DEPARTMENT OF PLANT PATHOLOGY

Academic Unit Review

For the period 2012-2019

Review held Autumn 2020

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

plantpath.osu.edu

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Electronic files and associated webpages
for the Plant Pathology Academic Unit Review
can be found online:
plantpath.osu.edu/review

Executive Summary

The Department of Plant Pathology is one of nine academic units in the College of Food, Agricultural, and Environmental Sciences (CFAES) at The Ohio State University (OSU), and is the sole academic unit dedicated to plant-microbe interactions in Ohio's Higher Education system. The department consists of faculty, students, postdocs and staff who are split roughly equally between the Columbus and Wooster campuses of OSU. Funding comes from the Ohio Agricultural Research and Development Center (OARDC) and Ohio State University Extension (OSU Extension) line items and from OSU Academic Programs (GF); higher levels of financial support are obtained from external grants, contracts and gifts.

Research programs in the department encompass basic investigations of plant-microbe interactions at the molecular level to studies of epidemics at the population level, and in parallel, mission-oriented investigations of management tactics for diseases of major crops and forest trees. Graduate education is one of the foundations of the department. Currently, there are about 2.5 M.S./Ph.D. graduate students per faculty advisor, with many of our graduates going on to leadership roles in academia, government and private industry. Our new terminal/professional Master in Plant Health Management (MPHM) degree developed and administered in collaboration with the Department of Entomology—is gaining momentum. Since 2014, 27 MPHM students have graduated, with a current enrollment of 20. The department is fully committed to undergraduate education and administers two majors, Plant Health Management and Plant Pathology, as well as a minor in Plant Pathology. A new minor in Mycology is nearly complete, which should attract new students to the department. Further, our new on-line course to be taught this fall 2020, Psychedelic Studies: Neurochemistry, Plants, Fungi, and Society, is already attracting many new students to the department. Although our undergraduate enrollment is small, our students are very successful with roughly half obtaining employment in industry and the other half enrolling in graduate school.

Through the use of oral, printed, and electronic media, we are at the forefront of the College in outreach and engagement efforts, primarily through our Extension education programming. Furthermore, the department is engaged globally, with leadership in international research and development projects.

Our vision is to be the most credible source of unbiased, science-based information on plant diseases and plant health management in the U.S. Based on success indicators described herein and our ongoing benchmarking analyses, we strongly believe that we are among the leading Departments of Plant Pathology in the country, we have built and maintained this prominent role despite some major budget cuts from OARDC and OSU Extension in the past, and generally tight budgets in recent years, resulting most notably in the decline in the number of regular faculty members from 19 to 15 since 2000 (see faculty member bios and areas of research at plantpath.osu.edu/review and **Appendix 1**). In 2015, the number of faculty members dipped to a low of 12 due to retirements, but have rebounded in the past few years due to key hires. We see many opportunities to continue our leadership role and grow further in prominence through the making of careful investments in faculty, students, staff, and infrastructure. We are now at an important stage in planning our future. We are understaffed at the faculty level: to address new initiatives in education and outreach; to address new research needs; and to take advantage of new interdisciplinary funding opportunities. Therefore, our highest and most immediate priority is to fill two faculty vacancies in basic and mission-oriented programs. Additionally, it is imperative that we hire a new director for the MPHM program if it is to be sustainable and grow. We must also maintain and upgrade our greenhouses on both campuses and the phytotron (growth-chamber) facility in Columbus. These targeted investments are critical to maintain and expand our leadership role in plant health science and serve our stakeholders at all levels.

Table of Contents

List of Tables

List of Figures

Appendices

Glossary of Acronyms and Terms

AA Committee – Academic Affairs Committee

AA – **Academic Analytics** - online analytical platform used by OSU and other universities to collect and analyze data on research output by faculty

APS – American Phytopathological Society, the premiere professional society for plant pathologists

APT – Appointments, Promotion and Tenure document that details criteria and procedures for faculty appointments

ATI – Agricultural Technical Institute, two-year technical college on the campus of the Ohio Agricultural Research and Development Center in Wooster, part of CFAES

CAPS – OSU Center for Applied Plant Sciences

Carmen – Ohio State's course management system (*Canvas* web template for OSU courses)

CFAES – College of Food, Agricultural, and Environmental Sciences

Discovery Themes **Initiative** – OSU multidisciplinary investments in targeted areas. In Plant Pathology, we have a faculty position in the Discovery Theme, Emerging Infectious Diseases (Jonathan Jacobs)

DPT – Departmental Promotion and Tenure Committee (also referred to as P&T)

ESGP – Environmental Sciences Graduate Program (multi-disciplinary; some of our faculty advise ESGP graduate students)

FAHRP – Food Animal Health Research Program (food safety and animal health focus on Wooster campus)

GE – General Education

GSC – Graduate Studies Committee

HCS – Ohio State, Department of Horticulture and Crop Science

MCIC – Molecular and Cellular Imaging Center; provides equipment and services for microscopy, genomics and molecular biology

MPHM – Master in Plant Health Management, a professional degree administered by the Department of Plant Pathology and the Department of Entomology

OARDC – Ohio Agricultural Research and Development Center (the agricultural experiment station)

ODA – Ohio Department of Agriculture

OSC – Ohio Soybean Council, which manages Ohio's soybean checkoff funds research and marketing

OSP – Office of Sponsored Programs, handles research administration for sponsored projects at OSU

OSU – a common abbreviation for The Ohio State University (not to be confused with Oregon State University or Oklahoma State University)

OSU GF – OSU General Funds, synonymous with Academic Programs (includes the teaching budget)

OSUE – OSU Extension

POA – Pattern Of Administration, a document describing a unit or department's policies and procedures for governance

PHM – Plant Health Management undergraduate major in the Department of Plant Pathology

PI – Principal Investigator

PP – refers to Plant Pathology, the undergraduate major in the Department of Plant Pathology

PPDC – C. Wayne Ellett Plant and Pest Diagnostic Clinic

PPGSA – Plant Pathology Graduate Student Organization

RBB – Responsibility Based Budgeting, formula-based budget model for the OSU General Funds allocation to university departments (pertaining to academic programs)

SAC – Student Advisory Committee

SENR – OSU School of Environment and Natural Resources, part of CFAES

TPS – Translational Plant Sciences Ph.D. program, administered by the Center for Applied Plant Sciences

USAID – independent federal agency that provides U.S. economic and humanitarian assistance

USDA – U.S. Department of Agriculture

USDA NIFA – USDA National Institute of Food and Agriculture

USDA ARS – USDA Agricultural Research Service; research arm of this agency

Wooster campus – comprises academic departments from several units in CFAES (Ohio Agricultural Research and Development Center) and the Agricultural Technical Institute (ATI), an associate-degree program in CFAES

COVID-19 Impact

Due to the COVID-19 pandemic, much of our operations have been disrupted. Impacts have been and will continue to be felt in research operations, education programing, student advising, student recruitment and retention, Extension programing, and budgeting. Statements of these impacts will be made in the relevant sections of this document.

Academic Unit Review and Strategic Planning

The department takes self-assessment seriously and there is continual formal and informal assessment of the status of the department in terms of research, classroom teaching, advising, extension and outreach, and service. Through our peer-based Annual Program Review (see General Operating Procedures section), faculty members and senior staff have an opportunity to assess all the programs in the department on an ongoing basis, which then influences the decisions that are made in terms of new directions in the unit and resource allocation. Through the workings of other committees (e.g., Graduate Studies, Academic Affairs, and Vision), the current status of key components in the department is assessed and new approaches are proposed and adopted. In the college (CFAES), performance of every academic unit is evaluated annually using a range of metrics for research (OARDC), Extension (OSU Extension), and teaching (Academic Programs), and these evaluations affect the decision making in the department as well as the funding appropriated to the department.

A formal strategic planning process was implemented within OSU several years ago, and every college and department were required to develop a Strategic Plan. The departmental strategic plans were required to fit into the plan for the college. Several *ad hoc* committees and the former Chair (Boehm) developed the plan for Plant Pathology, which was approved by the college (CFAES) in 2009. However, this plan is dramatically out of date. As such, with the hiring of a new Chair (Mitchell) and the recent hiring of a new CFAES Dean (Kress), the department has begun the process of developing a new strategic plan and has hired an outside consultant to manage the process. Further, we afforded the time and funds for a senior staff member to become trained in group techniques to assist in the process. Performing this self-study and Academic-Unit Review was the first step in our strategic planning efforts, which will continue through 2021.

