology*, Global perspectives on field-evolved resistance to transgenic Bt crops (2018-2023), Guest Editor, *PNAS* (2021), Editorial Board Member, *Insect Science* (2023).

Kathleen Walker, Subject editor, *Annals of the Entomological Society of America* (2023-)

4. Teaching

a. Courses taught and teaching loads.

Thirteen Entomology faculty are currently responsible for teaching courses in person and online (Table E2). In accord with CALES guidelines, the standard teaching load is a mean of 1 hour of course credit delivery per year for every 5% instructional responsibility. For tenure-track faculty with the standard 15% Instructional FTE (Table A1), this translates to one 3-credit course taught per year. Both of our Professors of Practice (Lanan and McKnight) have the equivalent of 75% Instructional FTE (90% Instruction times 0.833 total FTE, Table A1), which translates to five 3-credit courses taught per year. New tenure-track faculty are not responsible for teaching courses during their first year to enable them to establish their research programs. As described in Section G.3.b, we increased instructional efficiency by frequently delivering two popular General Education courses (ENTO 160 and 170).

Table E2. Courses taught by Entomology core faculty

Number*	Title	Faculty instructor(s)**
160***	Busy Bees & Fancy Fleas: How Insects Shaped Human History	Lanan, McKnight, Schlenke
165***	Edible Insects: The Food of the Future is Already Here	Davidowitz
170***	Secrets of Success: How Insects Conquered Earth!	Hunter, Lanan, Matzkin, McKnight
297	Discovering Biodiversity (prefix is CALS)	Moore
300	Insect Pest Management for Desert Cropping Systems	Palumbo
401/501	Ecological Physiology	Davidowitz
407	Insect Discovery	Walker
415/515	Insect Biology	Walker & Moore
417/517	Insect Systematics	Moore
432/532	Comparative Immunology	Schlenke
436/536	Agro-ecology	Carrière & Walker
457/557	Medical-Veterinary Entomology	Riehle
468/568	Integrated Pest Management	Xianchun Li
553****	Evolutionary & Functional Genomics	Matzkin
544	Insect Ecology	Carrière
596	Entomology Graduate Seminar	Various faculty

* < 500 is for undergraduate courses (ENTO or CALS) and > 500 for graduate courses (EIS)

** Commas indicate different offerings taught by different faculty; & indicates co-taught courses; in addition to core faculty teaching listed above, Associate in Extension Dr. Shujuan Li has taught online summer courses.

***General Education courses, 165 will be offered for the first time in Fall 2024

****Co-taught 2017, 2018 & 2020 with EEB faculty member (50%) who retired, will not be offered in the future

b. Quality of teaching. The high quality of teaching by Entomology faculty is reflected in the overall mean student evaluation scores of 92% (range: 90 to 96% among the four categories evaluated) for undergraduate courses and 95% (range: 89 to 100%) for graduate courses based on Student Course Survey evaluations of courses taught from Spring 2020 to Spring 2023 (Fig. E1). For each of the two to four survey items for each of the four categories, the score can range from 0 to 100% (best).

For each of the four categories evaluated, the mean score was higher for courses taught by Entomology faculty than for courses taught by these four related units: the Department of Ecology & Evolutionary Biology (EEB) in the College of Science and three units from CALES (the Department of Environmental Science (ENVS) and the Schools of Animal & Comparative Biomedical Sciences (ACBS) and Renewable Natural Resources & the Environment (SNRE)) (Fig. E2). The UA Instructional Data team indicated they could not provide us with the college-wide or university-wide comparative data we requested.

Peer reviews of teaching conducted by senior faculty also indicate consistently strong teaching. We first assess teaching quality when recruiting for faculty positions that have instructional responsibilities, including a teaching presentation and discussion during interviews of finalists. Teaching is evaluated every year by the Peer Review Committee and Department Head as part of the annual performance review and by the Promotion and Tenure Committee and Department Head for promotion and tenure reviews (Appendix E1). We promote improvement in teaching via this feedback and by encouraging faculty to participate in Faculty Learning Communities (FLCs).

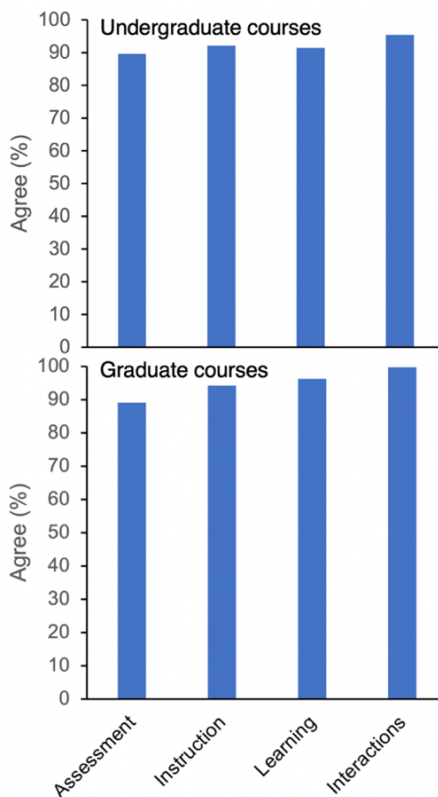


Fig. E1. Student evaluations of courses taught by Entomology faculty from Spring 2020 to Spring 2023. Bars indicate the mean percentage of respondents to Student Course Surveys who agree or strongly agree with two to four positive statements for each of the four categories shown on the x-axis. Each score can range from 0 to 100% (best). The overall mean for the four categories is 92% (range: 90 to 96%) for undergraduate courses and 95% (range: 89 to 100%) for graduate courses. 40 undergraduate courses were evaluated with 2,011 enrolled and 835 survey respondents. 22 graduate courses were evaluated with 213 enrolled and 124 survey respondents. See Appendices E2-E4 for details.

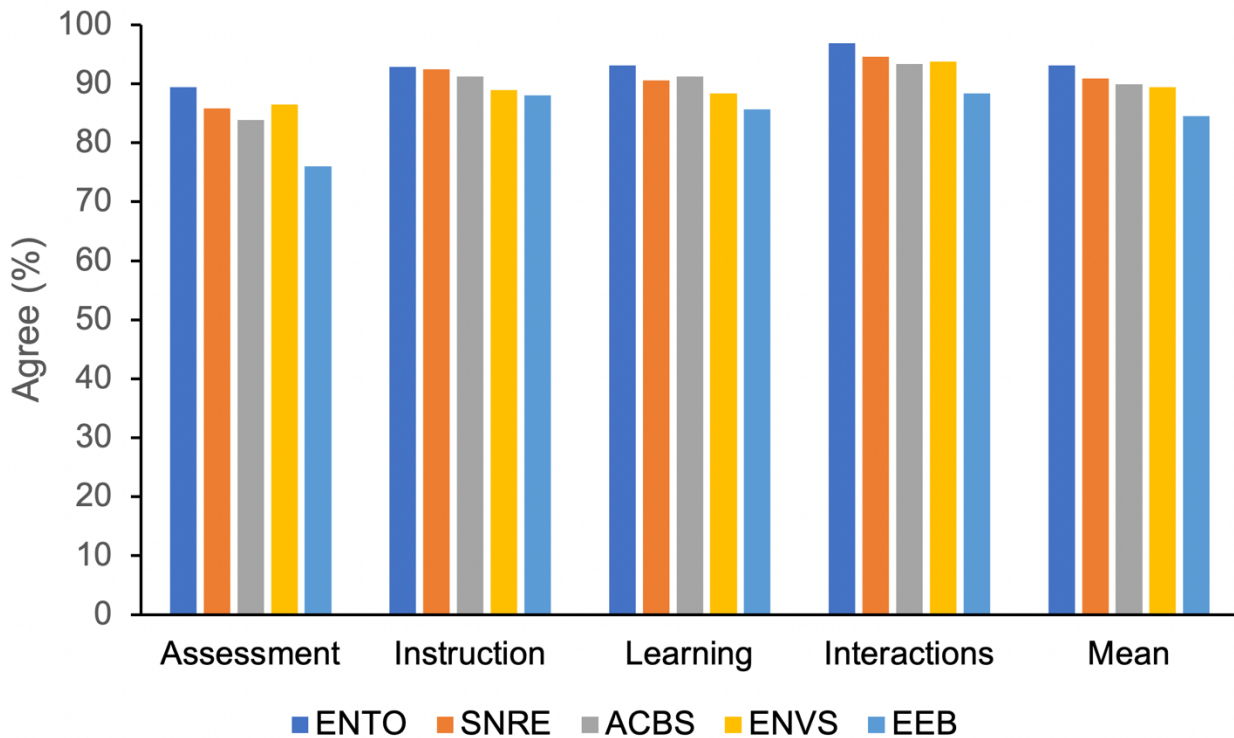


Fig. E2. Student evaluations of courses taught by Entomology faculty and by four related units. Bars indicate the mean percentage of respondents to Student Course Surveys who agree or strongly agree with two to four positive statements for each of the four categories shown on the x-axis. Each score can range from 0 to 100% (best). The scores for each unit are means based on data pooled from undergraduate and graduate courses from Spring 2020 to Spring 2023. The bars at the far right above “Mean” show the mean of the score of the four categories for each unit. Based on pairwise comparisons between ENTO and each of the four other units, the mean scores across the four categories were significantly higher for ENTO than for each of the other units (four paired t-tests, $df = 3$ for each test, $P = 0.045$ vs. SNRE, $P = 0.037$ vs. ACBS, $P = 0.003$ vs. ENVS, and $P = 0.017$ vs. EEB).

5. Faculty Recruiting

From July 2016 to August 2023, seven Entomology core faculty were hired, one retired, one resigned, and five were promoted (Table E3). Also, two Associate Professors are being evaluated now for potential promotion in 2024. The core faculty hired since June 2016 are two Associate Professors, Todd Schlenke (2016) and Luciano Matzkin (2017); one Associate Specialist, Al Fournier (2018), two Assistant Professors of Practice, Tristan McKnight (2019) and Michele Lanan (2022); and two Assistant Professors, Natasha Tigreros (2023) and Paulina Maldonado-Ruiz (2023) (Table E4). Since 2016, two core faculty departed for the following reasons: one resigned to accept a position as Dean at California State University, Chico (Patricia Stock, 2021) and one retired (Diana Wheeler, 2019).

We now have 17 core faculty versus 14 in June 2016. We anticipate a total of 19 in the near future with Dr. Maldonado-Ruiz starting in January 2024 and a May 2024 start date projected for a new hire we are currently recruiting as Assistant Specialist in Extension to be stationed at the Yuma Agricultural Center. If we succeed as expected in hiring this Extension Specialist, we will have hired four new faculty in about two years (2 per year), which is triple the rate of faculty hiring in the previous six years (0.67 per year; Table E3). The hiring of seven faculty from 2016 to 2023 (0.9 per year) is triple the rate for the previous decade (3 hired from 2006 to 2015 = 0.3 per year).

Hiring an additional Assistant Professor of Practice could be warranted if our new course in Edible Insects (ENTO 165) attracts sufficient enrollment. It is under evaluation as a General Education course and slated to be taught first in Fall 2024. We might also consider hiring an additional faculty member in Extension in the next few years to meet the urgent needs of stakeholders in Arizona. However, CALES has paused tenure-track faculty recruiting because of budget constraints. Moreover, we do not expect to have the resources to hire additional tenure-track faculty in the next year or two. Currently, Entomology must pay 65% of the startup cost for new faculty members, which recently has been an investment of ca. \$400,000 to \$500,000 of department funds per tenure-track faculty member. Future directions in hiring will be influenced by the contributions and ideas of new faculty members as well as retirements. Restoration of the contribution to startup from UA central administration would facilitate the hiring needed to fill gaps created with 5 to 7 retirements of senior faculty (mostly tenured faculty) expected in the next 5 years.

We have obtained resources for faculty hiring using all available means, including one hire supported by the UA Strategic Priorities Faculty Initiative (SPFI) and two hires supported by the GIDP-Shared Hiring Process (formerly known as the GIDP-Partnered Hire), as noted in Section C. We will continue to seek all resources available for faculty recruiting and hiring. We are currently pursuing a UA President's Postdoctoral Fellowship for a promising candidate. According to the program's website, "The University of Arizona views these presidential postdoctoral fellowships as an exceptional opportunity to recruit potential new faculty to the University whose research, teaching, and service will contribute to the diversity and equal opportunity at UArizona."

Table E3. Entomology core faculty at all ranks hired, retired, resigned, and promoted (2016-2023). All faculty evaluated for promotion were promoted.

Year	Hired	Retired	Resigned	Promoted
2016	1	0	0	2
2017	1	0	0	1
2018	1	0	0	1
2019	1	1	0	1
2020	0	0	0	0
2021	0	0	1	0
2022	1	0	0	0
2023	2**	0	0	0*

*Two Associate Professors are being evaluated now for potential promotion in 2024.

**Dr. Paulina Maldonado-Ruiz was hired in 2023, will start in 2024.

6. Faculty Compensation

Table E4. Entomology annual faculty salaries by rank.

Universities	Assistant		Associate		Full	
	n	Mean	n	Mean	n	Mean
UA	4	89,887	5	109,839	8	125,730*
ESA 2021**	35	91,300	17	95,561	42	122,236*
ESA 2023***	35	95,922	17	100,399	42	128,424*
Peer mean	19	95,310	16	116,945	42	182,234
Peer 1		86,802		99,175		162,270
Peer 2		93,176		108,440		134,047
Peer 3		94,206		130,471		183,628
Peer 4		101,074		114,390		230,354
Peer 5		101,293		132,250		200,872

* Excludes Department Head/Chair

** Data from Entomological Society of America (ESA) survey based on 2021 salaries.

*** ESA 2021 salaries multiplied by 1.05 (equivalent to 2.5% increase per year)

Methods and notes: The annual salaries above are base salaries that do not include amounts faculty pay themselves using grants or other sources. The mean salaries above are from pooled data for academic year salaries (9 months) and calendar year salaries. UA salaries are as of August 21, 2023. Peer salaries were provided by peer departments at public universities during July 2023. The set of five peers for this analysis are similar but not identical to the five peers in Section D because some peers identified in Section D did not provide salary data. Peers are labeled 1-5 and sample sizes are not given for each peer because a subset of the peers that provided salary data asked to not be identified. The sample sizes for Peer mean are based on only four of the peers because one of the peers did not provide sample sizes. The cost of living for Tucson is 1.04 versus a mean of 1.15 for the cities of the five peer universities according to Sperling Best Places (<https://www.bestplaces.net/>).

7. Faculty Gender and Race/Ethnicity

Although women and Latinos tend to be underrepresented in STEM disciplines such as entomology, four of our last five faculty hires identify as female, Latinx, or both. We have succeeded in recruiting diverse faculty by creating a welcoming, collegial, and inclusive work environment, and by advertising widely. We have also benefited from the UA Strategic Priorities Faculty Initiative (SPFI), which enhances the University's distinctive strengths in advancing inclusive excellence. Of the 18 core Entomology faculty, 39% identify as female, 6% as Asian, and 17% as Latinx (Table E5).

Table E5. Gender and race/ethnicity of core Entomology faculty.

	Number	Percentage
Gender		
Female	7	39%
Male	11	61%
Race/ethnicity		
Asian	1	6%
Latinx	3	17%
White, not Latinx	14	78%

8. Curriculum Vitae

Appendix E5 provides one-page CVs for each of the 18 core Entomology faculty that include recent publications, other notable scholarly work, honors, awards, and synergistic contributions.

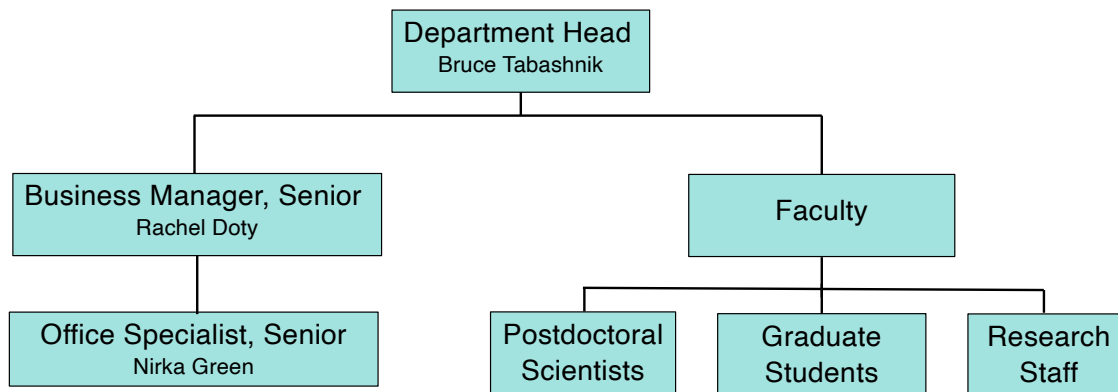
SECTION F: UNIT ADMINISTRATION

Department of Entomology

1. Governance and organization

The Department Head provides administrative leadership for the unit. Administrative decisions are made by the Head following appropriate consultation with faculty, staff, and students. Faculty votes on major issues. Although votes are not binding, the Head's decisions virtually always align with the majority. Routine faculty meetings of about one hour are held monthly during the academic year. Special faculty meetings are scheduled as needed to deal with critical issues, such as choosing among finalists for faculty hiring. Faculty and non-voting representatives of the graduate students and staff attend faculty meetings. The Head supervises the faculty who supervise postdoctoral scientists, graduate students, and research staff (Fig. F1). The Head supervises the Business Manager, Sr. (Rachel Doty) who supervises the Office Specialist, Senior (Nirka Green) (Fig. F1).

Figure F1. Department of Entomology organization chart



Committees that evaluate faculty for promotion and tenure or continuing appointment (the equivalent of tenure for Extension faculty) are composed of all faculty above the rank of the faculty member being evaluated, excluding any who have a conflict of interest with the candidate. Annual evaluations of all faculty (including the Department Head) are performed by the Peer Review Committee, consisting of four tenure-track faculty and two continuing-track faculty (excluding the Department Head) chosen by the Department Head to serve 2-year terms in accord with the policy approved by a unanimous vote of the faculty.

2. Staff

The 42 Entomology staff members consist of two administrative staff (Fig. F1), one IT staff member (0.2 FTE), and 39 research and Extension staff (Appendix F1). The 39 research and Extension staff include 6 Assistants in Extension (5 of which have a PhD), 12 Research Technicians, and 5 Research/Laboratory Aides (Appendix F1).

3. Gender and race/ethnicity of Entomology staff

Table F1. Gender and race/ethnicity of Entomology staff.

	Number	Percentage
Gender		
Female	13	33%
Male	26	67%
Race/ethnicity		
Asian	2	5%
Latinx	11	28%
White, not Latinx	26	67%

4. Adequacy of staff support

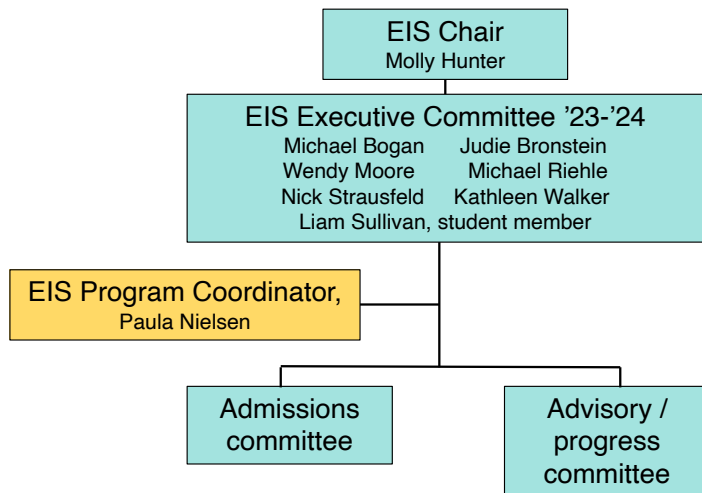
With the FY2023 surge in grants and the concomitant increase in administrative work for the next few years, we need to increase Entomology’s administrative staff support. We need at least 2.25 FTE and currently have 1.75 FTE (Rachel Doty, Business Manager, Sr. 1.0 and Nirka Green, Office Specialist, Sr., 0.75). For additional details, please see Section G.2.