In addition to the planning described above, the department had a 2-day retreat to continue with ongoing self-assessment and to prepare for the Academic-Unit Review. This document reflects the deliberations at that retreat and the writings of many individuals in the department.

Mission

We are dedicated to enhancing food security, global sustainability, and human welfare through environmentally and economically sound strategies for plant health management. To this end:

- we conduct fundamental and mission-oriented research on pathogenic and beneficial microbes, and their interactions with plants and the environment, to broaden our understanding of plant disease at biological scales ranging from the molecular to the epidemiological, and
- we educate students, professionals and the general public about the science of plant pathology and innovations in plant health management.

Vision

Our vision is to lead globally in research, education, and the delivery of unbiased science-based information on plant diseases, host-microbe interactions and plant health management.

Historical Synopsis

Research and instruction in plant pathology had already been underway at OSU for more than 75 years before the Department of Plant Pathology was established on July 1, 1967. When the university was founded in the 1870's, work in applied botany began in the Department of Agriculture. Classes first incorporated plant disease topics in the 1880's in the Department of Horticulture and Botany. The first plant pathology course was taught in 1891 in the Department of Botany by W. A. Kellerman, noted mycologist and plant pathologist who chaired the department from 1891-1908. During the first half of the 1900's, research and instruction in plant pathology continued to grow on the Columbus campus.

The Ohio Agricultural Experiment Station began on the Columbus campus in 1882 but was moved to its present location in Wooster by 1894. Soon thereafter, A. D. Selby was hired as Ohio's first experiment station plant pathologist. He was appointed botanist and chief of the new Department of Plant Physiology and Pathology in1902 and served in that capacity until 1923. Under his leadership, plant pathology research and Extension fully took root in Ohio. Selby was a founder and charter member of the American Phytopathological Society (APS) and its third president. Selby Hall in Wooster is named for him. Research and extension in plant pathology grew on the Wooster campus throughout the first half of the 1900s.

In 1948, common departments in Columbus and Wooster were joined and a Department of Botany and Plant Pathology was formed. In 1967, when the new College of Biological Sciences was formed from the agriculture and life sciences faculty, this department was split, and the Department of Plant Pathology was formed. Dr. Ira W. Deep was the first Chair of plant pathology from 1968-1984. During that time, when Roy M. Kottman was Dean and Director of the College, considerable strength was added to the unit and the department grew in size and in national prominence. Kottman Hall in Columbus bears his name. From 1967-82, the department operated as one unit academically, but budgets were separate for the two campuses. In 1982, the Ohio Agricultural Research and Development Center (OARDC) at Wooster was administratively merged as an integral part of OSU. Since then, the department has operated as a single academic unit housed on two campuses with a single budget, as it remains today.

The national and international visibility of the department expanded greatly in the 1980s and 1990s after the administrative merger. After peaking with 21 faculty members in 1990, plus three ARS adjunct faculty housed in Selby Hall in Wooster, the unit is now composed of 15 regular OSU faculty members, one assistant professor of clinical professional practice and three USDA/ARS adjunct faculty members. Traditionally, there have been roughly equal numbers of faculty on each campus for our department, and that situation remains today. All faculty members on both campuses in the department are involved in teaching. Traditionally, the Chair of the department has been based in Columbus, which makes sense based on the many university and college meetings that must be attended; however, there have been exceptions to this, for either permanent or interim Chair appointments.

Dr. Deep stepped down as Chair in 1984. Subsequent Chairs have been: Chuck Curtis (1984-96), Randy Rowe (1997-2007), Larry Madden (interim; 2007-08), Mike Boehm (2008-10), Larry Madden (interim, 2010-11), Terry Niblack (2011-2016), Larry Madden (acting and then interim, 2016-2019), and Thomas Mitchell (2019-present).

Trends

Positions in the College of Food, Agricultural, and Environmental Sciences (CFAES) of OSU are funded by the Ohio Agricultural Research and Development Center (OARDC; the "Experiment Station"), Ohio State University Extension (OSU Extension), and Academic Programs (OSU General Funds, or OSU-GF). The first two of these sources are state line items that are distributed to departments through the college. All faculty members in the department are supported by at least two of these three funding sources. The percent appointment (FTE split) in the three areas for a faculty member broadly reflects the position description and is not meant to reflect a strict percent activity. Changes in the FTE appointment are negotiated by the faculty member and the Chair based on wishes of the faculty member and the changing needs in the department. Chairs have some latitude, which has recently expanded, in making FTE adjustments as long as the total departmental dollars for the three lines do not change significantly for a given year, and the combined needs in research, Extension expectations, and teaching are met for the unit. All adjustments must be approved by college administrative cabinet.

COVID-19 Impact: While we do not have firm numbers yet, the budget for the next fiscal year for the Department is expected to decrease by 8-10%. To accommodate this reduction, the Department will see salary savings from restricted travel, restricted invited guests travel, and matriculation of existing graduate students. For the past 5 years, the department has been supporting more graduate students than traditionally in full or partial. At the 8-10% reduction range, the department will no longer be about to pick up student fees and tuition as fluidly as is in the past. To cover current shortfalls, the department has sufficient carry-over and cash to adjust.

The current faculty members in the department are:

- Professor and Chair, **Thomas K. Mitchell** • Fungal Biology, Molecular Genetics
- Distinguished Professor of Plant Protection and Associate Chair, **Laurence V. Madden** • Epidemiology, Statistics, Biomathematics
- Assistant Professor, **M. Soledad Benitez Ponce** • Phytobacteriology, Phytobiomes
- Professor, **Pierluigi (Enrico) Bonello** • Tree Pathology, Molecular and Chemical Ecology
- Associate Professor, **Francesca Hand** • Ornamental Pathology
- Assistant Professor, **Melanie L. Lewis Ivey** • Fruit Pathology, Fresh Produce Safety
- Assistant Professor of Emerging Infectious Disease Ecology (OSU Discovery Theme), **Jonathan M. Jacobs** • Bacteriology, Plant-Microbe Interactions, Intl. Agriculture
- Assistant Professor Clinical Professional Practice, **Monica M. Lewandowski** • Teaching, Outreach
- CFAES Distinguished Professor, **Sally A. Miller** • Vegetable Pathology, Diagnostics, Intl. Development
- Professor, **Pierce A. Paul** • Cereal Pathology, Epidemiology
- Professor, **Feng Qu** • Molecular Plant Virology, Plant Resistance
- Associate Professor, **Jason C. Slot** • Fungal Evolutionary Genomics
- Associate Professor, **Christopher G. Taylor** • Molecular Genetics, Nematology
- Professor, **Guo-Liang Wang** • Molecular Genetics, Host Resistance
- Assistant Professor, **Ye (Summer) Xia** • Biochemistry of Plant Pathogenesis and Immunity

A comprehensive list of faculty and senior staff is provided in **Appendix 1**.

There are two current vacancies in the department due to the movement of Thomas Mitchell to the Chair position and Anne Dorrance to the administrative position of Associate Dean and Director for the Wooster Campus and Associate Director for the Ohio Agricultural Experiment Station. We have administrative approval to replace the Soybean Pathology Position at the Assistant OR Associate level to be located in Columbus or Wooster pending negotiations (see Future Hires section). Proposed (draft) position description for the Mycologist position and advertised position for the Soybean Pathologist position are provided in **Appendix 2** and **Appendix 3**.

Benchmarking — Departmental Status and Reputation

There is no single, simple, or unambiguous method to determine the status and reputation of an academic department. Typical quantitative metrics for comparisons ignore quality and impact of work, and can be overly focused on quantitative research output, undervaluing excellence in teaching (classroom and extension), international research and development, and leadership in service. As with individual faculty members, each department is unique, with potential excellence in one or more of the major areas of scholarship, education, and service. Some departments strive to cover the full range of plant pathology and plant-microbe-interaction subdisciplines, whereas other units specialize in only some areas.

There has been no formal agreed-upon rating of plant pathology departments and the U.S. The American Phytopathological Society (APS) has always resisted efforts to become involved in rating departments or programs, knowing that such efforts will be counterproductive. This is different from many disciplines where there are formal rating systems, sometimes related to certification. The problem of benchmarking is compounded by the fact that there have been many mergers of departments involving plant pathology and other (closely or more distantly) related disciplines. There are 27 units (department, sections, or schools) in the U.S. that are either stand-alone plant pathology departments or have “plant pathology” in their name (e.g., Dept. of Entomology and Plant Pathology). Only about a dozen departments are strictly stand-alone plant pathology units. Academic Analytics (see below) identifies 31 higher-education institutions with plant pathology faculty. Some of the departments in these institutions are quite diverse, with multiple disciplines being represented, making it especially difficult to assess the relative performance of the plant-pathology component of these academic units.

The Department of Plant Pathology at Ohio State is one of the very few ‘stand-alone’ units in the country and is the only academic unit in the state that focuses on plant pathogens, plant diseases, plant-microbe interactions, and plant health management. The department covers a very wide range of subdisciplines, from genomics to quantitative epidemiology to food safety for a wide diversity of pathogen groups. In addition to making contributions in basic research, and in teaching of the basic sciences, we are especially proud of the way we integrate research, classroom teaching, and extension in advancing the field of plant health management, and in solving real-word problems. Furthermore, we have one of the few undergraduate majors in plant pathology and plant health management in the country, and we have a new (and growing) professional master’s program in plant health management. We also have a large graduate program relative to the size of our faculty cohort.

With all of the difficulties and challenges mentioned above about benchmarking, we can point out several measures of our status and reputation. Although dated now, the NRC Study of Graduate Programs in 2011 identified 116 ‘plant science’ programs in the U.S., including 23 with substantial (or exclusive) plant pathology emphasis. Our department was ranked in the top 3-5 doctoral programs in this group of 23 using their metrics. Most recently, the online platform Universities.com, which is geared towards helping students select universities for undergraduate or graduate degrees, released a list of the top plant pathology programs in the country. It is not clear how this company determines their final rankings, but their website indicates that they use government data, in-depth surveys, college-graduate interviews, and reviews of social media and news coverage. Despite the questions about the data, we are pleased that in March 2020 Ohio State Plant Pathology was **ranked number 2** (www.universities.com/programs/plant-pathology-phytopathology-degrees).

Ohio State and many other institutions are now using the Academic Analytics (AA) platform (www.academicanalytics.com) to obtain and compare certain performance metrics for departments. This platform collects, aggregates, curates, and analyzes data on publications (refereed articles, books,

conference proceedings), citations, faculty awards, and, in principle, federal grants for its clients. The online tool allows subscribers to see and compare results for all units and institutions in the database for almost any academic discipline. We used it as a resource to obtain comparative data for this review, with the full understanding that this information is only a piece of a much larger puzzle.

AA identifies 31 institutions with plant pathology faculty in the U.S.; 32 departments (with a total of 709 faculty) are identified because it has kept Cornell's original Department of Plant Pathology and Plant-Microbe Biology separate from the newly formed Section in their School of Integrative Plant Science (this will likely be fixed in the future). For unknown reasons, North Carolina State University (NCSU) is not included in this "full" database (this omission has been reported by us to AA). All faculty members in the identified departments are included in the statistics in the full database, even though several individuals in many of these departments are not plant pathologists (e.g. plant scientists in a Botany and Plant Pathology units). We utilized this database to determine our relative performance in publications per faculty member, citations per faculty member, and for a weighted index that includes these two metrics plus faculty awards (incomplete) and books. However, for a more focused comparative assessment, we identified and worked with AA to perform a full comparative peer analysis with a subset 15 institutions with a major plant pathology (or combined) departments that we could use for benchmarking purposes. We consider these our peer institutions for plant pathology. For an even more focused assessment, we further restricted the included faculty members at these institutions to those we identified as being primarily plant pathologists or plant-microbe-interaction specialists. This included a total of 237 faculty members in 15 institutions in the benchmark database. This custom benchmarking database does include NCSU (lack of data) and also the "two" Cornell sites, giving a total of 16 departments. The reasons for exclusions were for reasons stated previously and not intended to enhance results.

As shown in Table 1, Ohio State Plant Pathology ranked 7th (out of 16) in terms of refereed articles per faculty member and 10th in terms of citations per faculty member. We were ranked 8th for the weighted index (which also includes books and faculty awards). For these quantitative metrics, we are thus very competitive with our peer institutions.

For the full database of institutions (which include some very diverse departments and several faculty members who are not plant pathologists), Ohio State Plant Pathology ranked 6th out of 32 departments and 13th in terms of citations per faculty member (Table 2). We were also ranked 6th out of 32 for the weighted index.

It should be pointed out that AA has *some* data on federal grants in its database, but this is very incomplete. Subcontracts (subawards) are not included, nor are many grants from USDA included. DARPA grants are also not included, which we have a major award. We found that many of the grants in our department were not included. Thus, we ignored this metric in the database, and did not use it in the weighted index.

There are many caveats to the use of the metrics in Tables 1 and 2, as suggested at the beginning of this section. Impacts of research are inadequately addressed; for instance, although citations per faculty does reflect some aspects of impact, this is heavily influenced by the size of the (sub-) discipline and the hotness of a field at particular time. These metrics also do not show anything about Extension, teaching, or international work (unless there are manuscripts). However, the results do show that for some measures of research, our department is highly competitive with our benchmarking peers.

Other measures of the reputation of the department include the heavy involvement by many faculty members (and students) in the American Phytopathological Society (APS). As shown in **Appendix 4**, there have been several APS Presidents from Ohio State, as well as many individuals with leadership

positions (e.g., Director of the APS Office of Education, Office of International Programs, Treasurer, etc.). Some of our faculty members are more involved in other professional societies, such as the American Society for Virology (ASV), the Mycological Society of America (MSA), or the Society of Nematologists (SON). Faculty members have won numerous awards and recognitions, within the college and university, within the US, and nationally and internationally. Our students are also heavily engaged in national activities, especially at APS and in other societies. For instance, several APS subject matter committees (in addition to the Graduate Student Committee) have previously been chaired by our graduate students (**Appendix 5**).

Table 1. Summary comparative statistics for Ohio State Plant Pathology and benchmark institutions – Plant Pathology Subset[a] - in the US. Results based on Academic Analytics database and software[a].

Unit[b]	Refereed articles per faculty	Citations per faculty	Weighted index score[c]
Cornell University (Dept.)[d]	36 (1)[e]	411 (8)[e]	0.8 (1)[e]
University of California, Davis	32.8 (2)	795.5 (1)	0.8 (1)
Cornell University (Section)[d]	27 (3)	540.4 (4)	0.5 (3)
Iowa State University	25.9 (4)	298.5 (12)	0.3 (4)
University of Florida	24.6 (5)	454 (6)	0.2 (5)
Michigan State University	23.2 (8)	413.8 (7)	0.1 (6)
North Carolina State University	20.3 (11)	389.8 (9)	0.1 (6)
Ohio State University, The	**23.7 (7)**	**362.2 (10)**	**0 (8)**
University of Minnesota	24.2 (6)	466.8 (5)	0 (8)
Kansas State University	19.4 (12)	736.5 (2)	-0.1 (10)
Purdue University	23.1 (9)	579.4 (3)	-0.1 (10)
University of Wisconsin - Madison	17.1 (13)	272.5 (13)	-0.2 (12)
Washington State University	22.3 (10)	258.7 (15)	-0.2 (12)
Pennsylvania State University, The	16.4 (15)	331.8 (11)	-0.3 (14)
University of Nebraska - Lincoln	16.5 (14)	260.8 (14)	-0.3 (14)
University of Georgia	16.4 (16)	147.4 (16)	-0.6 (16)

[a] Statistics for the years 2012-2018 for refereed journal articles and citations, 2007-2018 for books, and pre 2000-2018 for awards. Data from 2019 not available.

[b]Plant Pathology unit at listed university, sorted by weighted index score. Selection of 15 out of 31 institutions with plant pathology faculty in the Academic Analytics database. Since several departments are combined in the US, we selected only the 237 faculty members within departments in these 15 institutions who are in the fields of plant pathology or plant-microbe interactions. Statistics based just on this subset. We consider the units listed to be our main benchmark institutions (at least for this review).

[c]Based on a customized weighted average of: number of articles per faculty member (45%), faculty awards (10%), books (5%), and citations per faculty (40%). Mean is about 0. Because the grant information in database is very incomplete (and questionable), we give no weight to grants, and do not report the comparative statistics for grants. Values for awards and books are not individually listed in table.

[d]Academic Analytics keeps the original Department of Plant Pathology and Plant-Microbe Biology separate from the Section in the new consolidated School of Integrative Plant Science at Cornell University. Future databases should probably combine these two units (out of our control).