EIS GIDP Administration

5. Governance and organization

The EIS GIDP reports to the GIDP Administration and the Dean of the Graduate College through its Chair. EIS obtains financial support from the Graduate College (GC) for operations, for a program coordinator, and for student tuition and stipend support. EIS also receives financial support from the College of Agriculture, Life Sciences, and the Environment (CALES) for student tuition, stipends, and teaching assistantship support. While CALES has no formal authority over or obligation to EIS, the College recognizes that EIS students are largely advised by Dept. of Entomology faculty and has supported us accordingly, albeit at a lower rate than CALES programs to adjust for EIS GC support.

Fig. F2. Organizational structure of the EIS program. For an overview of how EIS fits into UA generally, see Appendix A2.



The Executive Committee (EC) of the GIDP is charged with administration of the academic program (See Appendix F2 for EIS Bylaws). A half-time Graduate Program Coordinator assists the Chair and EC, currently Paula Nielsen. The EC consists of six faculty members plus the Chair, all of whom are elected to staggered, renewable three-year terms by the GIDP faculty. In addition, there is one student representative to the EC, with a one-year non-renewable term. In EIS, the balance between Entomology core faculty and faculty with primary appointments in other units is maintained by the stipulation in the by-laws that three EC members are from Entomology core faculty, and three are drawn from faculty with primary appointments in other units. Each year two EC members and the student member rotate off. The election process includes a nomination period in which nominations for Chair, EC members and the student member are first solicited and forwarded to the EIS Program Coordinator. Faculty members nominate and vote for the faculty Chair and EC members, while students nominate and elect the student member. Elections are conducted using an anonymous online tool such as Survey Monkey conducted by the Program Coordinator, where email addresses of all eligible voters are submitted. The results of the election are then forwarded from the Coordinator to the Chair, who notifies the Dean of the Graduate College. EIS EC and EIS Chair appointments must be approved by the Dean of the Graduate College.

EIS has two standing committees. The Advisory or Progress Committee is charged with overseeing graduate student progress. This committee meets annually to read and evaluate all graduate students' annual progress reports. Each student gets a letter from the committee, commending them on progress and suggesting things to take care of or consider. The committee evaluation allows faculty overview of common student obstacles and may suggest solutions, or policy changes. For example, in 2023 an observation of frequent delays on comprehensive exams prompted discussion of either a shorter format dissertation proposal, or a more formal assignment of comprehensive exams to all students in a certain semester. These thoughts will be discussed at our next EC meeting. The Advisory Committee may also identify students who are not making progress and communicate with the student and advisor to better understand how to help the student advance. For more detail on mentoring and annual progress reports, please see I.3.d.iii.

The Admissions Committee is responsible for coordinating the recruitment and admission of graduate students. After the admissions deadline on Dec. 1, potential major advisors for applicants are contacted for feedback on candidates. The Admissions Committee evaluates the applicants and meets to draw up an interview list. All domestic candidates are brought to campus, usually in late January or early February for a 1.5-day interview process. Candidates meet with members of the admissions committee, students, and postdocs in the laboratories of their potential advisor(s), and with potential advisors. A pizza lunch is provided on the second day for applicants and the community, and a casual reception and light dinner is provided at the house of the Chair on the second day for applicants, EIS students and faculty. The Admissions Committee then meets to evaluate the candidates and discuss priority acceptances given limited funding. One or two students may be placed on a wait list if they are strong applicants but not as competitive as the highest priority candidates. An effort is made to distribute accepted students into several laboratories, and if all else is equal, we prioritize PhD candidates over MS students. This is not

because of candidate quality or any limits to career opportunities but simply because the CALES formula for GRA support is based on PhD admissions.

Appointment to these two committees by the Chair has been a casual process, typically drawn from the Executive Committee and from the faculty and USDA associates. In recent years, the Chair has served on both committees and the student EC representative participates on the Admissions Committee. In general, EIS faculty are generously willing to serve on one or the other of these committees.

The responsibilities of the EIS Executive Committee and Chair are explained in the by-laws (Appendix F2).

6. Current Administration of EIS

Chair: Molly Hunter

2022-2023 Executive Committee (EC), with term expiration dates: Molly Hunter, Professor, Entomology (2024); Mike Riehle, Professor, Entomology (2025); Nick Strausfeld, Professor, Neuroscience (2024); Judie Bronstein, Professor, Ecology & Evolutionary Biology (2026), Michael Bogan, Associate Professor, School of Natural Resources and the Environment (2025); Wendy Moore, Associate Professor, Entomology (2024); Kathleen Walker, Associate Professor, Entomology (2026), Liam Sullivan, EIS student representative (2024).

2023 Advisory Committee: Molly Hunter (Chair); Wendy Moore (EC member); Mike Riehle (EC member), Luciano Matzkin (GIDP faculty), Vanessa Corby-Harris (USDA scientist and EIS associate).

2023 Admissions Committee: Molly Hunter (Chair), Michael Bogan, Michael Riehle, Kathleen Walker, and Meagan Ash EIS student representative.

7. EIS staff

We have one staff person associated with the program, Paula Nielsen, who is a Program Coordinator. Her position as EIS Program Coordinator is half-time (0.5 FTE). This level of staff-support is adequate, primarily because Paula is efficient and proactive. The program coordinator position is hugely varied, and includes events organization and publicity, website maintenance, working with the chair on student funding, providing logistical support for both major EIS committees, including travel and funding for student recruitment, among many other tasks. Paula has been very active recently as a member of the Self Study Committee, preparing figures and analysis. Perhaps most importantly, Paula provides individual attention and support for students throughout their program, registering students for research, thesis and dissertation and providing support and advice whenever asked. She is housed in the Marley building where many faculty and students are housed, works entirely in the office, and maintains an open-door policy every morning from 9 am to 1 pm.

SECTION G. RESOURCES: SUPPORT PERSONNEL AND INFRASTRUCTURE

Department of Entomology

1. Current support personnel

As noted in Section F.2, 42 Entomology staff consisting of 39 research and Extension staff, two administrative staff, and one IT staff member (0.20 FTE in Entomology) provide support services (Fig. F1 and Appendix F1). Nearly all of the research and Extension staff are paid partially or entirely by extramural funding. Accordingly, their work focuses on the objectives specified in the relevant grants, contracts, and gifts. One notable exception is Mr. Wesley (“Gene”) Hall. He is paid with State funding via CALES and provides substantial general support services for the department in addition to his contributions to Insect Diagnostic services and as Manager of the UA Insect Collection (see Section J). Gene is the building manager for the Forbes building, which houses personnel from CALES administration, Entomology, and other CALES units. He was absolutely essential in providing logistical support for all personnel in Forbes during the pandemic and continues in that role now.

2. Support personnel needs

As noted in Section F.2: With the FY2023 surge in grants and the concomitant increase in administrative work for the next few years, we need to increase Entomology’s administrative staff support. We need 2.25 FTE and currently have 1.75 FTE (Rachel Doty, Business Manager, Sr. 1.0 and Nirka Green, Office Specialist, Sr., 0.75). In early July 2023, Ms. Doty discussed this need with Janis Rutherford, CALES Assistant Dean, Finance and Administration. Ms. Rutherford encouraged us to formally request funding for the additional 0.50 position from CALES, implicitly recognizing that the cost of this position is not covered by the additional indirect cost return to Entomology generated by the surge in grants or by transfer of accounts to Entomology of faculty stationed at the Maricopa and Yuma Agricultural Centers (MAC and YAC, see below). However, on July 11, 2023, Jeffrey Ratje, ALVSCE Senior Associate Vice President, Finance and Administration, paused the posting of all staff positions (and all non-Extension faculty positions) funded by CALES. He indicated this “extraordinary step” was taken because the UA central administration did not approve the requested Strategic Budget Allocation and “CALES must reduce its expenditures by a significant sum this year.”

3. Changes that increased efficiency

The Department of Entomology made remarkable progress in increasing efficiency since the 2009 Academic Program Review, particularly in administration and delivery of undergraduate courses.

a. Administration. For Entomology administrative staff, the current 1.75 FTE is less than half of the 4 FTE in 2009. The administrative staff functions more effectively now than before, despite this 56% reduction in FTE and substantial increases in the administrative workload. Relative to 2008 (the last year included in the 2009 Entomology APR), extramural funding awarded to Entomology in funding tripled in FY2023; adjusted for inflation (42%), it still more than doubled. Relative to 2009, we now have 21% more core faculty. Moreover, accounts for four core

Entomology faculty at the MAC and YAC previously handled by administrative staff at those sites (not Entomology employees) are now handled by the Entomology administrative staff on the UA campus in Tucson. Overall, the number of faculty supported by the Entomology office staff has increased by 80% (from 10 to 18) since 2009. We have also implemented a new Undergraduate Minor in Entomology and an Undergraduate Certificate in Entomology & Insect Science, as well as dramatically increasing undergraduate enrollment in our courses. Furthermore, the administrative burden has grown for all programs because of heightened compliance requirements mandated by the government and the University.

The key factor enabling the department's tremendously increased efficiency is the stellar performance of Rachel Doty, Business Manager, Senior. She was hired as Business Manager at 0.75 FTE in 2021 and was soon promoted to Business Manager, Senior at 1.0 FTE. Paula Nielsen, the EIS GIDP Program Coordinator (a position funded by the Graduate College), now administers the graduate program. This has relieved the Department of Entomology of some of the administrative work that had been associated with the Entomology graduate program before the merger with the Insect Science GIDP in 2010 to create the EIS GIDP. However, ENTO still does the hiring for Graduate Research Assistant and Graduate Teaching Assistant positions for the EIS program and manages the funding for the subset of these positions that are funded by CALES. This requires close coordination between the two units, facilitated by the cooperation and capability of Rachel Doty (ENTO) and Paula Nielsen (EIS).

We also note that in 2014, CALES began providing pre-award grant support to Entomology from Contracts & Grants Manager Fatemah Dili. Her excellent work streamlined our grant submissions, freeing us up to focus on the intellectual work as deadlines approached. However, she left her CALES position in August 2023 to work for another university. Her departure and the concomitant retirement of her supervisor Parker Antin, CALES Associate Dean for Research, have created considerable uncertainty and concern.

b. Undergraduate courses. Entomology markedly increased teaching efficiency, enrollment in our undergraduate courses, and the associated revenue by developing and frequently delivering two popular General Education courses (ENTO 160 Busy Bees and Fancy Fleas: How Insects Shaped Human History and ENTO 170 Secrets of Success: How Insects Conquered Earth!). We now offer both of these courses in several modes online and in person during every Fall and Spring semester as well as during several of UA's many Summer sessions. Hiring Entomology's two Assistant Professors of Practice (McKnight in 2019 and Lanan in 2023) made it possible to increase the frequency of offering sections of these General Education courses about 10-fold, from one per year to about 10 per year. Data provided by CALES show a 113% increase in ENTO teaching revenue in FY2022 relative to FY2016, despite the 9% college-wide decrease in teaching revenue over the same period.

Because CALES shares teaching revenue with academic units, the increased enrollment dramatically improved Entomology's financial resources. This was instrumental for Entomology's commitment to contribute over \$800,000 to startup funds for two tenure-track Assistant Professor we successfully recruited in 2023 (Tigreros and Maldonado-Ruiz). Primarily because of the success of our two General Education courses, Entomology has recently ranked in the top two or

three of the ten academic units in CALES in student credit hours (SCH) delivered per instructional faculty FTE.

Because of Entomology's strategy to focus on General Education courses and our lack of an undergraduate major, the percentage of SCH accounted for by General Education courses has been highest for Entomology among the 10 academic units in CALES. This was intentional, in part because SCH in General Education courses largely determined the allocation of graduate teaching assistantships (GTAs) among graduate programs by CALES for many years. However, CALES abruptly changed this policy in 2022 to allocate GTAs based on all SCH equally rather than preferentially for SCH in General Education courses. This change cut the CALES funding for GTAs generated by Entomology from this source by ca. 60%. The impact of this cut has been exacerbated by increases in the mandated minimum stipends for EIS students (see I.3.c).

4. Projected changes with additional resources

Wendy Moore, Associate Professor of Entomology, received a grant of \$200,000 for 2023-2024 from the UA Provost's Investment Fund (PIF) for her project "Engaging Students in Specimen-based Research on Arizona's Insects of Importance to Agriculture, Human Health, and Natural Areas." This will provide funding to support some undergraduate and graduate students and to renovate our classroom (Forbes 412) as well as some of the space (Forbes 409) recently acquired from CALES to expand the University of Arizona Insect Collection (UAIC).

This project aims to permanently increase the capacity for ENTO faculty to teach undergraduates to make insect collections and conduct research on them, through Vertically Integrated Projects (VIPs) and courses, including Course-based Undergraduate Research Experiences (CUREs). Acquiring high-resolution images and raw DNA sequences will enhance our ability to offer undergraduates authentic research experiences without charging a course fee or compromising data integrity. Renovations of Forbes 409 will transform the old lab space into a safe, modern wet lab for interactive hands-on learning and research through VIPs and CUREs. Renovations of Forbes 412 will allow us to optimally tailor the configuration of desks and chairs for each course, seminar, or other use, including social distancing or arrangements to facilitate collaborative learning. Renovations will also allow us to stream our courses to remote learners, enabling us to dramatically increase enrollment.

A staff outreach coordinator at 0.5 FTE is an additional resource that would provide potent synergy between major community impact and education of graduate and undergraduate students. The coordinator would organize the Insect Festival and Insect Discovery (see J.1 and J.2), as well as collaborate with the ALVSCE development office to increase donor support for these programs, the Department of Entomology, and the EIS GIDP. The outreach coordinator would organize the logistics for the Insect Festival, a single-day event that attracts thousands of children and their families annually. The coordinator would also administer and participate in the Insect Discovery Cooperative Extension program that serves thousands of elementary schoolchildren and their teachers every year. The coordinator would provide continuity that cannot be achieved by graduate students, thereby enabling faculty members to focus on the design and educational impact of these wildly successful outreach programs.

Entomology & Insect Science GIDP

5a. Support personnel

The Graduate College (GC) supports the administration of EIS through a 0.5 FTE Program Coordinator, Ms. Paula Nielsen, housed in the Department of Entomology (Marley 641G), and centrally from GIDP Administrator, Alicia Lopez, who oversees and supports the administration of all the 22 GIDPs. The program coordinator has a long list of duties that span organization of events, web site, administration of admissions, daily email and in-person support for current and prospective students, assessment of learning outcomes, allocation of GC funds to incoming and current students, and updating the handbook. These activities all take place against the backdrop of constantly changing university computer systems that aim to increase efficiency but often have a steep learning curve. Ms. Nielsen does all these things capably and cheerfully and has retrieved several students from bureaucratic quagmires with patience and persistence. We have no need for further support personnel currently.

5b. EIS budget

EIS receives funding from two sources, the GC and CALES. Funding from the GC includes operations support, salary support (for the program coordinator), stipend support for the GIDP Chair and student support in three different flavors: cash (can be used for current students or incoming students), GC fellowship funds (for student support but student cannot be asked to work), and tuition-only funds (GC Tuition funds or GTS; Table G1). In addition, the GC houses the Hagedorn speaker endowment, produced by a fundraising effort in memory of a beloved faculty member, Henry Hagedorn. This yields approximately \$1000 annually and allows the EIS students to invite an annual speaker of their choice for the fall seminar series. The GC will also pay half of the salary for two years for Entomology's new tenure-track assistant professor Dr. Paulina Maldonado-Ruiz via the GIDP Shared Hire Program. She is scheduled to start her position in January 2024 and will be a member of the EIS GIDP faculty.

Table G1. 2023-2024 EIS budget from the Graduate College

Type of funding	Amount
Salary support program coordinator, 0.5 FTE (salary+ ERE)	\$44,205
EIS Chair stipend (stipend + ERE)	\$15,840
Operations (recruiting and other)	\$10,000
Graduate Assistantship funding	\$70,000*
Graduate Fellowship	\$15,000
Graduate Tuition Scholarship (for tuition awards only)	\$35,000
Total	\$148,386

*This includes a historical allocation of \$35,000 annually (funding allocated since the start of the EIS GIDP, increased from \$30,000 and set to expire in 2024), and \$35,000 additional funds.

Most EIS students are mentored by faculty in the Department of Entomology (which is in CALES) and accordingly, CALES funds EIS students. Relative to graduate programs that are entirely within CALES, first year support from CALES for GAs is half for EIS, in recognition of the funding EIS receives from the GC.

Table G2. 2023-2024 CALES funding for EIS graduate students in the Department of Entomology.

Type of funding	Amount
Assistantship support (principally meant for incoming student first year support)	\$38,171*
TA support (generated by ENTO teaching and used for current student TAs)	\$29,505*
Graduate Fellowship	\$13,000
Responsibility Center Waiver (for tuition awards only, equivalent for us to Graduate Tuition Scholarship, above)	\$18,162
Total	\$98,838

* These CALES fund amounts include tuition and ERE. This means these CALES funds go farther than the GC Assistantship support above. For example, one year of student support at current rates is \$31,467 of these CALES funds (because tuition and ERE are included) and ~\$47,000 of GC funds (from which tuition and ERE must also be deducted).

The number of students that we can support for first year funding and TAs within our control has declined by a minimum of 1.9 to a maximum of 2.9 student years of stipend support since 2014 Table G3. This is two to three students per year we can no longer offer either first year funding or a TA in the Department of Entomology annually. Less critically, our capacity for tuition support has also eroded, dropping from 7.5 student years of tuition to 3.9 student years Table G3. Because most of our students are on RAs or TAs, the tuition funding is generally more than enough. In 2023-2024, however, with one student self-funding and several others fully employed, we have used all our tuition budget and have none left for the spring semester.

Table G3. EIS student costs (stipend and in-state tuition) and funding from all sources in 2014 (last EIS APR) versus 2023.

	2014-2015	2023-2024
Student costs		
Stipend rate	\$22,000	\$31,467
In-state tuition rate	\$10,581	\$13,600
Stipend funding		
Cash funds for student support (tuition and ERE must also be paid from this)	\$30,000 (0.9 of a student year)	\$70,000 (0.74 – 1.5 student years)
State funds (includes tuition and ERE)	\$28,250 (1.3 student years)	\$67,676 (TA and assistantship funds) (2.1 student years)
CALS allocated TAships	1 per semester (1 student year)	NA (TA funds in cell above)
Fellowship funds	\$31,100 (1.4 student years)	\$28,000 (0.89 student years)
GIDP supported TA positions 2-4 semesters annually (includes tuition & ERE)	\$22,000-\$44,000 (1-2 student years)	Funds for GAs in first cell above
Approximate student years of stipend funding	5.6 – 6.6 student years depending on no. of TAships allocated by GC	3.7 – 4.5 student years depending on whether the one-year allocation of carry forward funds are included
Decline in stipend in student years from 2014-2017	1.9 – 2.9 student years	
Tuition funding		
Tuition only funds	\$80,000	\$53,162
Approximate student years of tuition support	7.5	3.9
Decline in tuition support in student years	3.6 years	

We are grateful for the financial support from the GC and CALES, especially because we understand the current constraints on their budgets. We are increasingly concerned, however, that substantially increased costs to support EIS students have not been fully matched by increased support. This will make it more difficult to provide stellar candidates with first year funding, and to provide our students with high impact TAs that teach science communication strategies and foster

scientific literacy in the target audience. Also, many EIS students have been supported as TAs for courses in the College of Science. We expect challenges in addressing gaps in funding from that source in 2024 and beyond.