[e]Rank within a column. Because there are 16 units in 15 institutions (two from Cornell), ranks range from 1 to 16.

Table 2. Summary comparative statistics for Ohio State Plant Pathology and benchmark institutions – Plant Pathology or Combined Units[b] - in the US. Results based on Academic Analytics database and software[a].

Unit[b]	Refereed articles per faculty	Citations per faculty	Weighted index score[c]
Cornell University (Section)[d]	26.2 (2)[e]	508.4 (4)[e]	0.8 (1)[e]
Cornell University (Dept.)[d]	26.2 (2)	508.4 (4)	0.8 (1)
University of California, Davis	28.8 (1)	721.6 (1)	0.6 (3)
University of Florida	25.9 (4)	476.1 (6)	0.6 (3)
University of California, Riverside	20.8 (10)	675 (2)	0.5 (5)
Colorado State University	20.8 (10)	410.4 (9)	0.3 (6)
Ohio State University, The	**23.6 (6)**	**361.7 (13)**	**0.3 (6)**
University of Kentucky	19.5 (14)	371.2 (12)	0.3 (6)
Iowa State University	22.4 (7)	278.9 (19)	0.2 (9)
Auburn University	19.6 (13)	268.6 (21)	0.1 (10)
Kansas State University	17.4 (19)	582.5 (3)	0.1 (10)
Michigan State University	22.1 (8)	458.6 (7)	0.1 (10)
North Dakota State University	19.5 (14)	193.4 (27)	0.1 (10)
University of Arkansas	21.9 (9)	223.5 (24)	0.1 (10)
University of Idaho	20.3 (12)	249.6 (23)	0.1 (10)
University of Wisconsin - Madison	17.8 (18)	437.7 (8)	0.1 (10)
Washington State University	24.8 (5)	269.7 (20)	0.1 (10)
Oregon State University	15.5 (24)	350.5 (14)	0 (18)
Texas A&M University	16.2 (22)	298.3 (16)	0 (18)
University of Minnesota, Twin Cities	19.4 (16)	372.4 (11)	0 (18)
Purdue University	18.3 (17)	399.4 (10)	-0.1 (21)
Virginia Tech	16.7 (21)	263.8 (22)	-0.1 (21)
Pennsylvania State University, The	15.1 (27)	292.4 (17)	-0.2 (23)
Rutgers - New Brunswick	16.9 (20)	286.9 (18)	-0.2 (23)
University of Nebraska - Lincoln	13.2 (30)	204.5 (26)	-0.2 (23)
University of Tennessee, The	15.3 (25)	152.2 (28)	-0.3 (26)
Mississippi State University	15 (28)	210.5 (25)	-0.4 (27)
Montana State University	14 (29)	340.9 (15)	-0.4 (27)
University of Georgia	15.2 26)	130 (29)	-0.4 (27)
Oklahoma State University	15.5 (23)	116.3 (30)	-0.5 (30)
Louisiana State University	9.9 (32)	100.4 (31)	-0.7 (31)
New Mexico State University	10.3 (31)	62.2 (32)	-1 (32)

[a] Statistics for the years 2012-2018 for refereed journal articles and citations, 2007-2018 for books, and pre 2000-2018 for awards. Data from 2019 not available.

[b]Plant Pathology (or larger combined) academic unit at listed university, sorted by weighted index score. 31 institutions with plant pathology faculty in the Academic Analytics database, for a total of 709 faculty members.

Several of the individuals may not be involved in plant pathology or in plant-microbe interactions, since several academic units include multiple disciplines.

[c]Based on a customized weighted average of: number of articles per faculty member (45%), faculty awards (10%), books (5%), and citations per faculty (40%). Mean is about 0. Because the grant information in database is very incomplete (and questionable), we give no weight to grants, and do not report the comparative statistics for grants. Values for awards and books are not individually listed in table.

[d]Academic Analytics keeps the original Department of Plant Pathology and Plant-Microbe Biology separate from the Section in the new consolidated School of Integrative Plant Science at Cornell University. Future databases should probably combine these two units (out of our control).

[e]Rank within a column. Because there are 32 academic units in 15 institutions (two from Cornell), ranks range from 1 to 32.

Future Hires

The departmental faculty members are nationally and internationally recognized leaders in several fields, including plant disease epidemiology, plant disease resistance, plant pathogen genomics, molecular host-microbe interactions and disease diagnostics. They are also innovators in extension and outreach programs, including in international agriculture. The research, teaching and extension programs encompass expertise in both fundamental and applied aspects of the discipline of plant pathology and associated fields. Our work is diverse, interdisciplinary, and collaborative in nature.

Due to faculty member departures mentioned earlier, the anticipated impending retirements of senior faculty members in the next few years, as well as the increasing educational demands of our Professional Master program in Plant Health Management (MPHM, see Education section), we see a need to conduct several strategic hires to maintain critical strengths, reinforce connections among faculty through complementary expertise and global collaborations, explore new research frontiers, and support and expand our teaching program. The following areas have been identified, in which the first three are immediate and urgent:

1. **Molecular Mycology:** We have identified the need to replace the research and teaching roles of the current Chair with a new faculty hire, and have identified several areas where we can grow and fill voids in order to prepare our students with the knowledge and skills needed for the modern research and industry landscapes. These areas include the biology and diversity of fungus-like organisms, including oomycetes; emergence, epidemiology, genomics, and evolution of fungicide resistance; modern techniques for molecular genetics of plant-pathogenic/plant-associated fungi; and big data analysis (bioinformatics, database management, mycobiome/metagenome). This strategic hire will also support an interdisciplinary mycology initiative led by the Department, which aims to further establish the role of Plant Pathology as the center of mycological studies at Ohio State (see **Appendix 2** for position description). This initiative includes the development of a new undergraduate minor in Mycology.
2. **Soybean Pathology:** Due to the departure of our soybean pathologist for an administrative position in the college, and the enormous importance of the crop in the state and nation, we urgently need to refill this position. The appointment includes research, extension and teaching responsibilities. The new faculty member will be expected to participate in interdisciplinary research efforts involving disease epidemiology, pathogen ecology, host plant resistance, identification and evaluation of disease-resistant soybean lines, and development of integrated health management programs for

soybean. The new hire would work closely with the soybean breeder faculty member in the Department of Horticulture and Crop Sciences. Extension programming will emphasize integrated health management for all agronomic crops, in cooperation with other department faculty and the multidisciplinary OSU Extension Agronomy Team. Expertise in next-generation technologies and techniques will be desirable traits for this new hire (see **Appendix 3** for position description). This position is currently advertised and being reviewed.

3. **MPHM Program Director:** To ensure the continued success of this professional master's degree program, we have identified the need for a full-time director holding a Faculty of Professional Practice (Clinical) position. In addition to overseeing the strategic planning of the program and coordinating financial and academic activities with university administration and other members of the program, the director will have the opportunity to strengthen ties with private partners and seek extramural funding for the program. The director will be expected to contribute to the teaching program and to develop new curricula to ensure the program meets stakeholder needs (see Education section for more details).
4. **Quantitative Epidemiology**: In view of the anticipated retirement of Larry Madden in the next couple of years, and the Department's long-standing reputation in the field of quantitative epidemiology, we see a major need to maintain expertise in this area. The new faculty member would be expected to develop mathematical and statistical models to describe and understand plant disease epidemics and also develop epidemiological methods for disease forecasting, risk prediction, and crop loss assessment. The individual will have a strong background in statistics and computational biology methods and be expected to develop curricula to help graduate students and faculty with experimental design and data analysis in agricultural research.
5. **Vegetable Pathology**: In view of the anticipated retirement of Sally Miller in the next several years, who is a globally recognized vegetable pathologist, we see the need to replace her position to maintain a strong teaching, research and Extension program in diseases of vegetable crops. The new faculty member will conduct innovative research emphasizing the ecology, epidemiology and management of pathogens affecting Ohio's vegetable crops, and design and implement appropriate teaching and extension programming in vegetable pathology.

Through this self-study and review, we have concluded that the department is fulfilling its mission in research, teaching and Extension. Despite our successes, we recognize the need to continue strengthening and broadening the portfolios in each mission area to maintain long-standing expertise in several aspect of the discipline, to support strategic initiatives at both the department and university levels, and to follow emerging trends in plant pathology and associate fields.