6. EIS Resource needs

Our greatest resource need is for support for student assistantships (recruiting research assistantships and TAs and fellowship funds) that are controlled by the EIS program (please see budget details above in Tables G1 – G3). While we are proud of our record of keeping our students funded throughout their studies (Tables I3 and I5), the lack of program control over most of the TAs that support our students (especially in Introductory Biology labs in courses offered by the College of Science), creates uncertainty each semester. Until this year, the 1-2 TAs allocated from the GC per semester to our program were a great help for this problem, and the one-year extra allocation of \$35,000 extra funds from the GC this year, while very welcome, is less than one student year of support. The GC and CALES are supporting us as much as they can. With additional TA support from the UA central administration, we could have an outsized impact on graduate student education, community engagement, and K-12 scientific literacy.

-
With a long-term commitment of two TAs per semester, we could a) hard-wire support for Insect Discovery, one of UAs most impactful outreach programs for scientific literacy of elementary school students in Tucson schools (see J.2), b) provide many EIS students with immersive, hands-on training in scientific communication with lay audiences, and c) reduce the threat of funding gaps for our students.

7. Program efficiency

EIS Program Coordinator roles and communication with the EIS Program Chair. Our Program Coordinator, Paula Nielsen, plays an active role in monitoring student progress and supporting students throughout their program. She follows each student's progress, resolves registration and GradPath and bursar statement problems, schedules monthly lunch seminars for the students and plans program events. She answers emails promptly and handles administrative issues as they arise. She also helps organize the EIS Admissions and Advisory Committees, oversees all steps of the recruiting season, arranges travel for recruits, and helps with offer letters.

We believe communication between the Program Chair and Coordinator is essential. The Chair and Coordinator currently have offices across the hall from each other, are in almost daily contact, and meet informally several times per week, and over coffee when a planning meeting is needed.

We are working more efficiently because Ms. Nielsen has now been in her position for 2.5 years and has accumulated institutional knowledge (in contrast to three one-year tenures of previous coordinators, two ending with a family move, and one ending with retirement). We also benefit by Ms. Nielsen's commitment to having a physical presence on campus and open-door policy; this is very helpful for students who regularly drop in to iron out problems.

8. Projected changes in EIS activities and quality outcomes if additional resources were available

Two TAships available each semester would be used to create predictable long-term TA support for Insect Discovery, and in concert with the addition of a half-time outreach coordinator (G.4), would provide some assurance that this wildly popular and impactful community outreach program would endure beyond the career of the one faculty member keeping it afloat, Dr. Kathleen Walker. EIS student TAs for Insect Discovery are immersed in teaching scientific concepts to 3000 elementary school children annually and in supporting that experience for undergraduates (see J.2), an experience that many report as one of the most meaningful in their college career. Dr. Walker has applied to numerous sources in Tucson and beyond for Insect Discovery funding over the last fifteen years and has not been successful.

We would also use one semester of TA support in alternate years (one of eight in a 2-year cycle) for a TA for the foundational, required EIS course in Insect Systematics (ENTO 417/EIS 517). This course has intense laboratory and field components as students grapple with the evolution and immense diversity of the most speciose animals on earth. With enrollment of ~20, this course does not generate enough student credit hours to garner a TA through regular channels yet is perhaps the course EIS and upper-level undergraduate students value most.

SECTION H: ENTOMOLOGY UNDERGRADUATE MINOR AND CERTIFICATE

The Department of Entomology does not offer an undergraduate major, but recently established an undergraduate minor and a certificate program. The CIP code is 26.0702 for both programs. As noted in Section A, 10 students are currently enrolled in the Entomology minor. We expect larger enrollment as awareness of this new program grows, especially considering the enthusiasm of our current students. Four students have completed the Undergraduate Certificate in Entomology and one is in progress.

As noted in Section C: In 2021, we established a 12-unit Undergraduate Certificate in Entomology that offers a flexible course of study students can tailor to their own interests (Appendix C1) <https://cals.arizona.edu/ento/content/undergraduate-certificate-entomology-and-insect-science>

In 2022, we established an 18-unit Undergraduate Minor in Entomology to provide students with advanced education and skills in insect-related fields to be competitive for employment in agricultural and biotech industries as well as for graduate programs in disciplines such as Entomology, Public Health, Environmental Sciences, Epidemiology, Biology, and Ecology (Appendix C1). <https://cals.arizona.edu/ento/content/undergraduate-certificate-entomology-and-insect-science/minor>

In addition to the Undergraduate Minor and Certificate programs noted above, more than 60 undergraduates are engaged in research projects conducted by Entomology faculty.

SECTION I. GRADUATE STUDENTS, DEGREE PROGRAMS, AND OUTCOMES

I.1. Degree programs

The EIS GIDP is an interdisciplinary graduate program with a focus on insects. The CIP (Classification of Instructional Programs) code is 26.0702 for Entomology. Entomology is described as “a program that focuses on the scientific study of insect species and populations in respect of their life cycles, morphology, genetics, physiology, ecology, taxonomy, population dynamics, and environmental and economic impacts.” Our students span the basic/applied spectrum and also levels of biological organization – from genetic and genomic (and metagenomic) studies to physiological studies to population, community ecology and spatial ecology. Students often incorporate approaches combining techniques and questions from across the biological hierarchy.

EIS offers Master’s and Doctoral Degrees. The program is flexible in its requirements, allowing students to design, in collaboration with faculty across campus, programs of study tailored to individual interests and needs. We particularly seek out creative, enthusiastic applicants who have multidisciplinary interests. For example, combinations of interests include insect ecology–plant chemistry, behavioral ecology–neurobiology, pest management–spatial ecology, epidemiology of vector-borne disease–climate science, and systematics–metagenomics. We encourage students to develop cross-disciplinary connections and bring together aspects of insect biology in unconventional ways.

All students must take two of three required courses (see major requirements below), and some units of graduate seminar (two semesters for MS students, four for PhD students). In addition, PhD students must complete two research rotations (potentially in one semester), at least one of which must be outside of the advisor’s laboratory.

I.2. Curriculum and courses

PhD program

The majority of current our students are pursuing doctoral degrees (in August of 2023, 17 of 26 students, 65%). **Requirements for PhD:** 36 units of coursework are required by the Graduate College. EIS program requirements include two of three core courses: EIS 517 Insect Systematics, EIS 544 Insect Ecology, and EIS 520 Insect Systems Biology and four semesters of the graduate seminar EIS 596A (offered for two and three units in fall and spring, respectively). In addition, PhD students must complete two research rotations, potentially in one semester, at least one of which must be outside of the advisor’s laboratory. Students completing research rotations enroll in EIS 792. At least 22 of the units in the major and minor must be letter-graded courses (not research or independent study units).

EIS PhD students are required to complete a minor in an area other than EIS. Recent students have minored in Ecology & Evolutionary Biology, Neuroscience GIDP, Biosystems Engineering

(including Metagenomics), Geography (including GIS), Ecosystem Genomics GIDP, among others. Students choose one graduate committee member with the appropriate affiliation to represent the minor and to approve the student's coursework in the minor.

Minor requirements for PhD: Most programs require nine units of coursework in the minor discipline to earn a minor in the field, but a few programs may require up to 15 units for completion of a minor in their department/program. **Dissertation Units:** At least 18 units of dissertation research are required.

MS program

For the MS program, 32 units of coursework are required. Like PhD students, MS students must take two of the three core courses, but take just 2 semesters of EIS 596A Current topics in Entomology and Insect Science (Seminar), typically in their first year. At least 15 of the 32 units must be letter-graded courses (not research or independent study units). **Thesis Units:** At least 8 of the 32 units must be thesis research units.

Table II. Current EIS courses, including courses cross-listed in EIS.

No.	Course title	Instructor	Dept. of Instructor
501	Ecological Physiology	Davidowitz	Entomology
503C	Intro to Computational Neuroscience	Fellous	Psychology
503L	Parasitology Laboratory	Cooper	Anim & Comp Biomed Sci
503R	Biology of Animal Parasites	Cooper	Anim & Comp Biomed Sci
505	Aquatic Entomology	Bogan	School of Natural Resources & Eenvt
512A	Biological Electron Microscopy	Staff	Physiology
513	Applied Biostatistics	Staff	School of Natural Resources & Eenvt
515R	Insect Biology	Walker / Moore	Entomology
517	Insect Systematics	Moore	Entomology
520	Insect Systems Biology	Riehle / Li / Gronenberg	Entomology, Neuroscience
532	Comparative Immunology	Schlenke	Entomology
536	Agroecology	Walker / Carrière	Entomology

544	Insect Ecology	Carrière	Entomology
553	Functional and Evolutionary Genomics	Staff	Ecol & Evol Biol
557	Medical & Veterinary Entomology	Riehle	Entomology
567	Pollination Ecology	Dornhaus	Ecol & Evol Biol
568	Integrated Pest Management	Li	Entomology
588	Principles of Cellular and Molecular Neurobiology	Zinsmaier	Neuroscience
597C	Controlled Environment Agriculture & IPM	Hooks	Biosystems Engineering
660	Infectious Disease Epidemiology	Ernst	Epidem & Biostat
596A	EIS seminar. Topics change with semester. The current skills and research support series: Fall: reading primary literature and presenting, Spring: proposal writing	Davidowitz (fall) Hunter (spring)	Entomology
792	Methods in Entomology (Research rotations)	EIS faculty	various
593/693	Internship	EIS faculty	various
599/699	Independent Study	EIS faculty	various
900	Research	EIS faculty	various
909	Master's report	EIS faculty	various
910	Master's thesis	EIS faculty	various
920	Dissertation	EIS faculty	various

I.2.a. Do EIS graduate students in undergraduate/graduate co-convened courses do extra work?

Yes. Some of the graduate EIS courses are co-convened with undergraduate courses in the Department of Entomology (e.g., ENTO 401/EIS 501). The graduate students in such courses have additional assignments relative to the undergraduates. For example, in EIS 536 Agroecology, the graduate students have an extra assignment worth 20% of the grade. In EIS 517 Insect Systematics, graduate students curate a more diverse insect collection, have extra exam questions, and do an in-class presentation. In EIS 532 Comparative Immunology, graduate students make a presentation

and write a grant proposal. Lastly, in EIS 557 Medical and Veterinary Entomology, grads do a literature review and present a topic for the class.

I.2.b. Are learning outcomes consistent across sections? Yes. One EIS course is online (Integrated Pest Management), and the others are in person. All courses are taught as a single section so there is one set of learning outcomes for each course.

I.2.c. Are courses in the program sufficient and balanced across specialties to meet student needs and interests? Yes. As a GIDP, we require a minimum set of foundational courses, enhanced with courses that ignite or broaden interests across disciplines (EIS prefix or not) and additional specialist courses after students choose an area of concentration (EIS prefix or not). EIS 517 Insect Systematics and EIS 544 Insect Ecology rotate as the fall classroom course. Incoming students take one of these (and the other the following year) as well as the EIS seminar. Foundational content is balanced with elective additional courses (Table I2). Cohort-building experiences in shared courses are balanced with interdisciplinary exploration.

Table I2. Courses from other programs that current EIS students have taken recently. This list shows the breadth of disciplines and interests of our students as well as the rise of data science and computational analyses.

No.	Course title	Dept. of Instructor
BE 534	Biosystems analytics (Python for data analysis)	Biosystems Engineering
BE 587	Metagenomics	Biosystems Engineering
BIOS 576A	Biostatistics in public health	Epidemiology & Biostatistics
BIOS 576B	Biostatistics for research	Epidemiology & Biostatistics
ECOL 596W	Special topics in Ecology and Evolution: Practical and reproducible data science	Ecology & Evolutionary Biology
ECOL 530	Conservation genetics	School of Natural Resources & the Environment
ECOL 528R	Microbial genetics	School of Plant Sciences
ECOL 506R	Conservation biology	Ecology & Evolutionary Biology
ECOL 519	Introduction to modeling in biology	Ecology & Evolutionary Biology
ECOL 526	Population genetics	Ecology & Evolutionary Biology

ECOL 587R	Animal behavior	Ecology & Evolutionary Biology
ECOL 600B	Fundamentals of ecology	Ecology & Evolutionary Biology
ENVS 567	Introductory statistics and multivariate statistics with R	Environmental Science
EPID 573A	Basic principles of epidemiology	Epidemiology & Biostatistics
PLP 550	Principles of plant microbiology	School of Plant Sciences
NRSC 572	Neurodevelopment in action	Neuroscience

Currently EIS 520 Insect Systems Biology, the third EIS core course, focusing on molecular biology, neurobiology, and physiology, has not been offered in several years, largely because enough students have not signed up for it to be taught. Now, retirement of one of the instructors, Dr. Wulfila Gronenberg, in spring 2024 necessitates a new approach. In the meantime, students with interests in molecular biology, neurobiology and physiology have been taking other courses (e.g., BE 587 Metagenomics, EIS 501 Physiological Ecology, EIS 532 Comparative Immunology, and others, Tables I1 and I2). Please also see Section L *EIS Policy changes and retreat*.

PhD students also do research rotations in their first year. Two are required and one can be in the laboratory of one's advisor. Since the last APR, a discussion at a retreat resulted in rotations being formalized to make them no more than 8 weeks, to prevent open-ended expectations from enthusiastic faculty from keeping students at a project beyond their utility for the students. Before the pandemic, students customarily performed three rotations, but since the onset of the pandemic two have been more common.

I.2.d. Does the program employ active-learning strategies? Yes. Our graduate classes inculcate active discussion, hands-on activities such as collection and curation of an insect collection for EIS 517, Insect Systematics, and independent reading, presentation and writing. Even more consequentially, both MS and PhD programs in EIS center around an original piece of research (a thesis or dissertation) that is entirely active learning, with classroom and non-classroom components. Guided by their advisor outside the classroom and in the fall semester seminar course, the students learn to read the literature critically and independently. They formulate an original research question that will move a field forward or address a critical applied problem in agriculture or public health. In the spring 'proposal writing' seminar and outside the classroom, students develop their research proposal. They learn what is feasible based on reading, discussion, experiments, observations, and feedback from peers, instructors, and advisors. Beyond the classroom, students work closely with their advisor and other faculty members on their graduate committee to execute their research, analyze it, and write it up for publication.

I.2.e. *Is instructional technology used in program courses?* **Yes.** Our graduate courses employ D2L for content delivery. Some use it to receive student assignments and post assignments for peer review. Additionally, Zoom was used heavily in 2020-2021, and is still used for our one online course (EIS 568 Insect Pest Management). Podcasts and/or YouTube assignments have been made. Most learning in our program occurs in person, in conversation among students, between students and faculty, and in hands-on experimentation in the field or laboratory. We believe frequent, positive personal interactions builds trust and facilitates graduate learning and growth.

I.2.f. *Are online courses available for program requirements?* **Yes.** *Do you offer or plan to offer any online graduate programs?* **No.** Most of our courses are designed for our graduate students on campus. However, one course, EIS 568 Insect Pest Management, includes EIS students but is aimed towards a much broader audience across Arizona and beyond. It is a self-paced online course, thus making it available to working people in a variety of industries. Non-campus students for EIS 568 include Extension personnel and those who want to be a licensed pest control agent, greenhouse or nursery manager, as well as farm workers, children of growers, and community college students.

In general, while many EIS faculty engage in online teaching for undergraduate instruction, we believe the program mission for EIS is best accomplished by faculty-student and student-peer interactions in classrooms, laboratories and in the field. Further, the development of a thesis or dissertation relies on close faculty mentorship of in-person laboratory or field research.

I.2.g. *Are adequate resources available for graduate students to carry out their studies?* **Generally, yes.** Office and laboratory space as well as supplies for our students are generally adequate. Students may have desks in laboratories or in separate offices as well as assigned laboratory benches. Office and research supplies are generally provided by the advisor and supported by grants. Students may also apply for small research grants through the Graduate and Professional Student Council or from extramural sources. Our students benefit greatly from the UA library's excellent loan program for infrequent office needs such as laptops and cameras (<https://lib.arizona.edu/visit/tech>) as well as from site licenses for software (e.g., Microsoft Office, Adobe Creative Cloud, Endnote, and Geneious for DNA sequence analysis).

We encourage our students to attend national and international conferences to present their research. Twenty-two of our current 26 students have given 64 presentations (see I.3.e). Student travel is supported by a variety of sources. Faculty grants support travel and the GIDP Administration in the Graduate College offers travel grants (Herbert Carter) that have often been awarded to our students (Table D3), generally \$600 awards. EIS has also supplemented travel funding for students who are unsuccessful in a Carter application. Lastly, the UA Graduate and Professional Student Council also provides travel grants. It is less clear, however, whether our students are unconstrained by travel funding; some faculty do not have extramural funding and small on-campus travel grant amounts have not increased over several years. An informal poll of students by the student member of the self-study committee found that students find it difficult to

piece enough funding together for conference attendance and are choosing closer conferences over more distant ones.

I.2.h. *What proportion of EIS PhD students take courses or complete minors in other disciplines?* EIS PhD students are required to complete a minor outside EIS. See I.1 above for examples of minor disciplines our students have chosen. *What about PhD students from other disciplines taking courses or completing a minor in your program?* Our graduate offerings often have students from other disciplines taking them, sometimes as many as EIS students. Eight students from other disciplines have minored in EIS since 2014.

I.2.i. *Provide the link to an electronic copy of your graduate student handbook.* The EIS GIDP graduate student handbook has been recently revised and updated (Appendix I1). It was reviewed by the Dianne Horgan, Senior Consultant for Graduate Education and she approved it, commended it and suggested it as a model to Senior Associate GC Dean of Academic Affairs, Dr. Pitts.

I.3. Graduate Students

I.3.a. *Describe mechanisms used to recruit students. Compare the quality of students in this (these) graduate program(s) with students in other similar programs and the quality since the last APR review (based on GREs, GPAs, or other admissions criteria).* In general, Entomology & Insect Science applicants find our program or particular members of our faculty. We have observed they are not applying widely to other biology programs, although they may be applying to Entomology programs nationally and may have a public health, ecology or molecular biology background. When faculty receive an inquiry from candidates, they generally correspond and perhaps arrange a Zoom meeting prior to the application due date. Once candidates apply, we evaluate them based on a) GPA and course preparedness, b) a personal statement showing maturity and a reasoned motive for graduate study, c) overlap of research interests with one or more faculty in the program, and d) letters of reference providing detailed assessment of the applicant's readiness and motivation for graduate study. We have dropped GRE scores as an application requirement (see I.1.b below). We have and will always lose students to programs that guarantee more years of stipend support via research assistantships. However, our students are excellent, hardworking, and self-motivated and this has not changed since our last APR. They are also caring, team players, and conscientious and effective teachers. Many are teaching assistants for multiple semesters, and we repeatedly receive unprompted testimonials from both the Introductory Biology Laboratory directors (MCB 181 and ECOL 182) about the high quality of our program's students.

We have no quantitative way to assess the quality of our students versus other programs or our own past students. We find GPA, although useful, not helpful as a sole predictor of graduate student success, in part because some of our students are older and their youthful self in college does not represent them well as applicants. Conversely, a graduate program requires creativity and adaptability that may not be captured by stellar course performance alone. However, we have a consistently high retention rate (Table I5) and our alumni find employment that matches their interests and training in our program at an extraordinary rate (Table I6).

I.3.b *Provide data on gender and race/ethnicity composition of the current graduate students with majors in the unit.* EIS is relatively gender-balanced with approximately 50% of our 26 students

female or non-binary, continuing a trend of approximate gender parity since Fall 2015 (Fig. I1). We note that these data may not capture our current cohort of students perfectly. Some of our students prefer they/them pronouns and may decline to identify as male or female.

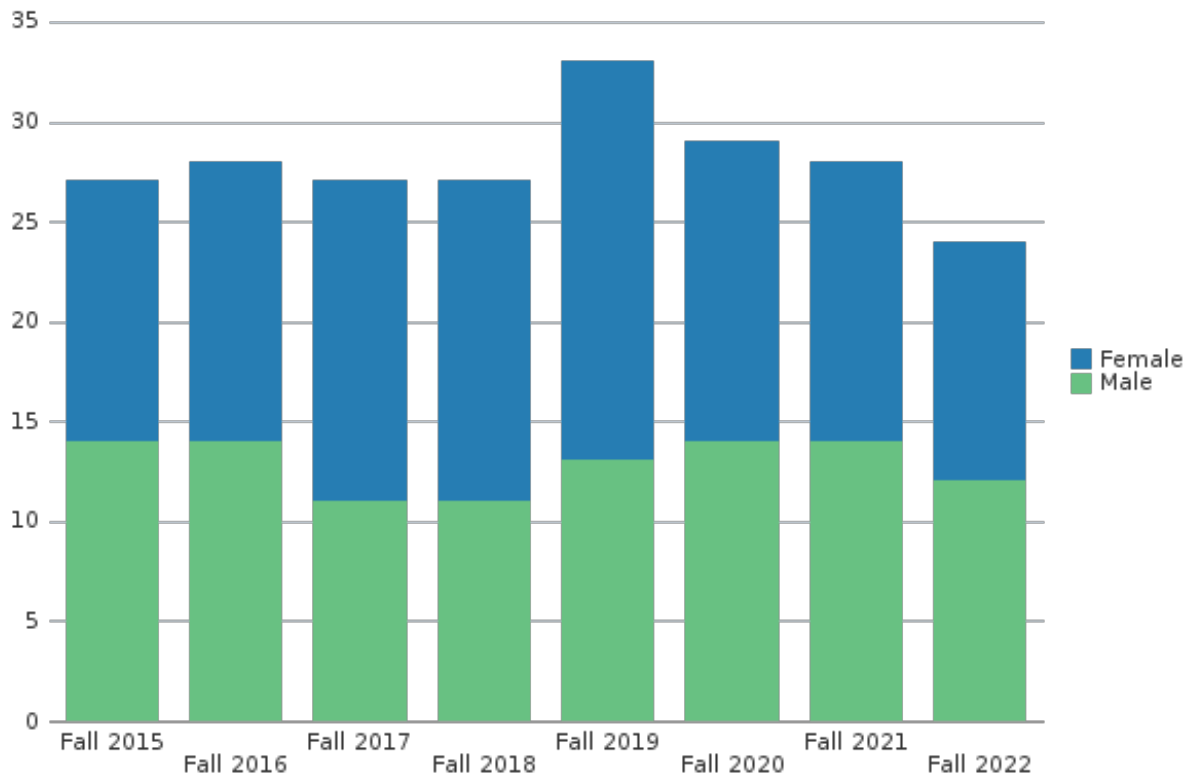


Fig. I1. Gender representation in EIS GIDP 2015 to 2022 (from UA Analytics).

EIS has also become slightly more diverse in ethnic and racial composition in recent years (Fig. I2), with students in 2022 identifying as “white” only slightly greater than 50%. As discussed in Section C, response to recommendation 5, EIS made a concerted effort to increase outreach to underrepresented groups with extensive advertising on recommended listservs following the last APR for EIS in 2014. Ultimately it is unclear what effect that had. Things have changed considerably since 2014, however, and it may be a good time to re-engage with the Office for Diversity and Inclusion to extend our outreach. Perhaps a more influential decision of ours than listserv advertising was to drop the requirement of GREs for applications. Besides published evidence that suggested GREs were weak predictors of graduate student success, some of our reading suggested these exams provide obstacles that discourage applications from first generation college students and students from underrepresented groups.

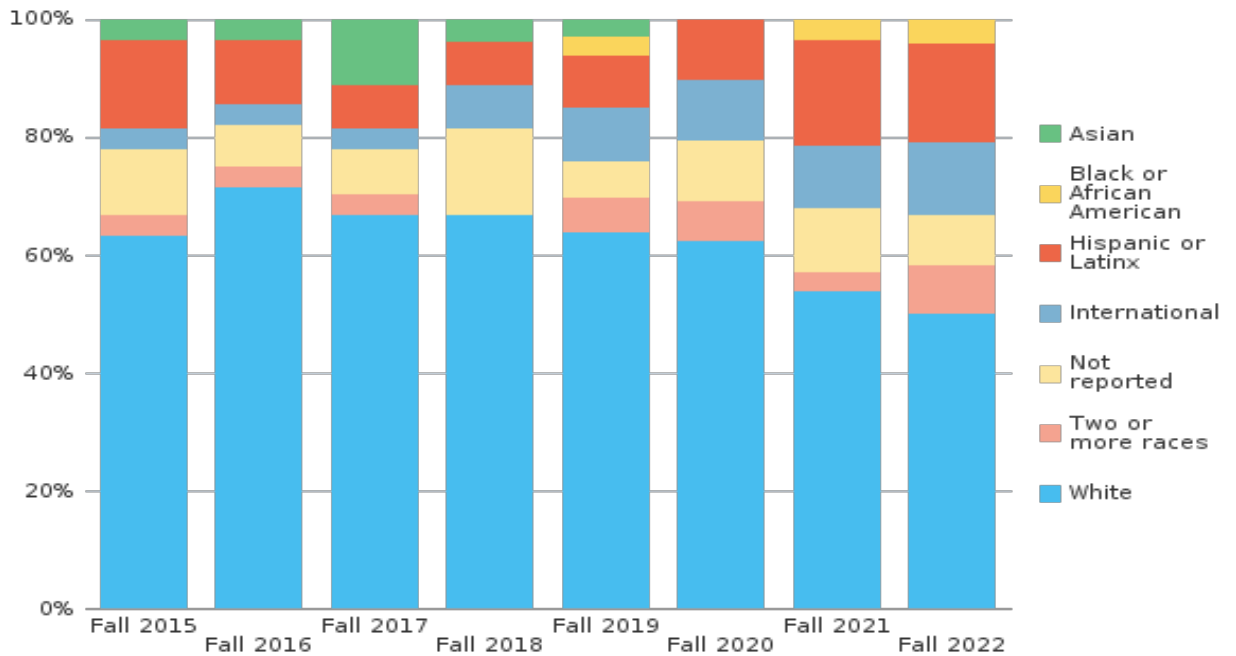


Fig. 1.2 Ethnic and racial representation in EIS GIDP 2015 to 2022 (from UA Analytics).

I.3.c. *Comment on the number and adequacy of the stipends and assistantships. In addressing this, indicate the percentage of graduate students in the program(s) that have a teaching or research assistantship; the salary range of stipends for half-time research assistantships and teaching assistantships.*

Both MS and PhD student in EIS are generally supported with stipends throughout their program, via first year EIS program funds (usually 2-3 offered per year), TAs, RAs funded from faculty grants or fellowships to the student, full-time employment (e.g., for UA Extension, USDA ARS Carl Hayden Bee Laboratory, USDA APHIS; Table I3). Rarely a student matriculates without a stipend offered, or is without a stipend in their finishing semesters, especially if they have moved from Tucson. In these last cases, and for full-time employees outside the UA system, we use allocated tuition funds to pay in-state tuition and health insurance for students without a stipend. Our success in attracting excellent students is dependent on our ability to match students with TAs when they need them, and although most of these TAs are not within our control (e.g., Intro Biology laboratory courses in the College of Science), and are variable in number from semester to semester, we have had a near perfect rate of success of keeping our students funded. A qualitative overview of the variety of funding typical in a full student career can be seen in Table I5.

Table I3. Fall 2023 funding of EIS MS and PhD students

First year RA funding (EIS or CALES)	TAship*	Student fellowship	Faculty supported RA	Full time employment	Self-funding#	Total
2	8	3	4	7	2	26
7%	30%	15%	15%	26%	7%	100%

*This semester 7/8 students are TAing for Molecular & Cell Biology (MCB) 181, Introductory Biology Laboratory. The last is a TA for ENTO 160.

#One MS student matriculated without a stipend. The other is completing her MS writing after relocating outside of Tucson. Both are receiving tuition support.

All of our current students are receiving full tuition remission as a result of being an RA or TA or on a fellowship (17 of 26) or are being paid tuition from EIS or CALES tuition funds (GTS or RC Waivers) for the self-funding students and those employed outside of the UA system (7 of 26), or have tuition paid by UA Qualified Tuition Reduction plan for full-time UA employees (2 of 26).

In the past year, the EIS annual 12-month stipend (0.5 FTE) increased from \$24,500, slightly above the Graduate College minimum, to \$31,467 for 2023-2024. This was mandated by CALES. A spring 2022 memo states: “effective July 1, 2022, all [CALES] graduate students on assistantships will be paid at an annual rate that exceeds the highest average rate being offered by any peer university within their discipline.” A task force that did not include EIS faculty analyzed peer stipends in different disciplines in 11 institutions and determined that EIS students should receive \$31,467 over a 12-month period to exceed peer rates, the third highest rate of 11 programs affiliated with CALES.

The response of the EIS and ENTO leadership was to celebrate the fact that all our students would be paid at a rate that would relieve their financial hardship due to rising housing and food costs in Tucson. However, this new mandate has put EIS and ENTO in a financial bind that is unresolved. Our faculty are writing the new stipend rates into grant proposals, and when grants are funded, students with such an RA will be paid appropriately. However, at any one time approximately 1/3 of our students are supported on TAs from the College of Science (Introductory Biology laboratory sections, Table G3), and the semester rate in 2023-2024 is approximately \$11,000. Therefore, students who TA in both the spring and fall semesters will need to be paid \$9500 in the summer to meet the annual 12-month stipend of \$31,467. We will ask the advisor to pay such shortfalls for each student when grant funds are available. The surge in grants in FY2023 (Section D) will be somewhat helpful in dealing with this, particularly for grants that include graduate student support. EIS and ENTO will contribute as much as possible, but this is a new financial liability for both entities. It is not clear how this will work given the modest budget of EIS (Tables G1, G2) and the many commitments for Department of Entomology funds, including faculty start-up (\$812,500 for two recent hires and recruiting underway for a third hire) and a projected payback to CALES of

\$735,000 in FY2024 in addition to the payback to CALES of \$188,000 in FY2023. Although a reader might question why a CALES mandate would apply to a GIDP, we greatly appreciate the student funding from CALES and do our best to comply with CALES policies. Lastly, despite what we perceive as stiff logistical challenges to meet this new standard, we think the mandated stipend is fair, we just need to determine a way to implement it sustainably. Each spring we plan to tally the amount paid to each student from TAs and RAs and calculate the shortfall from our standard rate. This will be paid to the student as supplemental compensation, from all possible sources.

I.3.d.i. *Comment on the average ratio of student/faculty thesis and dissertation supervision in each graduate program since the last APR and compare to other programs in this discipline.* The number of EIS MS and PhD students has varied between ~25-30 since the last APR. Currently, our 26 students are in 13 different laboratories. Twenty-two of the 26 are mentored among 10 core ENTO faculty laboratories, three are mentored by USDA scientists and co-advised by UA faculty, and one is in an Ecology & Evolutionary Biology laboratory. Our enrollment is limited by the number of applicants we can offer recruitment first year funds to, our promise to find stipend funding to students after their first year (often in TAs), and the number of spots and potential funding for new students in popular laboratories. In general, however, we believe we are about the right size for the number of qualified applicants we receive, and the number of employment opportunities available.

Table I4. Students, faculty and student/faculty ratios at UA and other entomology departments.

	UA	UC Davis	Wisconsin	UC Riverside	Washington State	Texas A&M
MS	9	5	--	5	10	10
PhD	17	24	--	37	20	44
Total	26	29	27	42	30	54
Faculty*	25	24	11	24	20	24
Student/faculty ratio	1.0	1.2	2.5	1.8	1.5	2.2

*For UA this is all active EIS faculty members (in ENTO and other units); for other universities this is faculty members in entomology.

When we compare our numbers of students per faculty member (Table I4), the ratio depends on what faculty are included. While any EIS faculty member can serve as major advisor of an EIS student, faculty in units other than ENTO are more likely to participate in EIS via graduate committee membership and teaching, because they are more likely to be major advisor of students in their own departments. At UA, if all 25 active EIS faculty are included, the ratio of students/faculty is 1.0, whereas including only the 13 ENTO faculty who are active EIS members the ratio is 2.0. Interestingly, peer institutions fall within this range or just outside.

I.3.d.ii. *Summarize information from exit interviews in your programs.* Exit interviews are an opportunity for the EIS Chair to speak informally to recent graduates and to invite comment on the strengths and challenges of navigating the EIS program, to learn about their future directions, and what they wished they'd known when entering the program. In general, graduates identify as strengths: the social cohesion of the students, the accessibility of faculty and the program coordinator, and the supportive climate of the program. One graduate spoke highly of the outreach opportunities she took advantage of, including Insect Discovery, the Insect Festival, UA Science Sky School (<http://skyschool.arizona.edu/>), opportunities at Biosphere 2 (<https://biosphere2.org/>), and various BioBlitzes.

Challenges included sudden immersions in academic culture new to them, for example the protocols for hosting and introducing a seminar speaker. Another student mentioned that as the first in his family to attend college, he did not know initially that he could step down from a PhD to a MS (although eventually he did) and would have appreciated more exposure to different careers available to graduates. This is clearly something we can implement and will look for a few possible opportunities to do this (e.g., invitations to alumni to talk to the group at program lunches in person or via Zoom).

A substantive change to the program emerged from an exit interview with one 2017 PhD graduate. He said he would have welcomed a formal structure to support his dissertation planning. He said he was told not to worry and so found himself 18 months in without much of an idea about what his dissertation would be about. After some thought, we revamped the fall and spring seminar classes that all students take. Now students read, present, and discuss the scientific literature relating to their thesis or dissertation project in the fall seminar and work on writing a proposal in the following spring semester. PhD students do this series twice but value a second pass at more reading and a proposal that was rough in the first year and more cohesive in the second. This structure has been in place for four years. In a 2023 summer exit interview, one MS graduate said that the spring seminar was especially helpful because by writing and peer editing others' proposals, he gained insight into the writing process and into the strengths and weaknesses of his own writing.

I.3.d.iii. *Describe your unit's mentoring practices, including graduate students' annual Individual Development Plan conversations with mentors and support for employment goals in multiple career pathways.* Faculty mentorship in our unit generally includes weekly or alternate week individual meetings with students in their laboratory, as well as group laboratory meetings, practice talks, research retreats and other activities. Students are encouraged to visit the program coordinator to learn about upcoming milestones in GradPath, the online Graduate College for plans of study, committee appointments, comprehensive exam planning etc. The program coordinator and the chair both have an open-door policy. We have not implemented Individual Development Plans formally, although some of the self-reflection in these is represented by progress reports and advisor mentoring.

The GC has recently enhanced resources for professional development, including mentoring workshops for students and faculty, fellowship writing workshops, one-on-one writing mentoring, and career planning resources. EIS students have benefited tremendously from fellowship

mentoring and writing workshops. Also, Shelley Hawthorne-Smith, Associate Director of the Graduate Center and Assistant Professor of Graduate Writing, has visited our seminar class to explain the resources available. We aim to take full advantage of these resources and are considering options to do so, including requiring two or three workshops for first-year students and directing faculty to participate in mentoring workshops.

In addition to frequent meetings with mentors, all students fill out an annual progress report (due in the third week of May; the form is Appendix 2 in the EIS GIDP Handbook: https://insects.arizona.edu/sites/default/files/2023-08/GIDP_EIS_Handbook_%2723_8.25.pdf).

Students are asked to report their progress on program milestones, to describe their research project, to reflect on progress on their goals for the previous years and to set new goals. They also attach a 2-page CV with the previous year's activities and achievements highlighted. Importantly, the report is then discussed with the mentor. This is an opportunity for the student and advisor to discuss the past year's goals, the next year's goals and how the student's work will provide them with the skills they need for positions of interest after graduation.

All the students' progress reports are read by the EIS Advisory Committee, which meets to discuss the progress of each student. The committee members write a letter to each student, commending them on recent progress and making suggestions for the coming year. The Advisory Committee meeting also serves as an opportunity for one group of faculty to achieve an overview of our students' strengths and challenges. For example, the 2023 meeting showed that several of our students were delinquent on scheduling committee meetings, filing plans of study and scheduling their comprehensive exams. Since the letters were sent, a clear uptick in activity has been observed.

I.3.d.iv. *Analyze your annual survey data of current graduate students' professional development needs.* This is not something we've done, but seems like a good idea, and we would appreciate examples from other programs that have done this. As we describe in I.3.d.iii above, we are considering ways to make professional development a more integral part of student training and faculty mentorship by accessing GC resources.

I.3.e. *Discuss the scholarly activities of your graduate students (being mindful of FERPA policy), such as conference presentations and publications.* As we mentioned, our current 26 students, including five first year students who have not yet had time to complete research, have given 64 presentations, an average of 2.9 per student for the 22 current students who have completed at least one year. We encourage our students to present their research frequently in poster and oral presentations on and off campus. On campus opportunities include EIS program lunches (4-6 per year), the GIDP Showcase, where two posters per program are selected for sharing in a gathering of all the GIDPs, and others. Our students also travel to conferences to present their work. Despite the pandemic interruption to travel and in person conferences, our current students (with variable numbers of years in the program) have given 33 presentations at national conferences (largely Entomological Society of America conferences), 6 international conference presentations, 15 outreach and/or extension presentations and 10 on-campus presentations. EIS students are also active in publishing their research before they graduate. As mentioned in section D, EIS students coauthored 74 of 275 journal articles that are products of ENTO & EIS faculty scholarship (27%

of these papers) and two of the nine book chapters (22%; Appendix D1). Our students have also been recipients of numerous awards (Table D2), including intramural and national awards.

I.3.f. *Provide a table of the trends, time to degree, and number completing the degree for the last seven years, for each graduate degree program, providing student data pulled from the APR Dashboard in UAccess Analytics. Also indicate the six- and eight-year completion rates.*

We downloaded data on all students completing and not completing the EIS PhD and MS programs from UAccess Analytics from 2014 and corrected it for errors (e.g., students that appeared to arrive and graduate the same year) and redacted names (Table I5). We did not include any students in progress in the program. We included those individuals that graduated from a different EIS program they entered (two from MS to PhD, two from PhD to MS) as students who had completed. We also indicate sources for student stipends, both to show the wide variety of funders and the potential impact of outside employment on time to EIS program completion.

Table I5a. EIS PhD students 2014-2022: Time to degree, retention, and funding. Summary statistics for retention of MS and PhD students combined are below Table S1b.

Student code	Matriculation	Graduation date	Years to graduate	Sources of funding while a student				
				Teaching assistant	Research assistant	Fellowship	Full time position	Self-funding
PhD								
1	Fa 2017	Sp 2022	5	X	X		X	
2	Fa 2015	Sum 2023	8	X	X		X	
3	Fa 2009	Sum 2015	6	X	X			
4	Fa 2011	Sum 2016	5	X	X			
5	Fa 2017	Sum 2022	5	X	X	X		
6	Fa 2016	Sp 2019	3	X		X		
7	Fa 2016	Sum 2021	5	X	X			
8	Fa 2012	Fa 2020	8	X	X		X	
9	Fa 2010	Sum 2017	7	X	X			
10	Fa 2011	Sum 2018	7	X	X			
11	Fa 2011	Win 2019	8	X	X		X	
12	Fa 2016	Fa 2020	4	X	X			
13	Fa 2013	Win 2021	8	X	X			
14	Fa 2013	Sp 2020	7	X	X			
15	Fa 2012	Sp 2020	8				X	
16	Fa 2011	Fa 2016	5	X	X			
17	Fa 2011	Win 2017	6	X	X			X
18	Fa 2011	Fa 2016	5		X			
19	Fa 2016	Sum 2023	7	X	X			
20	Fa 2014	Sp 2020	6	X	X			
PhD students that did not complete*								
38	Fa 2018			X	X			
39	Fa 2017			X				
40	Sp 2019			X	X			
41	Fa 2015					X		
42	Fa 2015			X	X			
43	Fa 2020				X			

*Reasons for non-completion included illness, moving with advisor to a different institution, visa issues and a change to a different UA graduate program.