Department Leadership

The Chair is the administrative leader of the department and reports to the Vice President and Dean of the College of Food, Agricultural, and Environmental Sciences (CFAES).

Selection of the Chair is done by the Dean, based on recommendations from the departmental faculty and the members of the administrative cabinet of CFAES.

The Chair has general administrative responsibility for all aspects of departmental programs, and for representing the department to the administration of the college and university. The Chair is appointed for a term of 4 years and is eligible for reappointment after faculty evaluation and vote, and approval by the CFAES Vice President and Dean. The primary duties of the Chair are: 1) to develop and prepare, in consultation with the faculty and according to university policies, a departmental Pattern of

Administration (POA, online), and an Appointments, Promotion and Tenure (APT, online) document.; 2) to consult with the faculty on major policy matters; 3) to plan with the faculty members to stimulate a progressive and high quality program of research, teaching and Extension; 4) to provide appropriate supervision to faculty and staff and to evaluate faculty members and staff periodically for annual performance and to evaluate faculty members for promotion and/or tenure consideration in accordance with procedures specified in the departmental (as well as college and university) APT document(s); 5) to recommend to the CFAES Vice President and Dean, after consultation with department faculty, appointments, promotions, dismissals and matters affecting the tenure of the members of the department in accordance with procedures specified in the departmental APT document; 6) to promote continuous improvement of instruction within the department; 7) to prepare, in consultation with the faculty, annual and special budget recommendations and performance reports of departmental activities for consideration by the CFAES Vice President and Dean and the CFAES Administrative Cabinet; 8) to oversee the business and HR functions of the department; and 9) to appoint, with appropriate input from the faculty, members of committees and designate chairs of standing and ad hoc committees.

The Associate Chair is located on the campus where the Chair is not located (presently the Chair is located on the Columbus campus and the Associate Chair is located on the Wooster campus). This position is not a full-time administrative position, but rather an administrative appointment to a member of the faculty who has other research, teaching, and/or Extension responsibilities, as defined in consultation with the Chair. The Associate Chair is appointed by the Chair after consultation with the faculty and approval by the CFAES Vice President and Dean, and receives an administrative salary increase for their term. The term of office is 4 years, concurrent with the Chair, with option for renewal on satisfactory evaluation. The primary duties of the Associate Chair are to handle local operations on the campus on which he/she is located. Specific duties include: 1) to act as oversight administrator and facilitator for faculty, staff and students located on that campus, with regard to research, teaching and Extension functions; 2) to oversee management of departmental business and HR operations, including the operational budget for that campus, personnel issues, and facilities management on that campus; 3) when located on the Columbus campus, to oversee the academic programs of the department including classroom and curricular logistics, teaching equipment and budgets, student issues, and other activities as appropriate; and 4) to represent the Chair at events when the Chair is not available. The Associate Chair and Chair work as a team to facilitate efficient administration of the department at both the Wooster and Columbus locations.

General Operating Procedures and Committees

Usually, the Department operates on the faculty-governance or consensus principle, although certain issues related to HR and personnel may require more confidential decision making involving a small number of individuals. Department governance proceeds on the rule-of-thumb that the more important the matter to be decided, the more widespread the agreement on a decision needs to be.

Matters of general importance are usually dealt with first through one of the standing or ad hoc committees and then discussed in a full departmental meeting and eventually resolved by faculty consensus or vote. Matters of lesser importance or of a more specific or more immediate nature may be decided by appropriate departmental committees themselves or by the Chair and/or Associate Chair. Any item or matter of concern can be placed on the agenda of a faculty meeting. Voting may take place through online tools when immediate decisions are needed.

Traditionally, the department holds a full faculty (and senior staff) meeting every 3-4 months during the academic year, and at other times when necessary. The regular faculty meeting locations alternate between the Columbus and Wooster campuses, or may occur at an intermediate location (e.g., Mt. Vernon). Retreats and specialized meetings are also held to address specific needs (such as planning this review). Matters brought to the faculty for a vote will be decided by a majority vote of the voting faculty present, provided a quorum is in attendance (but note that promotion and tenure votes and selection of new faculty require a super-majority (2/3) for a positive recommendation). Senior staff members with leadership roles in the department (such as program specialists in Extension and the Academic Coordinator) are expected to participate in these departmental meetings. Additional representatives of the staff and graduate students are selected by each of these groups and invited to participate in the faculty meetings. Staff and student representatives can submit agenda items, fully participate in the meeting, and present staff and student issues for faculty consideration, but do not have voting privileges. Minutes of faculty meetings are taken, prepared and distributed to all members of the faculty following the meeting.

The department has a longstanding tradition of conducting two types of annual peer reviews of faculty performance, each with a unique and specific purpose. The Annual Promotion and Tenure Review is held each June by the Departmental Promotion and Tenure (DPT) Committee, which consists of three tenured full professors elected by the faculty and the Chair (ex officio, nonvoting). Traditionally, there were four full professors on the committee, but because of past downsizing and limitations to the number of full professors, we are currently working with three.

In June, the DPT committee meets individually with each member of the department faculty to obtain his/her views on the progress towards promotion and tenure of each promotion-and-tenure-eligible member of the department faculty. A draft dossier prepared by each assistant and associate professor, prepared through *Vita* (online database operated by OSU) provides relevant data during these meetings. Following the meetings that take place over 2 days, the DPT committee makes recommendations to the Chair on faculty progress towards promotion and tenure. The APT document describes the many additional steps in the promotion and tenure process within the department; more information is given in the Mentoring sub-section of the FACULTY section of that document. The entire process is heavily faculty driven.

The Annual Faculty Program Review (AFPR) is conducted in late winter/early spring by the AFPR Committee (see the POA at plantpath.osu.edu/reviews for details). The AFPR committee consists of five persons: the Chair and Associate Chair, and other faculty members elected by the entire faculty. The exact membership structure for the AFPR committee is somewhat complicated because it involves, by definition, some members of the DPT committee. However, other members are usually Assistant or Associate Professors; in fact, it is common for the newest member of the faculty to be elected to serve on the FPR committee. New faculty members bring valuable insight to the review process, and the work on this committee quickly educates a new faculty member on the many activities in the department and expectations.

The purpose of the Annual Faculty Program Review is for the committee: 1) to evaluate the extent and quality of the teaching, Extension, student advising, research, and service activities of each member of the department faculty during the previous calendar year, 2) to engage each faculty member in a constructive, evaluative discussion of his/her performance, and 3) to make recommendations to the Chair regarding the content of the Chair's annual performance report on each faculty member. The AFPR is a cornerstone for the department because it reflects the full participation of the faculty (including new hires) in the evaluation of all programs in the department. It is our understanding that we are the only department in the college that uses this AFPR protocol, a tradition in the department that goes back more than 40 years.

Many other committees are of utmost importance in the workings of the department. The Graduate Studies Committee (GSC) has oversight of all matters dealing with the graduate program, including admissions, setting of academic standards and requirements, and assessment of student performance. The Academic Affairs Committee has oversight of curriculum development and the assessment of learning outcomes for courses and the entire curriculum. Membership on these committees is by election; graduate students are also elected to serve on these committees.

The consensus of the department is that the committees work well, and that we have an effective governance structure. There is strong participation by faculty and, as appropriate, students and staff. New faculty members are especially encouraged to participate in the full workings of the department. The recent retreat confirmed that operating procedures are generally appropriate for the functioning of our department.

Diversity

Faculty and Staff

Improving diversity is a high priority in the university and college, and the Department of Plant Pathology strongly supports this priority. As with most academic departments in the sciences, our faculty members come from diverse backgrounds and countries. Seven (47%) of our current regular faculty members are women; seven (47%) are naturalized citizens or have permanent residence in the U.S., including one first generation Guyanese-American, three are Chinese (two of them first generation Chinese-American), one is African American, and two are first generation Italian-Americans. Our clinical faculty member is an Asian-American woman, and four (80%) of our adjunct faculty members are women (one of them is a U.S. Asian/white). Three (60%) of our senior staff are women, and one is first generation Ugandan-American. Similar to other agricultural science departments, we are underrepresented in traditional minorities (U.S. citizens who are Black, Hispanic, or Native American).

When it comes to faculty searches and recruitment, however, we do give priority to advertise in a way that makes it clear that positions are open to everyone on a non-discriminatory basis. Each search committee includes a diversity officer who helps ensure that diversity is considered during the evaluation of possible candidates; we work hard to avoid implicit biases in evaluating applications and in interviews. We also utilize personal connections with colleagues across multiple disciplines to help recruit a diverse pool of candidates by contacting potential candidates and/or their advisors directly.