Summary statistics for PhD completion: Median time to degree = 6 years, mean time to degree = 6.15 years (n=20). Among the students with full time employment for part or all of their programs, the median time to degree = 8 years, and the mean = 7.4 years. Among the students who did not have full time employment during their programs, median time to degree = 5.5, and mean = 5.6 years.

Summary statistics for PhD retention: 20/26 students completed their PhDs in this period, a retention rate of 77%. This is also the 8-year completion rate. The 6-year completion rate is 11/26 = 43%.

Table 15b. EIS MS students 2014-2022: Time to degree, retention, and funding. Summary statistics for retention of MS and PhD students combined are below this table.

Student code	Matriculation	Graduation date	Years to graduate	Sources of funding while a student				
				Teaching assistant	Research assistant	Fellowship	Full time position	Self-funding
MS								
44	Fa 2019	Sp 2022	3	X	X			
45	Fa 2017	Sp 2020	3	X	X			
46	Fa 2014	Win 2016	2	X	X			
47	Fa 2015	Sp 2018	3	X	X			
48	Fa 2017	Fa 2019	2				X	
49	Fa 2014	Sp 2017	3				X	
50	Fa 2015	Sp 2017	2	X	X			
51	Fa 2019	Sp 2022	3	X	X			X
52	Fa 2015	Fa 2021	6				X	
53	Fa 2019	Sum 2023	4			X		
54	Fa 2017	Sp 2019	2	X	X			
55	Fa 2019	Sum 2021	2	X	X			
56	Fa 2014	Fa 2016	2	X	X			
57	Fa 2019	Sum 2021	2	X	X			
58	Fa 2015	Sum 2017	2		X			
59	Fa 2021	Sum 2023	2	X				
60	Fa 2018	Fa 2020	2	X	X			
61	Fa 2020	Sp 2020	2	X	X			
62	Fa 2017	Sum 2019	2	X				
63	Sp 2019	Sp 2020	1.5	X	X			
64	Fa 2016	Sum 2020	4	X				
65	Fa 2018	Sum 2021	3	X	X			X
MS students that did not complete*								
66	Fa 2018				X			

*This student did not return after the first semester of their program.

Summary statistics for MS completion: Median time to degree = 2 years, mean time to degree = 2.6 years (n=22).

Summary statistics for MS retention: 21/22 students completed their MS in this period, a retention rate of 95%.

Summary statistics for EIS program retention (combining MS and PhD) = 41/48 students who entered an EIS program completed an EIS program (including two who switched from PhD to MS), a retention rate of 85%.

Our analysis of these 2014-2022 data shows several trends. The EIS program continues to demonstrate strong retention. In the PhD program, 20/26 students completed their PhDs, a

retention rate of 77% (Table I5a). In the MS program, 21/22 students completed their MS, a retention rate of 95% (Table I5b). The overall EIS program retention (combining MS and PhD) shows 41/48 students who entered an EIS program completed an EIS program, a retention rate of 85%. Comparing these trends with data from UA Analytics across programs for students admitted in 2014, across programs, 74% of PhD students completed, and 83% of MS students. Our PhD retention rate is higher than the UA average rate (77 vs. 74%), and our MS retention is strikingly so (95 vs. 83%).

The median time to degree for EIS PhD students is 6.0 years (mean 6.5; Table I5a). The 6-year completion rate is 43%, lower than the UA rate of 65%. Clearly, our students are taking longer to finish their PhDs than students across campus. The 8-year completion rate is the same as the retention rate, 77%, and higher than the UA average rate of 74%. One reason for the longer times to graduation may be that some of our students are employed full time outside the program while completing their PhD, either for UA or outside industries or federal agencies (Table I5a). Looking just at those students who worked full time for one or more years of their program (some working throughout their program), the median time to degree is 8.0 years (mean 7.4). When these students are excluded from the data set, the median time to degree is 5.5 years (mean 5.6), and more comparable to the UA average rate.

In the PhD program six of the students who started in 2014-2022 discontinued their degrees. Three left due to illness, one followed an advisor (with a primary appointment in Ecology & Evolutionary Biology) to a new institution, one moved to a different graduate program at UA, and one attended remotely from China the first year and was unable to get a visa to come in person (in 2020). After several attempts, he got a visa to study in Canada and transferred to a Canadian university.

In the MS program, the median time to degree was 2.0 years (mean 2.6; Table I5.b). The 95% retention rate compared favorably with the UA average rate of 50% for the 2-year rate and 66% for the 3-year rate. Just one of 22 entering MS students did not complete and the reason is unclear. After one semester, the student did not return after the winter break.

Table I6 shows current employment from PhD and MS graduates since the last EIS APR in 2014.

Table I6a. Current employment (Sept. 2023) for EIS PhD graduates 2014-2023. Names redacted to protect privacy.

Student code	Grad date	Position
a	2014	Project Manager and Implementation Coach, Helps Education Fund
b	2014	Assistant Professor, Arkansas State University, Querataro, MX
c	2014	Lecturer, School of Life Science, Zhengzhou University, CN (Faculty ranks in China start at Assistant Professor, then Lecturer, then Associate Professor and Professor)
d	2015	Assistant Professor, Dept. of Entomology, University of California, Riverside

e	2016	Foreign Service Officer, USAID Agricultural Development
f	2016	Data Scientist, Tokyo Electron, Chandler, AZ
g	2016	Laboratory Manager, University of Georgia, Dept. of Entomology
h	2016	Assistant Professor, Missouri State University
i	2016	Assistant Professor of Practice, iSchool, The University of Arizona
j	2017	Identifier (Entomologist) USDA APHIS
k	2017	Laboratory Manager, University of Georgia, Dept. of Entomology
l	2018	Program Director, Santa Clara County Vector Control District, California
m	2018	Field Operations Manager, Entomologist, Oxitec, Panama
o	2020	Senior Technical Manager, Ventana Medical Systems, Tucson
p	2020	USDA NIFA Postdoctoral Fellow, University of Arizona
q	2020	State Botanist, Bureau of Land Management, Phoenix
r	2020	Teaching Professor, Xavier University
s	2020	Conservation Biologist, US Fish and Wildlife, Portland, OR
t	2021	Molecular Diagnostics Scientist, Arizona Veterinary Diagnostics Laboratory, Tucson
u	2021	Postdoctoral researcher, University of Kentucky
v	2022	Computational and Data Science Educator, University of Arizona Data Science Institute
w	2022	Epidemiologist, CDC Inter Tribal Council of Arizona
x	2023	Wildlife Biologist, US Geological Survey, Tucson
y	2023	Founder, Arbo Scientific, a vector surveillance company and US Army Medical Entomologist

*Graduate “n” is deceased and was omitted from the table and summary statistics.

Table I6b. Current employment (Sept. 2023) for EIS MS graduates 2014-2023. Names were redacted for privacy reasons.

Student code	Grad date	Position
a	2014	Biologist, US Environmental Protection Agency, Washington, DC
b	2014	Postdoctoral scientist, Syracuse University
c	2014	U.S. Naval Entomologist, Okinawa, Japan
d	2014	Curator of Entomology, Bio Park in Albuquerque, New Mexico
e	2014	Postdoctoral Scientist, Dept. of Entomology, Washington State University
f	2014	Laboratory Director, Salt Lake City Mosquito Abatement District
g	2016	Conservation Program Manager, Appleton Whittell Research Ranch of the National Audubon Society, Elgin, AZ
h	2016	Entomologist Technician, USDA APHIS OTIS, Buzzards Bay, MA
i	2017	State Entomologist, Arizona Department of Agriculture
k	2017	Microbiologist, Northstar Medical Radioisotopes
j	2017	Soil conservationist, USDA NRCS, Poughkeepsie, NY
l	2018	Weights and Measures Agricultural Inspector, Los Angeles County
m	2019	Field Technician and Beekeeper Relations, Dalen Animal Health, Inc.
n	2019	PhD graduate student, University of Arizona
o	2019	Laboratory Assistant, University of California, Berkeley
p	2020	Biological Science Technician, USDA ARS Carl Hayden Bee Laboratory
q	2020	PhD graduate student, University of Arizona
r	2020	Research Scientist, Neilson Lab, Program Coordinator, Center for Environmentally Sustainable Mining (CESM), University of Arizona
s	2020	Biologics Engineer, Ginkgo Bioworks, Sacramento, CA
t	2020	PhD graduate student, Wayne State University
u	2021	Biological Science Technician, USDA ARS Carl Hayden Bee Laboratory

v	2021	Assistant in Extension, University of Arizona, Maricopa Agricultural Center
w	2021	Pesticide Certification and Licensing Specialist, Oregon Department of Agriculture
x	2021	PhD graduate student, University of Arizona
y	2022	Field biologist, SWCA Environmental Consultants, Pensacola FL
z	2022	Legal Processing Support Clerk, Pima County Office of Children’s Counsel (within Public Defense Services)
aa	2023	PhD student, New Mexico State University
bb	2023	Border Restoration Intern, AmeriCorps and Bureau of Land Management

All 24 (100%) of the PhD EIS graduates since 2014 are employed by universities, government, or in private or non-profit companies, all in areas related to their training. Of the 28 MS students, all are employed, and all but one recent grad are employed in an area related to their training. We are extraordinarily proud of all our MS and PhD graduates.

I.4. Graduate Student Learning Outcomes Assessment

Starting in 2014, EIS used an outcomes assessment based on six learning outcomes (LOs). At each graduate committee meeting, comprehensive exam and defense, faculty and students were asked to assess student performance on each LO on a five-point scale, using paper forms filled out in the room to ensure the assessment was performed. The forms were collected, hand-tallied on Excel spread sheets, and indeed we collected a lot of data. What the analysis of the data appeared to show was that, like the children of Lake Woebegone, all of our students were above average (~4), for every LO. While heartening, these data were not helpful in providing areas to target for improvement. The assessment plan was in place during the pandemic, when all meetings went to Zoom (so no paper forms) and further, the impetus for doing something that we no longer believed to be useful was lost.

In summer 2023, we instituted a new system, devised with input from Dr. Elaine Marchello, Asst. Director of Assessment, and approved by the EIS Executive Committee in an August 23 meeting, and the EIS faculty by email. The new learning assessment has three major LOs (Table I7). We will ask faculty and students to provide qualitative feedback on relevant LOs at comprehensive exams and final defenses (for PhDs) and at final defenses (for MSs).

Table I7. Learning outcomes for EIS MS and PhD students.

Learning outcome	Learning area /When assessed	
1	<p>Content knowledge</p> <p>MS – final defense</p> <p>PhD – comprehensive exam</p>	The student demonstrates understanding of key concepts in insect biology as well as those underlying his/her general subject area (e.g., physiology, molecular biology, genomics, ecology, systematics, evolution or behavior).”
2	<p>Research skills</p> <p>MS and PhD – final defense</p>	The student exhibits a) critical thinking skills to evaluate the scientific literature and articulates how their research fits into and advances the discipline. The student b) develops creative and innovative research ideas and approaches. The student c) uses multiple research approaches to collect scientific data related to their research area, and can interpret, analyze, and critique their data.
3	<p>Communication skills</p> <p>MS and PhD – final defense</p>	The student communicates their research project effectively through oral presentation and can express the potential impact of their work on society in lay terms.

We are now developing a web-based (Qualtrics) survey, with a link to be emailed to faculty and the student after the student’s comprehensive examination (PhD students only) and final defense (for both MS and PhD students). For each LO, faculty will be asked: “What are the strengths of the student’s understanding with respect to LO 1, 2 and 3?” and “Are there areas for improvement, and if so, what are they?” Similarly, students will be asked to reflect on their own performance (a form of indirect assessment) and will be asked “What do you think your strengths are with respect to (LO 1, 2 or 3)?” and “Are there aspects of this set of ideas and skills that you still developing and if so, what are they?” We plan to aggregate these data by student and look at faculty and student responses for several students to look for patterns in strengths and weaknesses.

We have posted our new learning outcomes assessment plan on the Planning and Self Study website https://planning.watermarkinsights.com/?connection_name=universityofarizona and will assess the results on an annual basis in Fall of each year. We are asked to identify how we might modify our analysis of student learning to identify any achievement gaps with respect to student demographics, but our program is too small to identify patterns relating to underrepresented groups or first-generation college students. We will look for gender-specific patterns, even if we expect the small sample size will make subtle differences difficult to detect and non-binary identifying students will be excluded. Assessment findings will be considered among EIS faculty and the EIS Executive Committee and program changes implemented as necessary.

J. OUTREACH AND EXTENSION

The Department of Entomology and the faculty and students of the EIS GIDP are actively engaged in outreach and Extension programs that educate the public in Arizona and have tremendous social, environmental, and economic impact. These programs are described below.

1. The Arizona Insect Festival: An Annual Community Celebration

The Arizona Insect Festival is a free, single-day outreach event on the UA campus hosted by the Department of Entomology in collaboration with our local community of insect enthusiasts. The Festival began in 2011 and quickly became a beloved educational experience for the public in Tucson and beyond. It is thought to be the largest annual academic outreach event on the UA campus hosted entirely by a University unit. Visitors are treated to approximately 25 insect-themed booths run by more than 150 knowledgeable faculty, staff, graduate students, undergraduate students, and other volunteers (<https://www.arizonainsectfestival.com>). The Festival attracts about 5,000 visitors each year and is covered by the local media. Families with young children make up a large proportion of attendees. This is often their first time on a university campus. The Festival is exceptional because of the diversity of the insects displayed, the opportunity for visitors to hold many of these insects, and the remarkable expertise of the scientists interacting with the public. In many cases the researchers have studied their insects for decades and are world experts in the subject matter of their booths.

The Festival helps us to accomplish the following goals:

- (a) enhance the connection between UA and the public, including potential students and donors;
- (b) provide the public the opportunity to meet and talk with ENTO/EIS scientists and students;
- (c) inform the community about exciting insect research conducted by ENTO/EIS;
- (d) educate the public about the roles of insects in ecosystems and in their own daily lives; and
- (e) reduce fear and increase appreciation of insects.

In recent years, we have attracted more Hispanic visitors to the Festival to support UA's mission as a Hispanic-Serving Institution. We have documented success in this effort, which includes print and radio ads in Spanish and collaboration with elementary schools in South Tucson, a city known for its Hispanic heritage. After a 2020-21 pause because of the pandemic, the 2022 Festival was perhaps the best attended ever! The annual cost of the Festival is about \$13,000 with about \$3,000 recovered from profits from sales of Festival t-shirts. Before 2020, local businesses provided some financial support for the Festival. We are actively pursuing community sponsors to sustain the Festival.

Future scientists inspired by the Arizona Insect Festival



More Images from the Arizona Insect Festival



Arthropod Zoo volunteers



Edible insects



Making friends with roaches



Congresswoman Gabby Giffords ready to hold a gentle whip scorpion



Build your own bug

ARIZONA INSECT FESTIVAL



Free event! Free parking!
arizonainsectfestival.com



COLLEGE OF AGRICULTURE & LIFE SCIENCES
Entomology

Sunday, October 1st, 10am – 3pm ENR2 Building, 1064 E Lowell St., University of Arizona

FESTIVAL DE LOS INSECTOS



Evento y estacionamiento gratis!
arizonainsectfestival.com



COLLEGE OF AGRICULTURE & LIFE SCIENCES
Entomology

Domingo, 1 de Octubre, 10am – 3pm Edificio ENR2, 1064 E Lowell St., University of Arizona

Posters for 2023 Arizona Insect Festival designed by EIS student Alex Lombard



Photo by Davehood
at English Wikipedia

This year's theme insect is the big and bold tarantula hawk, *Pepsis formosa*.
Known for its sting, it paralyzes and lays its eggs on tarantulas, providing a large meal for its developing offspring.
It's easily recognized by its jet black body, bright orange wings, and often curled antennae.
They can be surprisingly large and are often seen sipping nectar from flowers all over Tucson.

2. Insect Discovery: Sparking Scientific Curiosity in Elementary School Children and Providing Science Communication Training for EIS Students and Undergraduate Students

Insect Discovery is a UA Cooperative Extension program that sparks scientific curiosity and builds scientific literacy in elementary school students in the Tucson area (Pima County) through hands-on activities with live and preserved insects. This age group is particularly excited about school-based science, but the teachers of this age group tend to have less science background and are focused on the enormous tasks of developing basic literacy and numeracy skills. Insect Discovery provides support for these teachers not just in offering classroom visits and field trips, but also by providing lesson plans and other on-line resources to make the most of their students' fascination with insects. This early engagement in science stimulates interest in pursuing scientific careers.

Started in 2005, the program has sent EIS graduate students to elementary school classrooms in the fall and provides on-campus workshops at the UA Flandrau Science Center in the spring. Insect Discovery engages over 3000 children a year, primarily from Title 1, lower-income and majority Hispanic schools. As of 2023, over 40,000 schoolchildren and their teachers have participated. Insect Discovery is a tremendous educational opportunity for EIS graduate teaching assistantships (TAs) in outreach each year, giving graduate students a unique opportunity to hone teaching and communication skills while bringing science (and a scientist!) into Tucson schools. EIS students have participated in 50 TAs for Insect Discovery. The experience has strengthened their science communication skills, one of our three core learning outcomes.

Funding for these TAs has primarily been from GIDP Administration-funded TAs but in 2023-2024 this funding has ended and additional financial resources for TA support are needed (see G.6 and G.8). NSF grants of EIS faculty members who support Insect Discovery as part of the broader impacts of their research have also provided funds but grant funding limitations usually restrict these to 1 or 2 semesters of support. As TAs funded by the GIDP Administration and grants become more uncertain, we seek sustainable funding for these TAs as a matter of some urgency (see G.6 and G.8).

Insect Discovery also provides unique opportunities for UA undergraduates. Over 300 undergraduates have participated as field trip instructors through the Insect Discovery Course (ENTO 407). Many describe the course as one of the best in their college experience and have gone on to careers in science, medicine and/or education.

We are proud that Insect Discovery continued during the pandemic by providing virtual classroom visits. The program returned to in-person visits in 2022. The spring workshops now take place in a dedicated classroom renovated specifically for Insect Discovery at the Flandrau Science Center. In addition to workshops and classroom visits, the program participates in larger science outreach programs such as school science nights, the Tucson Festival of Books, Tucson Village Farm, Boyce Thompson Arboretum, and Insect Insanity at the Arizona-Sonora Desert Museum. Insect Discovery has also developed insect science curricula for 4-H and K-12 educators outside of Pima County <https://extension.arizona.edu/4-h-insect-discovery-activities>.

The logistical challenges of the Arizona Insect Festival and Insect Discovery are daunting for Dr. Kathleen Walker and other faculty who have carried the load for years. It would be a great benefit to obtain long-term support for a 0.5 FTE staff outreach coordinator to make these two high-impact programs for community science engagement sustainable for many years to come (see G.4).

Insect Discovery Sparks Scientific Curiosity



3. The University of Arizona Insect Collection: A Treasure Trove of Millions of Specimens

The University of Arizona Insect Collection (UAIC) in the Department of Entomology houses over 2 million insect specimens, particularly endemic arthropods of the desert Southwest (Appendix J1). It is considered one of the gems of the University and is used extensively for research, teaching, Extension, and outreach. Dr. Wendy Moore, Associate Professor of Entomology, is the Curator of the UAIC. She has obtained more than \$1.5 million in external funding (three NSF grants and donations from the Schlinger Foundation) to conduct three major renovations of the UAIC since 2012, including the current renovation. These renovations have enabled expansion of its holdings and its service to researchers and the public. Dr. Moore has also raised over \$1 million from private foundations to endow the UAIC's non-salary operations and host visits from arthropod systematists in perpetuity.

The UAIC serves as an important resource for interactions between EIS students, faculty, and members of the community, including students at Pima Community College and scientists and volunteers at the Arizona-Sonora Desert Museum. It is also the cornerstone of the Tucson Bee Collaborative, recognized by the UA as a Vertically Integrated Project (VIP) that engages undergraduate and graduate students in ambitious, long-term, specimen-based, multidisciplinary research led by Dr. Moore. Students and staff also work together to create artful, educational displays of insect specimens. Some displays are donated to local non-profits (such as Las Mipitas Community Farm of the Food Bank of Southern Arizona). Others are shown at the annual Arizona Insect Festival, in the Insect Discovery Program, and in other classroom visits to Tucson area schools and UA classrooms. EIS students are involved in the frequent tours of the UAIC, for example during the Festival of Books, for the Undergraduate Biology Research Program students, and for community groups. EIS students and the UAIC staff also use the collection to help provide the public and agencies with identifications of arthropods associated with homes, gardens, crops, livestock, forensics, and venomous attacks.



J. OUTREACH AND EXTENSION (continued)

4. Integrated Pest Management (IPM) Programs

Entomology faculty members with Extension appointments (Ellsworth, Fournier, Gouge, Palumbo, and Walker) develop and implement IPM programs that combine problem-solving, issue-driven research with engaged outreach to address pest problems in agriculture, communities, and public health. This includes capacity-building efforts in underserved communities. We also engage the public to increase awareness of entomology and its role in addressing societal issues such as hunger, health, disease, and food production.

Our outstanding IPM programs generate, synthesize, and transfer knowledge to yield more sustainable, profitable, and environmentally friendly pest management in agriculture and communities. For example, our Cotton IPM program has saved Arizona growers more than \$600 million since 1996. Major changes since the 2009 Academic Program Review include a 185% increase in competitive base federal funding for Extension IPM programs, supporting additional staff to implement outreach; establishment of an outstanding Public Health IPM program that addresses needs of both city and rural communities; departure of Extension faculty member Baker (urban IPM/termites) in 2015 and appointment of Fournier (IPM assessment) in 2018. In 2020, stakeholder donations enabled creation of the Endowed Chair in IPM for Extension faculty member Dr. John Palumbo, reflecting the value stakeholders place on his IPM and Extension activities. The structure and impacts of our IPM programs are described below. Please also see Appendices J2-J6 for related information and Appendix J7 for Extension publications.

The Arizona Pest Management Center (APMC)

We founded the APMC in 2003 to strengthen multi-disciplinary connections, to focus limited resources on priority pest management needs, and to promote excellence, innovation, and investment in IPM programs. The APMC encompasses and synergizes the full set of University of Arizona research and Extension resources involved in IPM in Arizona, activating highly leveraged, talented personnel, and providing foundational capacity for stakeholder engagement, program delivery and measurement of outcomes. The mission of the APMC is to “*create a working environment in which the science and implementation of IPM can thrive in Arizona.*”

The APMC is led by Entomology faculty who have extensive collaborations with other academic units, county programs, and stakeholders (Appendix J2). Dr. Peter Ellsworth, state IPM Coordinator (a federal designation), and Dr. Al Fournier, IPM Program Manager, serve as Co-PIs on the competitive federal grant (USDA-NIFA Crop Protection and Pest Management Program, Extension Implementation Program (EIP), that provides base funding for the APMC. Ellsworth convenes a 20-member IPM Coordinating Committee of UA and external stakeholders (Appendix J3) that guides the APMC, while Fournier supports day to day operations, grant development, needs assessment and evaluation of programs. Drs. Gouge, Palumbo and Walker lead and/or serve on IPM program teams.

In 2009, the federal IPM funding shifted from 3-d formula funds to competitive grants. That year the APMC garnered an 81% increase in funding. In the following 3-year cycle, funding increased

another 43% and our proposal was ranked 2nd in the nation. Additional increases followed in subsequent cycles. In the 2021-2024 grant cycle, our proposal ranked #1 and we secured the highest funding of any state (\$854,873). This represents a 185% increase over formula funding levels (Fig. J1). The APMC has expanded from two staff members in 2009 to nine full time staff positions in 2023. The APMC manages focused IPM Teams, each partially funded through this program. In the current grant cycle, an average of only 3.83 FTE/year is funded through the grant, providing base funding for 7 of 9 staff members and the IPM Program Manager (Fournier). These personnel resources are highly leveraged, providing a 5-fold return on EIP investments (Fig. J2, Appendix J4).

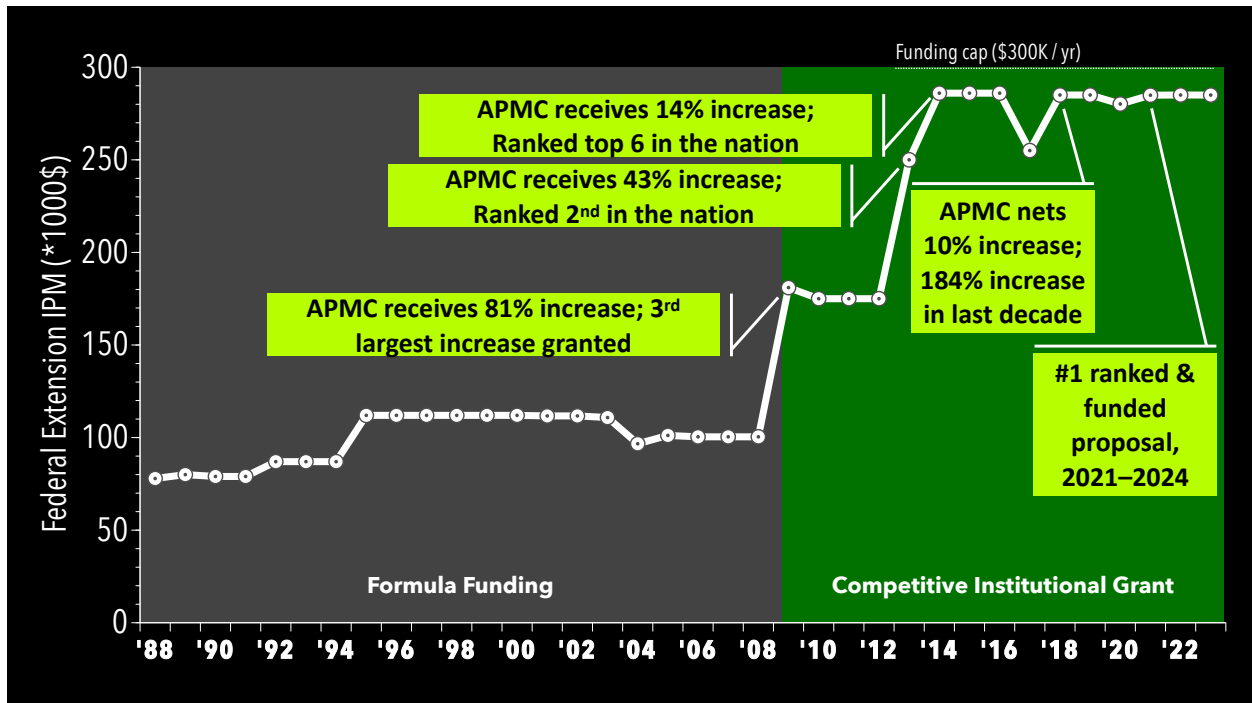


Figure J1. Arizona Pest Management Center (APMC) funding. The APMC secured significant increases in federal IPM funding following a shift from 3d formula funds to a competitive grants program. In the 2021-2024 grant cycle, APMC had the top-ranked, highest-funded proposal in nation, representing a 185% increase over formula funding levels.

Team	Leverage	Investment	N-fold
Veg IPM	\$ 1,633,536	\$ 390,173	4.19
Ag IPM	\$ 2,022,930	\$ 339,335	5.96
School IPM, Public Health IPM, PSEP	\$ 1,768,302	\$ 354,452	4.99
	\$ 5,424,768	\$ 1,083,961	5.00

Figure J2. APMC IPM team funding. IPM teams secured an average 5-fold increase in IPM program investments through leveraged funds in grants, contracts and gifts from 2017 to 2021. These dollars support key personnel that work with stakeholders to deliver IPM outcomes and impacts throughout Arizona.

We attribute the APMC’s continued success to our unique model for the coordination and adoption of high-impact IPM programs by Arizona stakeholders. Our proven approach is centered around full-time Assistants or Associates in Extension (AiE, Extension Educators) who interact with County Agents, Extension Specialists and other disciplinary faculty and collaborators who provide the full range of IPM expertise (e.g., arthropod, weed, vertebrate, pathogen, economics, agronomy, food safety) to support program development and delivery. Most AiEs have master’s or Ph.D. level training in Entomology or a related discipline. Each AiE is supported by a unique Leadership Team of appropriate subject experts that oversee IPM program development and guide and manage AiEs to ensure efficient functioning and delivery of IPM programs (Fig. J3). AiEs then form operational teams to implement and deploy Extension programming. Our outreach approach emphasizes use of field demonstrations; stakeholder-engaged translational research projects; and delivery of short, effective and graphically rich publications, presentations and advisories. We maintain constant contact with stakeholders via IPM Newsletters and social networking. The AiE serves a coordinating function, catalyzing outputs and impacts of each IPM effort. Each Leadership Team Chair sits on the IPM Coordinating Committee, which provides stakeholder input and serves as the advisory body for the APMC. This ensures accountability.

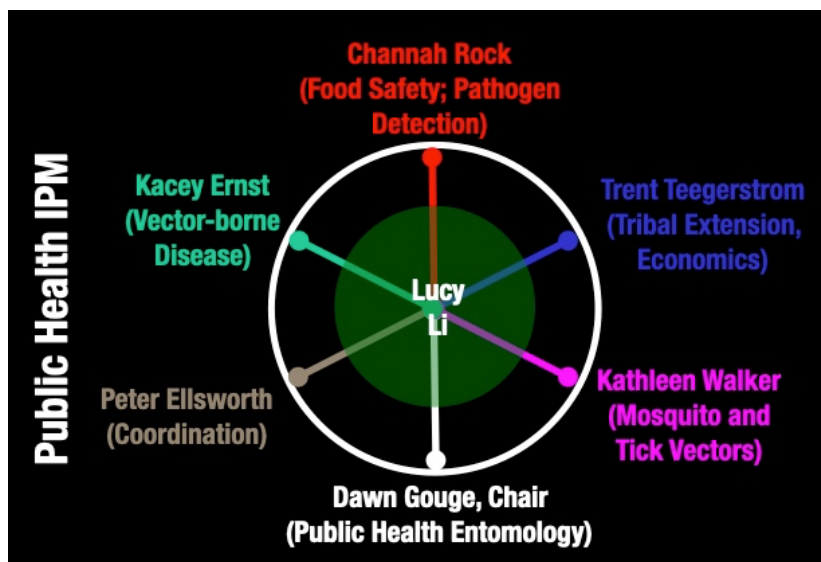


Figure J3. Public Health IPM: Example of multidisciplinary APMC Leadership Team. Each team provides diverse expertise to support Extension Educators that lead program areas (e.g., Lucy Li). This team includes 3 Entomology faculty (Chair Gouge, Walker and Ellsworth); Kacey Ernst, Professor & Department Chair, Epidemiology and Biostatistics; Channah Rock, Professor and Extension Specialist, Department of Environmental Science; and Trent Teegerstrom, Associate Director for Tribal Extension Programs and Agricultural Economics Extension Specialist.

Each AiE position is supported up to 50% from the foundational Extension Implementation Program (EIP) grant. AiEs and their Leadership Teams are obligated to secure the balance of their fulltime funding from competitive grants or other resources. By planning for sustainability, teams must secure stakeholder support, and ensure that funded projects enhance IPM outcomes. Leadership Teams include Agronomic Crops, Vegetable Crops, Climate Smart Guayule, Insect

Diagnostics, Community IPM, and Public Health IPM. The APMC provides common resources to support needs assessment, websites and communication networks, and evaluation of impacts. A unique IPM Assessment Leadership Team, led by Fournier, supports these activities for all APMC efforts.

The APMC’s IPM Programs are stakeholder-driven, based on the needs of communities these programs serve. Faculty and APMC staff are highly networked with stakeholders. A 2019 network analysis of Maricopa Agricultural Center faculty, including three entomology faculty and four APMC staff, demonstrated diverse and overlapping connections to stakeholders and to each other’s programs (Fig. J4).

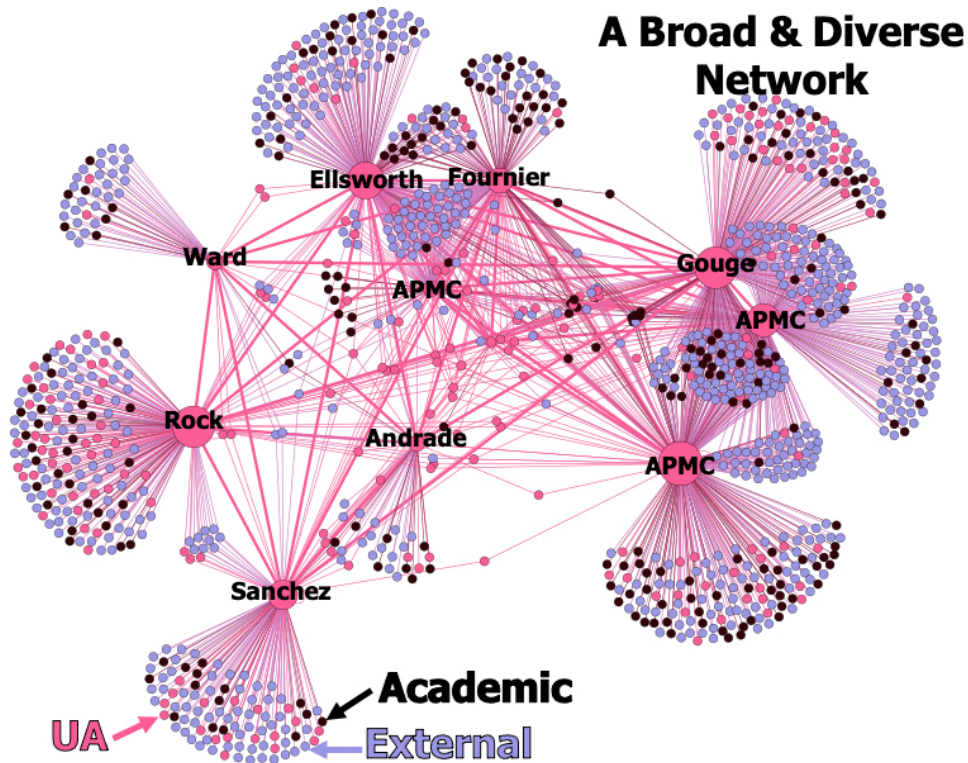


Figure J4. Network analysis of Maricopa Agricultural Center Faculty. Conducted in November 2019 and incorporating 4 APMC staff members. This shows rich and diverse connections to stakeholders that drive program successes. Each dot represents a stakeholder connection. Pink dots are UA faculty, staff or students (18%), black dots are from other academic institutions (21%), lavender dots represent other stakeholders (61%), including growers, pest managers, state and federal agencies and industry connections. Ellsworth, Fournier and Gouge are Entomology faculty. Dr. Channah Rock, Environmental Sciences Department, has a leadership role in the multidisciplinary APMC. “APMC” denotes APMC staff members included in the analysis.

Arizona Pest Management Center programs are organized in five focal areas: Detection & Diagnostics, Agricultural IPM, Community IPM, IPM Assessment, and Pesticide Research & Education. Faculty often work across focal areas and participate in many programs. A description of each focal area and highlights of recent outcomes follows.

Detection & Diagnostics

Insect Diagnostics

Gene Hall is an Entomology staff member and an expert taxonomist who works with Dr. Wendy Moore as Collections Manager for the University of Arizona Insect Collection (UAIC). The collection is the cornerstone for entomological research and insect diagnostics in Arizona. The UAIC includes approximately 2 million specimens representing 35,000 species, making it the most comprehensive collection for the Sonoran Desert Region. Mr. Hall, partially funded through Cooperative Extension, provides expert insect diagnostics to support our diverse IPM Programs and stakeholders. During 2015-2022, Insect Diagnostics processed 4,300 samples and inquiries.

Accurate insect diagnostics enable quick responses to new pest threats. For example, the UA Insect Diagnostic Lab, along with University of California and USDA collaborators worked with the Vegetable IPM Team to determine the identity and damage potential of several new pests on desert crops, including the cabbage budworm, alfalfa leaf tier, dot-lined angle moth, and white-lined sphinx moth. Mr. Hall and Dr. Moore also led an innovative project that used DNA barcoding to detect the invasive pecan bud moth for the first time in Arizona, enabling a rapid response. Barcoding was also used to identify a mirid insect (*Neurocolpus montanus*) of unknown pest status in pecans. More recently, a USDA Specialty Crop Block Grant funded a project to DNA barcode pest and non-pest insects occurring on Arizona specialty crops.

Arizona Plant Diagnostic Network

The Arizona Plant Diagnostic Network (AZPDN) is a multi-disciplinary, multi-institutional team of diagnostic and regulatory experts that help identify new and emerging plant pests and pathogens in Arizona and respond to regulatory issues. The team includes UA Extension specialists and diagnosticians in plant pathology, entomology, weed science and taxonomy and regulatory officials from the Arizona Department of Agriculture and USDA Animal and Plant Health Inspection Services. The team has developed communication and response procedures for new invasive pests, field-tested these procedures through training exercises, and improved ongoing communication among partner organizations. The AZPDN is led by Dr. Alex Hu (School of Plant Science) and is connected to a western region PDN and the National Plant Diagnostic Network.

Early efforts of the group contributed to detection of invasive weed kudzu and glassy-winged sharpshooter, an insect vector of Pierce's Disease. In both cases, early detection facilitated rapid treatment, significant suppression, and containment of these pests. The AZPDN maintains active survey and validation programs for key diseases and insect vectors, including Citrus greening/HLB ('*Candidatus*' *Liberibacter asiaticus*), Pierce's Disease (*Xylella fastidiosa*), Phytoplasmas in grape and other crops, pecan bud moth, and a number of plant viruses and phytopathogenic fungi.

Agricultural IPM

Our multidisciplinary agricultural teams address client needs in an integrated crop management framework and include cotton, vegetables (e.g., lettuce, cole crops, melons) and guayule. Entomology faculty either lead or co-lead these efforts, which include regular internal meetings for planning of organized applied research and outreach efforts. As nearly 100% of Arizona's acreage of these crops is professionally scouted and managed by pest control advisors, many of our programs target these professionals, as well as growers, regulatory personnel and private industry.

Cotton IPM

Dr. Peter Ellsworth leads Cotton IPM. Through a combination of fundamental and translational research, as well as organized outreach programs, we have witnessed and facilitated transition from an insecticide-dependent industry to one that has become a worldwide model for low-impact, reduced risk Integrated Pest Management (Fig. J5). Through the adoption and use of transgenic cotton, the eradication of pink bollworm, adoption of selective insecticides and conservation of natural enemies, growers have all but eliminated broad-spectrum insecticide use and generated profits while protecting the environment (Fig. J6). We can conservatively estimate that collectively Arizona cotton growers have saved over \$600M since adopting IPM programs first developed in 1996, averaging about \$25M per year in reduced yield losses to insects and reduced costs of their control. Over this same period (1996–2021), we estimate that growers have prevented over 40M pounds of insecticide active ingredient from reaching the environment. Furthermore, we estimate that 42% of these economic gains are due to the biological controls enabled through proper deployment of the IPM plan. Natural enemies, including predator species we've identified as key biological controls, have become increasingly abundant in area fields. In 2022, pest managers reported the lowest insect pest pressures ever, with 33.6% of Arizona's cotton acres remaining unsprayed for insects.