We have good involvement in the APS Committee for Diversity and Inclusion, which is a useful way to network with those who are dedicated to enhancing diversity. Current members of that committee from our department include vice chair Krystel Navarro (she was elected while as a student!), Marlia Bosques (graduate student, recently graduated), Monica Lewandowski (Assistant Professor Clinical), and Jonathan Jacobs (Assistant Professor).

We historically have not done directed searches with, for example, HBCUs and tribal colleges, but we also understand that many universities are working with institutions that have primarily minority populations and we run the risk of coming off as predatory for their best and brightest. This is a growth point that we recognize.

Students

Table 3. Distribution of our students by gender, race and ethnicity (Autumn 2019 enrollment).

Demographic data* of our academic programs				
	B.S. PHM[1] and PP[2] (n = 16)	**M.S. (n = 9)**	**Ph.D. (n = 29)**	**MPHM (n = 20)**
Female	4 (25%)	5 (56%)	13 (45%)	12 (60%)
Male	12 (75%)	4 (44%)	16 (55%)	8 (40%)
International	1 (6%)	3 (33%)	19 (66%)	0
Native American	0	0	0	0
U.S. Asian	0	0	1 (3%)	0
U.S. Black	1 (6%)	0	0	1 (5%)
U.S. Hispanic	1 (6%)	3 (33%)	3 (10%)	1 (5%)
U.S. Caucasian	13 (81%)	3 (33%)	6 (20%)	18 (90%)
Veteran	0	0	0	1 (5%)

* Data on sexual orientation not available

[1] Plant Health Management; [2] Plant Pathology

A large proportion of the students in our undergraduate and MPHM programs are Caucasian and come from rural backgrounds, which reflects the national pattern of students studying agricultural topics. However, in other ways we do observe an increasingly more diverse population, broadly defined. For example, the MPHM program includes many/mostly non-traditional students – working, career change, family-balancing, or returning-to-school.

College-level efforts are underway to increase diversity overall, not just ethnic. The college's student population is becoming more diverse in terms of percentages of working students, veterans, students experiencing a campus change or transfer students, students with disabilities, etc. The college is also trying to increase enrollment of urban/suburban students, which should comprise a more diverse population, by way of development of new college majors such as Sustainable Agriculture. This is a joint effort with Central State University in Wilberforce, OH (an HBCU), the Agricultural Technical Institute (ATI) in Wooster, and community colleges in an attempt to improve access to education with a curriculum for those interested in urban agriculture, sustainable farming, local farms, and farm-to-table movements. All these efforts should increase diversity in our plant pathology programs in the future, but it is clear we face the same significant challenges experienced by many of our peer departments. Some obstacles to increasing ethnic diversity in agricultural fields are certainly cultural and historical, making it difficult to reach certain demographics. Even so, some instruments have helped in recruiting underrepresented minorities to our graduate program. For example, through the Summer Research Opportunity Program (SROP), and the consortium of Big 10 Academic Alliance Universities, we have recruited four minority students since 2011, and two more have been admitted in 2020 (acceptance

pending and expected). One other minority student was recruited as a McNair Scholar, which is a federal diversity program.

When it comes to teaching, for example in Extension education, we consider the diversity of educational backgrounds of our clientele and adjust information delivery to accommodate those differences. A number of faculty members work with members of the Plain Community who have limited formal education and English is their second language. Some Plain sects, like the Amish, have restrictions on technology (e.g., won't watch PowerPoint presentations) as well. We are also conscious of cultural differences and try to adjust our educational efforts accordingly.

Faculty Engagement and Support

It is in our best interest to maximize the chances that the faculty members we hire will be productive and will have high-impact and long careers at OSU. The department strongly believes that the best way to retain faculty is by giving them a sense of community and opportunities for professional exploration and advancement.

One way to provide a sense of community is by encouraging all faculty members to play important roles in the life and local governance of the department, such as through participation in committees, which should contribute to a sense of value. For example, new faculty members are invited to be part of the Annual Review Program Committee (see Departmental Leadership section) during their first or second year in the department. By inviting them to serve on this committee, we reinforce our commitment to inclusiveness and give new faculty a voice in the system. At the same time, new faculty members are given the opportunity to interact with graduate students and contribute to the direction of new knowledge acquisition and dissemination in the department by serving as the instructor-of-record for the departmental seminar series. However, we also try not to overburden new faculty members with service activity as they work to develop a new research, teaching, and/or Extension program. They are encouraged to be involved in early career and leadership service opportunities, depending on their predispositions and preferences. For example, the current chair of the Academic Affairs Committee is an assistant professor (Soledad Benitez), and Jonathan Jacobs, our newest faculty member, is the current chair of our Vision Committee. It should be noted that we feel strongly that the Vision Committee, which discusses the strategic planning of the department and new faculty positions, is composed only of junior faculty members (non-Full Professors).

We provide many leadership development opportunities. To name just a few, our clinical faculty member, Monica Lewandowski, participated in the "Fast Track Leadership Intensive" in March 2020, at the invitation of the Chair, as did Francesca Hand and Tom Mitchell in 2019; Francesca Hand is currently participating in the OSU President and Provost Leadership Institute; a number of more senior faculty members have participated in Lead 21; and all faculty members are strongly encouraged to take leadership positions in APS, other professional societies (based on their interests and disciplines), or local and international groups. Further, OSU offers a series of workshops for new Assistant Professors that are taken advantage of by most of our new faculty members.

Faculty Mentoring

Being a faculty member is a difficult and challenging job. The department realizes that effective mentoring of newer faculty members is critically important.

Mentoring in the department occurs on multiple formal and informal levels. The goal of mentoring is to maximize the chances that junior faculty will be successful in their mission and will be promoted at Ohio

State. Soon after joining the department, assistant professors identify, with advice from unit leaders and others, faculty members that they think will work well with them and give them good advice on establishing a program and being successful as a faculty member. Three faculty members that are senior to the mentee (i.e., associate and/or full professors) are then appointed by the for their Mentoring Committee (MC). Details on the process for appointing the committee are the APT document (plantpath.osu.edu/review).

Following promotion to tenured associate professor, a Teaching Evaluation Committee (TEC) is formed, consisting of two full professors. The MC also serves the function of the TEC for assistant professors, but the MC has a broader charge. At a minimum, MCs and TECs formally meet at least once a year to: (1) evaluate the mentee's performance in classroom teaching and/or Extension education (as relevant); (2) develop goals and strategies for subsequent years to maximize effectiveness and impact in teaching (broadly defined); and (3) provide advice on the departmental expectations of faculty members with appointments in classroom teaching and/or Extension. Each MC and TEC writes an annual summary letter to the Chair of the Departmental Promotion and Tenure Committee (PTC), and this letter becomes part of the Promotion and Tenure (P&T) dossier.

The PTC meets with each junior (Assistant and Associate Professor) faculty member in formal proceedings each year in late Spring to review their performance in all aspects of their program, and to assess their progress towards promotion. This committee solicits input from all faculty members and gives verbal advice to the candidate. A summary letter is written to the Chair by the PTC committee based on the comments given during the deliberations of the PTC. This is copied to the candidate.

Each junior (and senior) faculty member also meets yearly with the Annual Program Review Committee (APRC), as described previously. Feedback on performance is provided through a letter from the Chair that reflects the discussion between the faculty and APRC, and the APRC's deliberations.

Through the years, the department has made significant strides in the important areas of diversity, recruitment, and retention, but we can always improve. We believe, however, that we have laid strong foundations for improvement and we are committed to consider diversity, recruitment, mentoring, and retention as key components of a successful Department of Plant Pathology.

Research

Research in the Department of Plant Pathology is productive and impactful, with several high-profile characteristic described below.