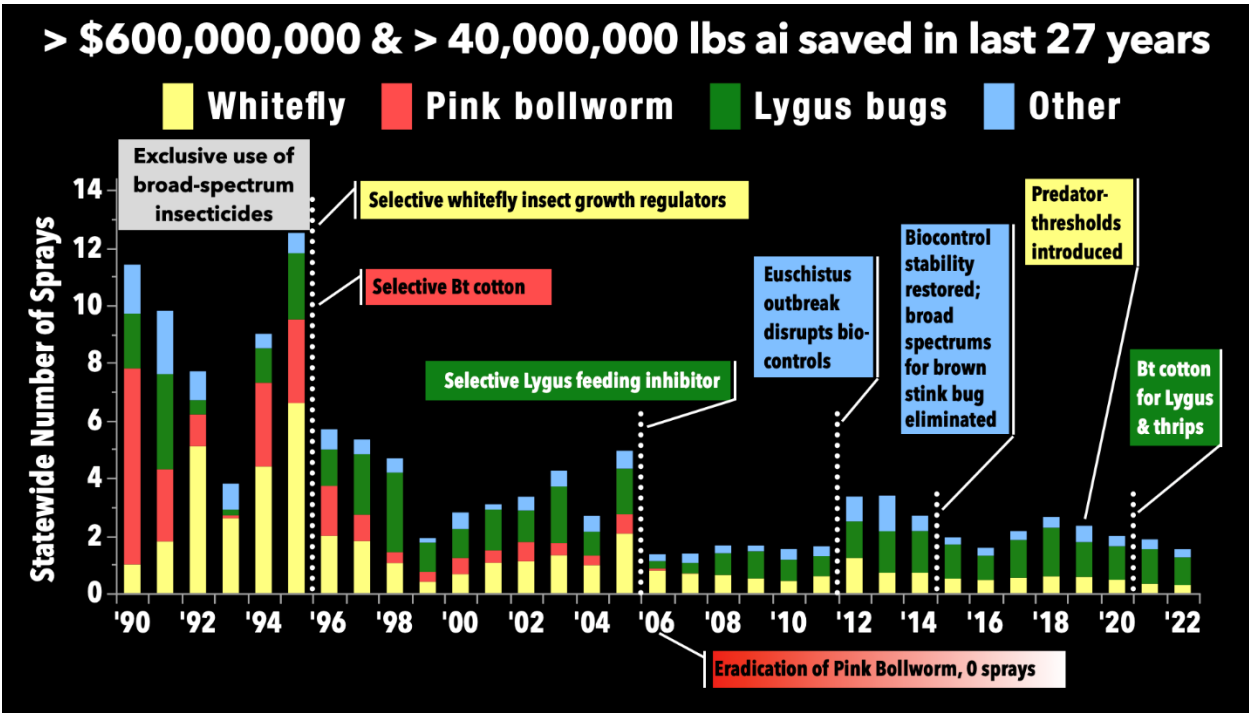
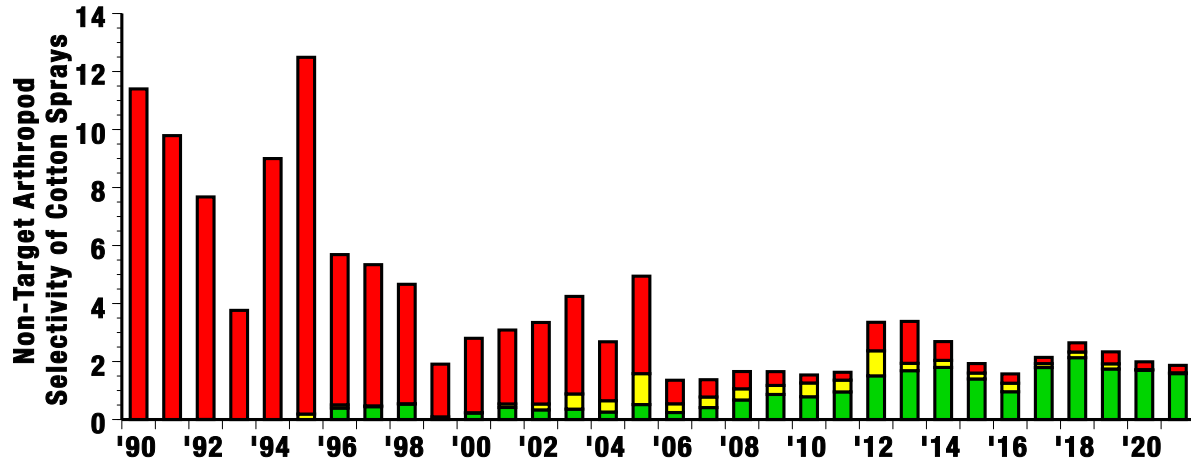


Figure J5. Average number of sprays made statewide to Arizona cotton, 1990–2021, by major insect pest group, noting major pest management periods. 2022 continues a trend towards fewer sprays (1.53). The 17-year statewide average is 2.04 ± 0.16 sprays for all arthropod pests. Cumulatively since 1996, Arizona cotton growers have saved over \$600M and prevented more than 40M lbs ai of insecticide from going into the environment. Source: Cotton Pest Losses Database, Ellsworth, unpubl.

The Cotton IPM Program is dedicated to the development of measurement systems and tools for both understanding sustainability and improving IPM in cotton. This includes systems-level risk analyses of pest and pesticide use patterns in Arizona cotton. It also includes information to support biodiversity and the implementation of thresholds based on the presence and numbers of key beneficial arthropod predators in grower’s fields. Current initiatives include demonstration and teaching of Predator Thresholds for whitefly management and modified thresholds for Lygus in genetically modified ThryvOn cotton.



■ Fully Selective
 ■ Partially Selective
 ■ Non Selective

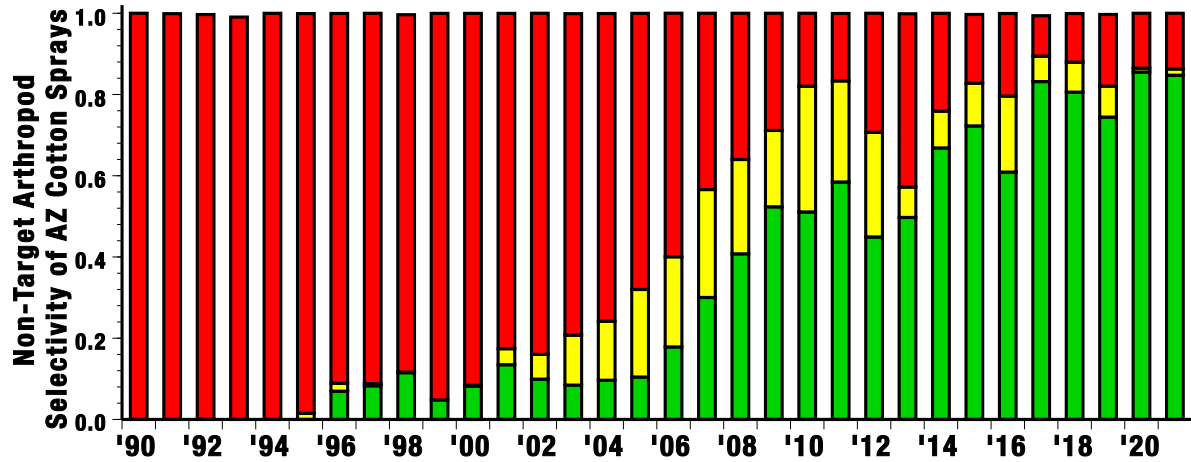


Figure J6. Longitudinal analysis of use of selective cotton insecticides (spray frequency at top and proportional use at bottom). Each bar depicts proportion of sprays made that are fully selective (green), partially selective (yellow) or non-selective (red). This shows a dramatic shift toward higher selectivity to non-target arthropods in Arizona in recent years. There are concomitant reductions in spray frequencies, increases in safety towards predators that support conservation biological control, and large savings to growers. However, when growers use non-selective insecticides, increased spraying results in significant losses. For example, in 2012–2014, as rates of non-selective insecticide use increased in Arizona to cope with a brown stink bug outbreak, the frequency of spraying doubled because of lost biological control of whiteflies, mites, and aphids. Source: *APMC Cotton Pest Losses and Pesticide Use Databases*, Ellsworth & Fournier, unpubl.

Genetically modified ThryvOn cotton, resistant to *Frankliniella* thrips and *Lygus* bugs, was successfully introduced on a limited scale in 2021. Our research and Extension supported the use of this new technology. In 2022, ThryvOn cotton increased from 6% to 8% of upland cotton in Arizona and was grown without restriction in commercial production in 2023. Our data show that

growers of ThryvOn cotton saved about 1 to 1.3 foliar sprays on their crop, valued at about \$20 to \$26 per acre, or about \$150,000–178,000 saved by the cotton industry per year since 2021.

In a contracted project with Better Cotton Initiative (BCI) in 2022, Ellsworth & Fournier analyzed use of seven highly hazardous insecticides in cotton in Arizona, California, and the rest of the cottonbelt. Today less than 1% of Arizona’s cotton acres make use of any of seven highly hazardous pesticides targeted for elimination by Better Cotton’s sustainability standards (Fig. J7). The Arizona Cotton IPM program has helped prepare Arizona cotton growers to better withstand environmental and regulatory disruptions, while providing opportunities to market their cotton as a premier sustainable product in the global marketplace. We have received additional funding from Better Cotton Growth and Innovation Fund in 2023 to expand our analysis to additional pesticides, to conduct demonstration-outreach to growers and pest managers, and to review Better Cotton’s procedures for tracking grower pesticide use to improve assessment of program outcomes.

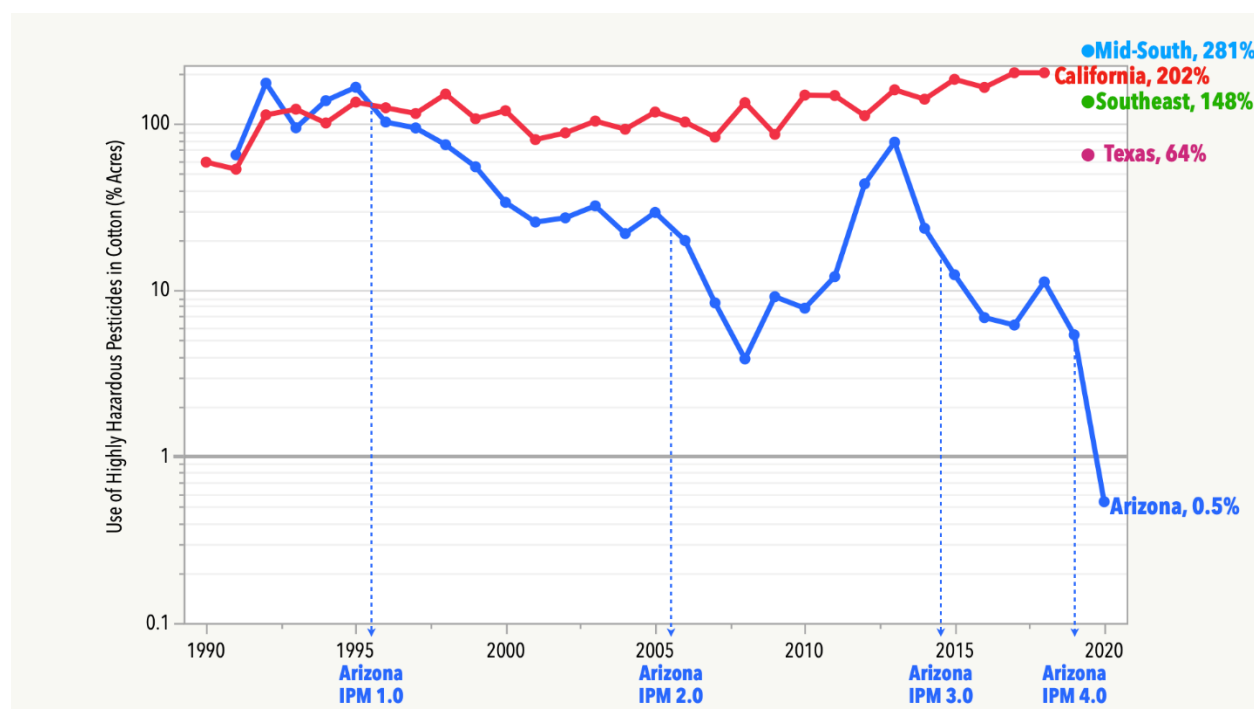


Figure J7. Use of highly hazardous pesticides in cotton as a percentage of acres treated, shown on a log scale for Arizona, California, Texas and Southeast and Mid-south states. Due to innovations spanning 25 years, today <1% of Arizona’s cotton acres make use of any of seven highly hazardous pesticides (aldicarb, oxamyl, phorate, abamectin, bifenthrin, dicotophos, and lambda-cyhalothrin) targeted for elimination by Better Cotton’s sustainability standards. In contrast, California uses these same pesticides on over 200% of its acres, and the rest of the cotton belt remains highly dependent on one or more of these insecticides (historical use data available only for Arizona and California).

We educate growers and pest managers through decision-support tools that help them factor pesticide risks into their pest management decisions. Our Cotton Insecticide Use Guidelines (Appendix J5) include information on risks to aquatic life, wildlife, pollinators, and inhalation

risk alongside efficacy, resistance, and selectivity information for each pesticide. This empowers growers and pest managers to proactively preserve pollinators and natural enemies and to protect the environment.

Vegetable IPM

Dr. John Palumbo leads Vegetable IPM. His program provides insect pest management expertise to the produce industry centered around Yuma, Arizona. In 2020, Arizona fresh vegetables (lettuces, leafy greens, brassicas) and melons were valued at over \$1.15 billion. IPM plays a critical role managing insect pests, weeds and plant diseases while balancing human health, environmental and economic risks to deliver product to market. The Vegetable IPM Team addresses these significant challenges in a fun and engaging way that makes growers and pest managers true partners in the program. The team maintains “constant contact” with stakeholders through bi-weekly Arizona Vegetable IPM Update newsletters delivered via email, smart phone and web, reaching over 1,000 growers, pest control advisors and others engaged in desert vegetable production in the Southwest region. Based on user surveys, 80% of growers and pest managers adopted reduced-risk pest management practices *because* of timely research and information from the Vegetable IPM program. 83% reported increased yields and 80% reported decreased use of broad-spectrum chemistries. 70% reported that our outreach helped them avoid economic losses through IPM. Adoption of reduced-risk IPM strategies saved average grower operations an estimated \$480k to \$1.5 million annually in insect management costs.

The Vegetable IPM program has facilitated a shift in the industry from broad-spectrum insecticides in the 1990s and early 2000s to selective materials which pose fewer risks to people and the environment. For example, with the exception of pyrethroids, broad spectrum and broadly toxic insecticides have been all but eliminated on head lettuce (Figs. J8 and J9), where selective reduced risk materials now account for over 60% of all reported insecticide sprays (53,795 acres reported in Fall 2022 and Spring 2023).

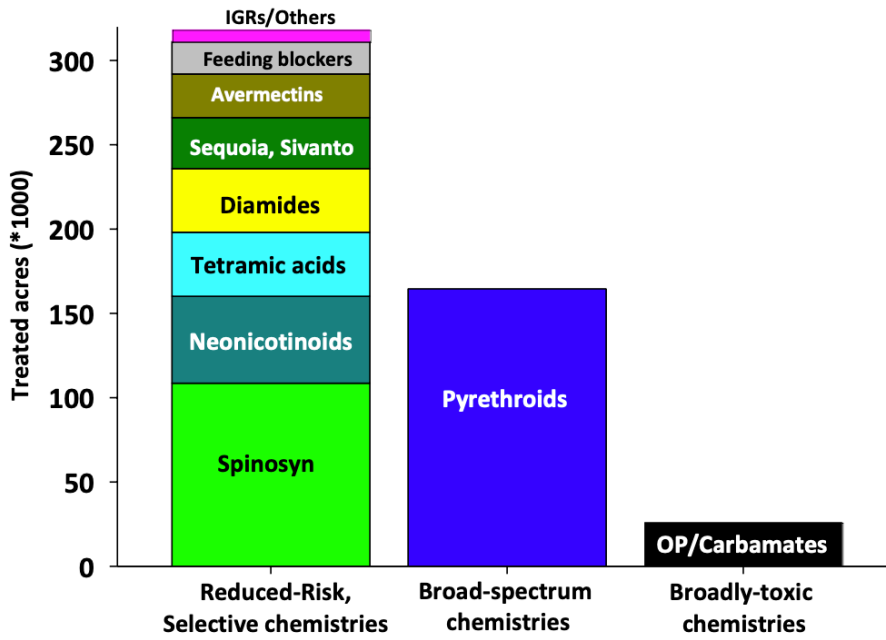


Figure J8. Insecticide use for seasonal insect control on lettuce, 2022-2023.

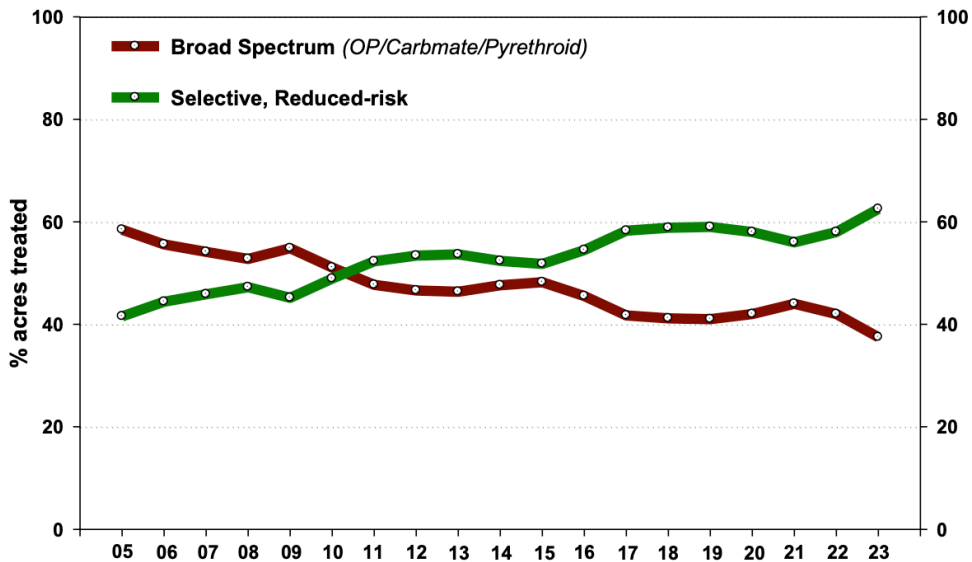


Figure J9. Percentage acreage treated with broad spectrum versus selective, reduced-risk insecticides on desert lettuce, 2005-2023.

The team continues screening new biopesticides and insecticide alternatives for organic production, determining how they fit into local IPM and resistance management programs. This

work has resulted in new insect management recommendations for certified organic lettuce, an important growing market.

In collaboration with local pest managers, growers and shippers, the team completed several research and educational outreach projects focused on better understand Impatiens Necrotic Spot Virus (INSV) and Western flower thrips in lettuce. Efforts in 2022 led to more clearly determining the epidemiology of INSV infection in the desert, defining seasonal thrips dynamics and developing new IPM guidelines for cultural and chemical management.

Guayule IPM

Arizona faces the challenge of climate change. Water-strapped Central Arizona needs cropping alternatives that provide economic success for growers while also reducing greenhouse gas emissions and water use. Guayule is a desert-adapted shrub grown for rubber production and other uses, currently in development by Bridgestone America. Guayule's potential as a low water use alternative to traditional field crops could provide climate benefits in carbon sequestration, reduced greenhouse gas emissions, reduced tillage and lower insecticide use. However, guayule seedlings are vulnerable to attack by the large flea beetle, *Systema blanda*, which can kill plants and significantly reduce stands.