1. A comprehensive research portfolio. Faculty members in our department are engaged in an exceptionally broad spectrum of research activities, covering the major pathogen types (fungi, oomycetes, bacteria, viruses, and nematodes), with work on both basic and applied aspects of these pathogens and their interactions with their plant hosts. Research ranges from genomics and molecular plant-microbe interactions to epidemiology and ecology, from applied to basic. Faculty biographies and research foci can be found in **Appendix 1** and on our website: plantpath.osu.edu/review. Most of our faculty members consciously integrate both basic and applied activities in their programs. For example, while Jason Slot primarily focuses on understanding the evolutionary trajectories of metabolic gene clusters in fungal communities, he also collaborates with Jonathan Jacobs in trying to understand why closely related plant pathogenic bacteria evolved different lifestyles, with some of them infecting plant vasculatures exclusively. Similarly, while Anne Dorrance's research focuses heavily on the discovery of soybean genetic resources conferring resistance to oomycete pathogens, she is engaged in multi-PI teams aimed at understanding the mechanisms of such resistance responses and also works closely with the soybean breeder in developing new genotypes.

2. Emphasis on research-education integration. We are particularly proud of the department's efforts at recruiting and training diverse and socially responsible students through research-oriented advising. Being a relatively small department with 15 faculty members, we nevertheless have maintained an annual M.S./Ph.D. graduate student body exceeding 35. The Graduate Studies Committee members, in unison with Monica Lewandowski (clinical faculty member), work continually to identify outstanding students and to find ways to fund them. Dr. Lewandowski especially excels at preparing nominations for competitive university graduate fellowships and college associateships and works to accommodate the needs of each student. Major effort is made at identifying promising candidates with disadvantaged or underrepresented backgrounds (see Diversity section). The department recruits international students, especially those from developing countries, including Tanzania, Cameroon, Nepal, Bangladesh, and Ecuador, among others. Our faculty are committed to individual advising and mentoring of each graduate student to ensure successful research projects and development of well-rounded professionals. The consistent emphasis on rigorous training has resulted in many students who have gone on to become faculty members and industry leaders worldwide. Recent examples include Dan Anco, faculty member at Clemson University, Alissa Kriss, biological data analytics at Syngenta, and Nathan Kleczewski, University of Illinois, to name just a few. See the **Appendix 6** for placement tables of recent graduates.

3. Embrace the cutting edge. Researchers in the department always strive for the cutting edge of their fields. Examples include Guo-Liang Wang, Larry Madden, Pierce Paul, and Tom Mitchell, who actively participated in research projects that assessed the potential risk of wheat blast spreading to U.S. wheat fields. More recently, with the recognition of the phytobiome as a potentially crucial player in managing plant pathogens and maintaining crop health, Sally Miller, Chris Taylor, Soledad Benitez Ponce, Ye Xia, and Jonathan Jacobs have all been actively engaged in understanding microbial communities associated with various crops and cultivation systems. Finally, understanding the impact of global climate change on the health of forests worldwide has been a lifelong passion of Enrico Bonello, and he is currently using satellite, drone, and artificial intelligence technologies to detect forest disease spread before symptoms and tree decline are visible.

4. Research with relevance and impact. Scientists in the department pride themselves on doing research that is relevant and with measurable impacts (see Sample Impact Statements section). For example, Francesca Hand's research directly responds to the needs of nursery and ornamental greenhouse growers. She is now leading our most recent efforts in the investigation of hemp. Similarly, Pierce Paul and Larry Madden's long-term focus on Fusarium head blight of wheat ties closely to the agricultural and human health implications of this disease. Likewise, Melanie Ivey's research into smart spraying technology is expected to result in huge costs savings for fruit-crop farmers. The impact of our research in the department is not limited to direct influence on growers. Fundamental research is having paradigm-shifting effects on our field. Guo-Liang Wang's ground-breaking research on resistance to rice blast has led to publications in highly prestigious journals, including *Science* and *PNAS*. This genomic work is affecting management tactics for blast around the world. Similarly, Jason Slot's work on the evolution of clustered genes in fungi is being highlighted heavily in the popular press, with major articles in *The Atlantic* and elsewhere. Tables 1 and 2 show the publication output for the department, in comparison to benchmark departments in the country. The department had over $21 million in spending from external sources in the past 5 years. Total annual publications have exceeded 60 for the department in recent years. Funding levels reflect the successful research being conducted in the unit (see Funding below in Table 4).

5. Collaborations. Faculty members in the department are prolific collaborators. All faculty members collaborate with someone else in the department, and most collaborate with others in the university, or with colleagues in the US or around the globe (see International Activities section). Many faculty members are members of different interdisciplinary teams, with two groups recently being awarded the OARDC Team Awards (**Appendix 4**). It is impractical to list all the meaningful examples of the team efforts; however, we note that over the last 5 years, publications from our department have averaged nine co-authors, with some papers having as many as 35, clearly demonstrating the degree of collaborative work. Many of the grants are specifically for teams from several departments and universities.

6. A tradition of excellence. The excellence of research in the department is a long running tradition; this is evidenced by the number of awards received by the faculty and their students (see Graduate Education section, and **Appendix 4 and 5**). Just a few very recent examples are given here. In 2019, Larry Madden received the Award of Distinction from the American Phytopathological Society (APS) for his 40 years of seminal contributions in plant disease epidemiology. This honor has only been awarded 15 times in the history of the society. Guo-Liang Wang's high-impact research on rice resistance has recently culminated in him receiving the Distinguished Scholar Award from OSU, which is the highest research award given by Ohio State. Sally Miller was recently awarded the honorific title of Distinguished Professor of Food, Agricultural, and Environmental Sciences by our college at OSU. This is the highest title in the college, and she is in the inaugural class.

Funding for Research

Faculty members support their research programs with funds from competitive grants, gifts, and contracts. All faculty members receive soft-money support; however, the sources of funding vary greatly, based on the nature of their research and appointment. Detailed records are available on total direct and F&A (Facilities & Administration; indirect; overhead) *expenditures* from grants and contracts (administered by OSU Office of Sponsored Programs; OSP), and from gifts (which are administered in OSU Development Funds). The numbers shown in Table 4 *do not indicate the total monies awarded* in a given year for funded proposals; rather, they indicate the *monies spent* from external sources exclusively by members of the department.

Table 4. Expenditures ($) from grants and contracts (processed through the OSU Office of Sponsored Programs) and from Development Fund gifts by faculty within Plant Pathology.

	Office of Sponsored Programs (OSP) Grants and Contracts					
Fiscal Year (FY)	Direct	F&A (Indirect)	Total	Devel. Fund Gifts	Grand Total	Per Capital Total[a]
15	2,098,705	282,860	2,386,565	774,116	3,160,681	263,390
16	1,726,694	219,868	1,946,562	853,475	2,800,037	215,387
17	2,128,218	255,449	2,383,666	830,315	3,213,981	229,570
18	5,136,852	575,066	5,711,918	644,399	6,356,317	454,023
19	4,610,324	531,065	5,141,389	546,120	5,687,509	379,167

[a]Total expenditures per faculty member. Based on number of tenure-track faculty in department each year (clinical faculty not included)

As shown in Table 4, over $21M of external funds has been spent during the past five fiscal years by the department. There was a marked increase in funding starting in FY 2018, partly attributed to a large multi-institution grant from DARPA (G.L. Wang, project director) and some other larger grants. To put these numbers in perspective, the department receives "hard money" annual support (FY 2020 values) of $1,719,621 from OARDC; $496,689 from OSU Extension; and $1,020,753 from OSU General Funds. OARDC and OSU Extension funds are from state line items.

An additional source of support for the department comes from the Indirect (overhead) funding of projects. A small portion of the listed overhead in Table 4 is returned to the Department. This supports various activities in the department (as "cash") and has been essential for departmental operations. This "cash" is used for equipment repair and new major equipment purchases (usually as a cost-share with faculty members and the college administration, the latter through an annual equipment grant program). A major portion of the start-up packages for new faculty hires come from this source of income. For research programs on the Wooster campus, there is a simple formula for overhead return (25% of the total F&A), but for the Columbus campus, the formula is complex and may be higher or lower than for Wooster. For the past 5 years, income from overhead return to the department has totaled $713,512 across both campuses.

As with most departments in the agricultural sciences, our overhead return is usually considerably below the university rate (now 64.8%). This is because many USDA grants and commodity groups pay lower or no overhead, and many other sources of funding pay no or little overhead.

Challenges to our research efforts

There are several challenges to our efforts of maintaining high productivity and impact in research. As mentioned above, the increasing non-flexibility in overhead (F&A) rate imposed by OSP is a major concern. Although the department benefits from greater overhead return, it may be difficult or impossible

to obtain grants and contracts with a 64.8% F&A rate. One of our faculty members just lost a $150K contract because the sponsor would not pay this rate, and no exception was granted. Another faculty member was able to negotiate a 20% F&A rate from a chemical company for a large contract, possibly because the original negotiations occurred before the new more-rigid policy took effect. This, combined with the complexity of doing business with OSP, makes working with industry partners overly burdensome and off putting. We have heard this many times from potential industry partners. We feel that we have a non-sustainable funding problem with the imposition of this F&A rate.