The Ellsworth lab is developing cultural and chemical controls for this flea beetle. Five years ago, his research led to the development of a seed treatment that limits losses to this flea beetle. His research supported the registration of this product under the state of Arizona's Special Local Needs program, making it available to the guayule industry of this state. Without this control measure in place, it would have been unlikely that this crop could be commercially developed further. Recently, his program contributed to the successful awarding of a USDA Climate Smart grant to the University of Arizona. This \$35M grant will help incentivize the uptake by growers of this climate-smart crop on at least 4,000 acres in central Arizona over the next five years and likely more than 25,000 acres over the next ten years. As part of this effort, the team will identify and measure hypothesized environmental co-benefits including reduced regional densities of Lygus bugs, a key pest of cotton, and increase regional densities of key generalist arthropod predators. As well, they hope to document increased habitat for and supply of native solitary bees.

Community IPM

Community IPM focuses on supporting the needs of communities, including issues of public health, food safety, and community resilience.

Public Health IPM

Our Public Health IPM Team (Fig. 3) is led by Drs. Dawn Gouge and Kathleen Walker with participation from Dr. Ellsworth (Entomology), Dr. Channah Rock (Environmental Science), and Drs. Mona Arora and Kacey Ernst (College of Public Health) and includes long-term program investments in housing and school environmental health, vector control programs for mosquito and tick management, as well as food safety programs that target agricultural producers in tribal

communities. The latter effort led by Department of Entomology AiE Dr. Shujuan Li and Dr. Rock.

Arizona is home to 22 tribal nations, more than any other state. Many tribal members live in remote areas with minimal access to medical facilities and advice. There is a documented critical need to provide education and resources within tribal communities to reduce threats from public health pests, risks of pesticide exposure and environmental risks of pesticides, and to improve food safety. Since the Public Health IPM Team was formed, contacts with tribal members have increased over 500%. We estimate that 249,000 residents in tribal communities have benefited from our public health IPM program on approximately 42,604 square miles of reservation lands. From 2018 to 2020, we directly reached 18,286 participants in meetings, workshops and conferences, demonstrations, and outreach events. Surveys from 2019 (n = 326) indicated up to 75% increase in knowledge of IPM, public health pests and pesticide safety. A majority of tribal collaborators have indicated they will use IPM to improve their lives and communities.

These programs form true and enduring partnerships with diverse tribal communities, based on their unique needs and respected customs, beliefs, and sovereignty. For example, a recent grant-funded project led by Walker focused on developing a sustainable tick surveillance program to combat Rocky Mountain spotted fever (RMSF), a serious disease transmitted in Arizona by the brown dog tick. Since 2002, there have been more than 375 human cases of RMSF with 21 fatalities, mostly children, in tribal communities in Arizona and many more in Mexico. Over the years of the project (2020 to 2023), partners at the Tohono O'odham Nation (TON) Vet Clinic, TON Community Health and the University of Arizona Department of Entomology have established an annual mobile rabies vaccination and tick prevention clinic that visits every village in the Nation. Over 5,000 animals have been vaccinated and treated with tick preventatives, and many have received treatment for other diseases such as mange and parvo. Both the mobile clinics and the UA/TON partnership are continuing with funds from additional grants and support from TON Council. In addition, Walker and team were awarded a \$500,000 grant from the Centers for Disease Control to conduct statewide assessment of ticks and tick-borne diseases. Similar efforts have provided outreach education, monitoring and testing programs for mosquito management across many tribal communities.

Since 2018, the IPM team has partnered with 15 of Arizona's 22 federally recognized Native American Nations (Appendix J6) and has reached nearly 250,000 residents through its programs, trainings, and information. At least four tribes have adopted integrated pest management within their disease-prevention programs, protecting over 24,300 tribal residents from illnesses such as Rocky Mountain Spotted Fever and West Nile virus that can be spread from brown dog ticks and mosquitoes, respectively. Outreach on School IPM has also been impactful across many tribal communities. Africa Dorame-Avalos, Pesticide Program Manager with the Inter Tribal Council of Arizona said of our programs, "The biggest impact is that our [members] want to learn more. They want to expand it to other communities, not just in schools, but in homes. People want more education and assistance on implementing more of these principles."

<https://cales.arizona.edu/news/uarizona-partnership-tribal-communities-knocks-out-pests-not-environment>

Gouge and Walker lead the “Healthy and Safe Homes” initiative within the Advancing Health Equity, Addressing Disparities (AHEAD AZ) project. This is a UA Center for Rural Health program funded by the Centers for Disease Control and Prevention (CDC), through the Arizona Department of Health Services (ADHS) and is part of the national initiative to address COVID-19 health disparities among populations at high risk for COVID-19. Building on existing relationships, Gouge and Walker engage tribal school and housing managers and local environmental health leaders to identify and address Indoor Air Quality (IAQ) and IPM needs in tribal homes and education facilities. Tribal environmental health leaders from the Tohono O’odham Nation together with indoor air quality experts from the Institute for Tribal Environmental Professionals and UA faculty have embarked on a community needs assessment (completed), professional development events, community environmental health assessments, resident outreach (planned), and corrective action and evaluation. Exercises and demonstrations of environmental health improvements as a component of public health, within a One Health framework are emphasized.

Gouge and Walker also lead a 4-year NIH funded pilot project (NARCH 12) partnering with the Cocopah Tribe to increase the tribe’s capacity to monitor and mitigate risks associated with vector-borne diseases. At the beginning of the second year, we have increased mosquito surveillance and testing for West Nile virus. Plans to initiate tick surveillance for the first time in the community are underway.

The Public Health IPM Team’s newest effort builds on existing relationships with tribes to deliver food safety programs to tribal growers, based on the IPM model, in collaboration with Dr. Channah Rock from the UA Environmental Sciences department. Arizona has the largest concentration of American Indian farms in the United States. According to USDA, nearly 21 million farm acres in Arizona are tended to by producers on tribal land. In 2012, these farms sold near \$67 million worth of agricultural products. Native farmers are exempt from the Food and Drug Administration (FDA) training and certifications which are required for non-tribal professionals, but they are not exempt from the marketplace. These new programs have the potential to protect millions of consumers from food-borne illness and to foster the economic success of tribal growers and communities.

School IPM Inside and Out

Our School IPM “Inside and Out” program is aimed at reducing student and staff exposure to harmful pests and pesticides through effective building and landscape pest management in K-12 schools. These programs have reduced pesticide applications an average of 71% and pest complaints by 78% and led to measurable improvements in air quality, affecting over 300,000 students statewide. In 2020, we worked at nine school sites in eight partner districts. Partner schools serve as hubs to expand our outreach programs to other school districts and community audiences. Since 2018, Department of Entomology AiE Dr. Shaku Nair has coordinated the

annual Arizona School IPM Conference, which has delivered education on indoor and outdoor pest management, pesticide safety and public health topics. In 2020, the conference was adapted for online delivery, with 146 participants, nearly triple the previous year. 89% of participants reported increased IPM knowledge and 91% said they would use the information in their jobs or daily life. Our School and Home IPM Newsletter reaches about 1,500 people in Arizona and over 5,000 nationwide 8 times/yr. Our online Extension publications average 2,000 annual page-views and downloads. Team members significantly contribute to nationally beneficial efforts including creation of EPA-funded Pest Defense School IPM training modules, which has provided training to over 8,000 school staff nationwide since 2020. In Arizona, our program has reached over 20,000 people through presentations, publications, online information and high traffic outreach events.

Dr. Gouge is lead author on a recent publication, “Improving Environmental Health in Schools,” which was published in *Current Problems in Pediatric and Adolescent Health Care*, Vol. 53, Issue 4. The article highlights common environmental challenges in schools and opportunities for improvement through a holistic “Integrated Environmental Management” approach, which incorporates IPM, indoor air quality, green cleaning, pesticide and chemical safety, food safety, fire prevention, building legacy pollutant management, and drinking water quality.

Stop Pests in Housing

Dr. Gouge has led long-term projects in elderly and/or disabled subsidized housing. Pest management services were minimized throughout the COVID-19 pandemic which has had serious impacts on the living conditions. Currently, a HUD-funded one-year impact assessment and IPM intervention effort is underway, and we are currently completing data collection on pest infestation reduction and resident wellbeing.

IPM Assessment

Our unique IPM Assessment Leadership Team, led Dr. Al Fournier, provides centralized common-pool resources to support needs assessment, websites and communication networks, and evaluation across all IPM programs and teams. The identification and prioritizing of IPM stakeholder needs serves as the foundation of all IPM program planning, ensuring the most effective allocation of limited resources, better program relevance and competition for extramural support, and increased documentation of impacts.

Pesticide Use Database. In cooperation with the Arizona Department of Agriculture and a stakeholder advisory committee, we developed the APMC Pesticide Use Database (1991 – present). The rigorously quality-assured data include all agricultural applications submitted by statutory requirement, representing the range of practices across over 120 different crops, with more than a million use records spanning 30+ years. These data (e.g., Figs. J6 & J7) are used to document impacts of our IPM programs, for research and education, and to support responses to calls for public comment on pesticide registration reviews on behalf of stakeholders.

Crop Pest Losses and Impact Assessment. Few agricultural industries actively measure even the most basic metrics of economic, environmental, or human health status. The Crop Pest Losses Signature Program of the Western IPM Center engages stakeholders to assess the current state of their industry, including yield losses to pests, pesticide use, and economic outcomes. Annual surveys for cotton and lettuce are administered by Dr. Ellsworth and Dr. Palumbo, respectively, developing data which complements our pesticide use data by revealing participant perceptions of pest impacts and intentions behind pesticide applications (i.e., target pests). We compile detailed information on yield impacts and control costs of insect, disease and weed pests during a series of annual interactive, face-to-face and/or virtual workshops in Arizona and adjacent low desert regions of California. The workshops also help us identify pest management needs and emerging issues that inform Extension program planning. These data (e.g., Figs. J5, J6, J8 and J9) are valuable for assessment of program impacts, education and outreach.

Since the 2009 Academic Program Review, we discontinued a pest losses survey on melons and elevated the program to a Signature Program of the Western IPM Center and supported the development of crop assessments in the Pacific Northwest, including cranberry, hazelnut, cherry, potato, mint, and onion. We supported collaborators at Oregon State University, who have analyzed the data and developed a series of “Pest Impact Reports” (Extension publications). This detailed process provides unique and actionable insights to improve pest management and economic and environmental outcomes.

Pesticide Research & Education

Pesticide Risk Assessment: Research, Education & Mitigation.

The APMC Pesticide Use Database combined with US-EPA risk assessment data is instrumental in understanding patterns of pesticide use and potential risks to workers, pollinators, other non-target organisms, and the environment. This approach, along with expert interviews, was the basis of the Better Cotton Initiative project described in the Cotton IPM section (Fig. J7). Similar risk analyses using EPA data informed pesticide recommendations to growers in our Cotton Insecticide Use Guidelines (Appendix J5). The flow is from research to education to mitigation of real pesticide risks to people and the environment in the field. In addition, Fournier and Ellsworth collaborated with Dr. Melissa Furlong (UA College of Public Health, Environmental Health Sciences) in a study she leads funded by the National Institute of Environmental Health Sciences. This project examines Arizona pesticide use patterns of certain insecticides in relation to child birth weights and other publicly available data. The results were recently submitted to the American Journal of Epidemiology.

Regional IPM Network, Arid Southwest

The Arizona Pest Management Center (APMC) maintains a vital information network for the arid southwest region (Arizona, New Mexico, Nevada, and the desert regions of California), culminating in evidence-based testimony to our regional and federal partners, especially the US-Environmental Protection Agency, with a focus on responding to pesticide registration reviews. This expert testimony involves pesticide use data from the APMC Pesticide Use Database and

Crop Pest Losses surveys from our region, as well as detailed input from growers, pest managers, industry professionals, Extension personnel and scientists. Our involvement is important to ensuring that EPA’s regulatory decisions and scientific models of risk incorporate accurate data and an understanding of grower practices and needs. One prominent stakeholder, referring to a specific set of EPA public comments we developed, stated in an unsolicited letter to the Dean that we had “created a professional and scholarly set of comments that...the industry could reference in our supporting comments to the federal agency. This was very helpful to our industry.” In another example where State Attorneys General were commenting on specific pesticide practices, another stakeholder cited the importance of our pesticide risk research in an unsolicited correspondence, “I imagine there are times researchers must feel a little unsure if a project will be meaningful and I wanted to make sure you knew how important your work has been to the industry.”

With Dr. Fournier as Director of the Southwest Regional IPM Network, we represent one of four sub-regions for which the Western IPM Center coordinates stakeholder comments on pesticide registration reviews (the others are California, the Pacific Northwest, and the Pacific Islands). A 2022 analysis of 85 comments submitted to EPA on behalf of Western agricultural stakeholders found that nearly 90% of comments provided substantive data that were considered in EPA’s registration review process (Fig. J10). This included 20% of comments that resulted in revisions to EPA risk models or otherwise altered regulatory decisions in ways that addressed grower’s concerns while mitigating risks to protect human health and the environment. The majority of comments analyzed (48) supported the economic interests of Arizona agriculture and urban pest management while providing scientific information to support effective public policy.

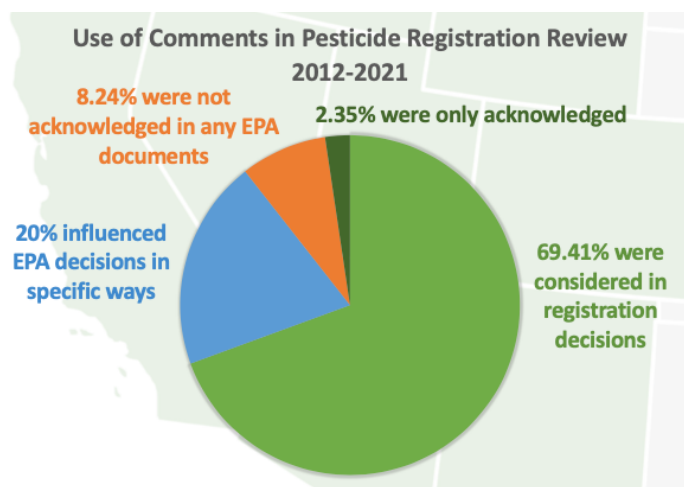


Figure J10. Analysis of EPA responses to 85 comments submitted by Regional IPM Network Coordinators in the West. Based on information in EPA registration review documents. This shows the extent to which information provided was considered by EPA during registration review.

Pesticide Safety Education

In the 2009 Academic Program Review, we reported a “distributed approach” to pesticide safety education following personnel loss after cuts to the federally funded Pesticide Safety Education Program (PSEP). Since then, a full-time dedicated person has been restored to this position. This was accomplished from 2014 to 2018 with 50% funds from the USDA EIP foundational grant to the APMC that were leveraged with other resources. Since 2019, Ms. Jennifer Weber (Associate in Extension), has coordinated this program as a collaboration between UA Cooperative Extension and the Arizona Department of Agriculture.

K. COLLABORATION WITH OTHER UNITS

Extensive collaboration occurs between the Department of Entomology and the EIS GIDP. The Department of Entomology as well as EIS GIDP students and faculty collaborate with the six additional units across three colleges that actively participate in the EIS GIDP: School of Natural Resources & the Environment in CALES; Departments of Ecology & Evolutionary Biology, Geography, Molecular & Cellular Biology, and Neuroscience in the College of Science; and the Department of Epidemiology & Biostatistics in the College of Public Health. Faculty at the Maricopa Agricultural Center (MAC) have an extensive collaborative network (Fig. J4). We also promote collaboration via our leadership. For example, Rachel Doty (ENTO Business Manager Sr.) chairs the ALVSCE Staff Council, Molly Hunter chairs the Graduate Interdisciplinary Programs Advisory Council, and Bruce Tabashnik chairs the CALES unit leaders team.

SECTION L: FACULTY PLANNING

Department of Entomology

The faculty’s collective view is that the future of the Department of Entomology is bright, particularly because of the seven faculty hires in the past eight years (Section E.5). We plan to continue to deliver outstanding research, instruction, Extension, and outreach in entomology that improves the lives of the people of Arizona and the world. Key factors driving this success will continue to be the exceptional quality of the department members, their dedication, and their collegial interactions.

Entomology & Insect Science GIDP

Faculty membership growth. At the time of the last APR in 2014, EIS had 33 faculty members in 10 departments in four colleges. We still have memberships in most of these departments, but there’s no question that the active membership in EIS beyond the Department of Entomology has shrunk since our last review, and this is why we chose to highlight an active membership of 12 additional faculty and EIS associates (USDA scientists) with faculty in five additional UA departments (Fig. A3). The reason for the shrinkage is partly a sub-discipline shift in Neuroscience to faculty studying mammals. Neuroscience was historically home of some of our most involved members, and some are now retired. Some of the shrinkage was clearly due to the pandemic era

when many people reduced their activities beyond their home departments and the community-building social events stopped or went online.

We therefore plan to increase active recruiting of new EIS faculty members within and beyond the Department of Entomology. Since the last review, we have gained more active participation from Epidemiology (Kacey Ernst and Heidi Brown). We have also recently recruited Keith Maggert, a *Drosophila* cell biologist who recently moved departments from the College of Medicine to Molecular and Cell Biology. Further, two new faculty are joining the Department of Entomology, Natasha Tigreros and Paulina Maldonado-Ruiz, who are both in the process of joining EIS. Dr. Maldonado, a tick physiological ecologist, is a GIDP Shared Hire, with the GIDP Administration providing partial salary for the first three years to support interdisciplinary teaching and mentoring. Four-five more faculty active in collaborations or graduate committee membership in our program will be asked to join in the next year.

Policy changes and retreat. In a recent meeting of the EIS Advisory Committee evaluating student progress reports (July '23), and a subsequent meeting of the EIS Executive Committee (Aug '23), some observations and suggestions for changes of policy were considered. A new program assessment plan was adopted by the EC (see section I.4). Other possible changes were discussed. These included small changes to speaking requirements, allowing flexibility in when (pre- or post-comprehensive exam) and where (on or off campus) the requirements are met). We also need to consider an adjustment of program course requirements, because one class (EIS 520 Insect Systems Biology) has not had sufficient enrollment to be taught in several years, and it is currently one of the three courses designated a “core course;” and students are required to take two of three. By default, then, all the students take the remaining two courses: EIS 517 Insect Systematics and EIS 544 Insect Ecology. A possible solution is to have all students take the two remaining core courses and one additional EIS course taught regularly, for example, EIS 532 Comparative Immunology, EIS 507 Medical and Veterinary Entomology, EIS 532 Agroecology, or EIS 501 Ecological Physiology. This is just one obvious topic for discussion.

We have had great success in the past in adopting new program policy from off-campus retreats of faculty and students. Program retreats were adopted since our last review. In mixed faculty and student tables of 3 and 4, policy issues are discussed, consensus views shared, and actionable items then brought at a later meeting of the EIS Executive Committee for a vote. We had three retreats (two at the UA Southern Arizona Experiment Station cabin in the Santa Rita mountains, one at Appleton Whittell Research ranch of the Audubon Society in Elgin, AZ), and planned to have one in Spring of 2020 before everything was shut down. There is a need for another one. We plan to devote a program lunch this fall to a few items for discussion and plan an off-campus retreat in the spring of 2024. For the latter, the agenda will be open to faculty and student input.

The future of EIS GIDP. To echo the Department of Entomology’s statement above, the quality and commitment of students and faculty of EIS promise a bright future. While we face some financial headwinds (e.g., Table G3), our students are diverse in identity and interests, finish their degrees at high rates (Table I5), and advance to careers or further education made possible by their EIS degree (see Table I6).