Pre-award processing of grant proposals is very efficient in our college, thanks to an office dedicated to this in the CFAES (Graduate Development Support Unit). Post-award management of funded projects, which is handled mostly by OSP, is unsatisfactory, however. Financial records are often out of date, and reports to sponsors and payments to contractors are often very slow. Setting up projects for new grants takes an excessively long time, such that personnel cannot be hired in time to conduct required work. Delays are as long as 6 months, which is unacceptable. This is endangering future work and future funding. Our department commits office personnel to some aspects of post-award bookkeeping because of the unsatisfactory support from OSP. Yet, many things must be done by OSP. The college has tried to help, but this is problem with OSP is very serious.

Another major concern is the ongoing challenge of maintaining laboratory and field equipment. The cost of new equipment and service contracts continues to rise. The greenhouse facilities in Columbus and Wooster are in stable condition, for now, but are badly in need of modernization (see the Facilities section). The department does not have the resources for any substantial renovation work on the greenhouses. Ultimately, additional greenhouses are needed in Columbus to keep up with the rapidly expanding research programs, especially with an additional faculty hire. The department will be looking to the college for financial support on maintenance and upgrades to remain competitive.

New annual costs, to the tune of tens of thousands of dollars, have recently been imposed on all departments in CFAES to pay for a new IT centralized computer hardware and support system, as well as a communication (phone and videolink) system. This includes charges for Skype For Business for all faculty and staff, even for those who do not use the system. There are annual costs for each computer (computers are now effectively rented). It is not clear how this will be paid for by the department. Our newly developed departmental policy (written in response to the college IT transformation) in summary states that the department will pay the associated computing and communication costs for administrative/coordinating staff, one computer per faculty member, and machines dedicated to run common equipment. Each PI is responsible for all additional computing resources specific to their program, students, and staff. This will be a burden on all faculty memebrers.

Selected Impact Statements

For several years, departments in the college have prepared Impact Statements on an annual basis, reflecting major accomplishments in research and other areas. We show a small sample of recent ones. Links to additional statements can be found at plantpath.osu.edu/review.

Integrating Plant, Animal and Human Health: Fungal Toxins in Grains

Pierce Paul (Professor) and Larry Madden (Distinguished Professor of Plant Protection); Jorge David Salgado (Ph.D. graduate and former research associate)

Summary

Fusarium head blight is one of the most economically important diseases of wheat. The Fusarium fungus damages the plant and also produces toxins that are a food safety concern to humans and animals. We have developed disease management guidelines that integrate fungicide application programs and resistant cultivars to minimize yield loss, reduce toxin contamination, improve grain quality, and consequently, reduce price discounts.

Situation

The fungus *Fusarium graminearum* infects the wheat spike causing the disease Fusarium head blight (FHB), also known as head scab, and contaminating grain with mycotoxins, particularly vomitoxin, which is a major food safety concern for humans and animals. Under wet, humid conditions, FHB and vomitoxin may cause millions of dollars in losses to the wheat industry as a result of reduced yield, damaged grain, price discounts, and grain rejection. In addition, FHB reduces the milling and baking quality of flour, and the consumption of toxin-contaminated grain causes vomiting and feed refusal in livestock. A single, well-timed fungicide application and FHB-resistant cultivars are the two most widely used approaches for managing FHB and vomitoxin, but neither is 100% effective. Losses may still occur even when the most effective fungicides are applied and the most resistant cultivars are planted.

Response

Because *F. graminearum* infects the wheat spike primarily during the flowering growth stage and infections are favored by wet, humid conditions, fungicide applications for FHB management are usually recommended during flowering and are most warranted when it rains. However, under favorable conditions for FHB development and vomitoxin contaminations, a single application at flowering is not sufficient to reduce yield and quality losses and price discounts.

Field experiments were conducted to develop new fungicide application programs to provide producers with more options for minimizing losses caused by FHB and vomitoxin. In particular, two-treatment (flowering plus post-flowering) fungicide programs were evaluated in combination with resistant cultivars as options for improving overall control of FHB and vomitoxin.

Impact

Producers now have additional and more flexible options for applying fungicides to effectively manage FHB and vomitoxin and improve the quality of grain harvested from FHB -affected fields. Data were generated showing that under favorable conditions for FHB, two-treatment fungicide programs may be 15-30% more effective than single-treatment programs.

Compared to fungicide and use of disease-resistant cultivars that individually provide about 50% reduction in FHB and 40% reduction in vomitoxin, **combining two-treatment fungicide programs with resistance provides more than 70% reduction of both FHB and vomitoxin**. The integration of fungicide application and resistance is the most effective approach for managing FHB and vomitoxin as it minimizes yield loss, reduces vomitoxin contamination and disease-damaged grain, and consequently, reduces price discounts and rejections. Using this integrated approach will save the wheat industry millions of dollars in lost income and reduce the risk of vomitoxin entering the food chain.

A national advocacy effort to improve management of invasive forest pathogens and insect pests

Pierluigi (Enrico) Bonello (Professor), Anna Conrad (Postdoctoral scholar), and Coralie Farinas (Ph.D. candidate)

Summary

CFAES researchers have been instrumental in providing policy and management recommendations for invasive pests/diseases of trees. A newly formed **Tree Resistance Advocacy Group**, comprised of forest health experts, have formulated a management strategy based on the development and use of disease- and pest-resistant trees. Pierluigi Bonello et al. have taken an active role advocating for support in this area of science and natural resource management at a federal level.

Situation

Invasive, non-native, pathogens and insects challenge the economic and ecological security of our forests and ecosystems. Unfortunately, in most cases management efforts have failed spectacularly, leading to the devastating and widespread mortality of native tree species worldwide. In the U.S. alone, Appalachian forests lost once-dominant chestnut to chestnut blight, and are now losing hemlocks to the hemlock woolly adelgid. Cathedral-like canopies of elm over streets and boulevards across eastern North America were lost to Dutch elm disease and gave way to ash, which in turn are dying by the billions due to the emerald ash borer. The iconic and culturally significant koa and ʻōhiʻa trees in Hawaiian forests face two new devastating diseases, koa wilt and rapid ʻōhiʻa death. Conservative estimates of the *annual* costs of bark and wood boring insect invasions alone reach $1.7 billion in local government expenditures and $830 million in lost residential property value.

Response

We have proposed a response based on the use and development of trees that are genetically resistant to specific invasive pests and diseases. Historically, when an invasive pest is discovered, the traditional response follows four stages: (1) prevention of pest entry; (2) eradication of the pest; (3) containment and mitigation, then if the pest cannot be contained, (4) forest restoration is necessary. Unfortunately, in most cases, the situation is typically past the first three measures and we are left to evaluate how to restore the forest ecosystem. The response, then, should be to engage in efforts to develop and deploy genetically resistant trees as soon as the problem is defined, so they can be used in restoration. However, this is never done at a wide enough scale. In response, we have established an advocacy group called TRAG, for Tree Resistance Advocacy Group, composed of academics and NGOs, with the goal of raising awareness among stakeholders, regulators and lawmakers.

Impact

The Tree Resistance Advocacy Group is advocating a renewed emphasis on the development and deployment of tree genetic resistance in response to invasive species. The group produced a one-page document highlighting key recommendations for stakeholders, regulators and lawmakers. This effort has elicited the interest of major NGOs involved in invasive species advocacy, e.g. the Center for Invasive Species Prevention (CISP) and the Reduce Risk from Invasive Species Coalition (RRISC). The latter organizes an annual National Invasive Species Awareness Week for Congressional lawmakers and their staffers. As a result of his leadership of TRAG, Bonello was invited to give a seminar on the Hill in 2019 to illustrate the importance of tree genetic resistance in fighting invasive forest pests to federal lawmakers and to advocate for support of efforts in this area of science and natural resource management. One idea Bonello has proposed through the tree advocacy group is the establishment of Centers for Forest Pest Control and Prevention (CFPCP) within the U.S. Department of Agriculture, akin to the Centers for Disease Control and Prevention (CDC). Such Centers should emphasize host resistance development and tree improvement for ecosystem restoration, in addition to other existing, desirable interventions, and should be regional in scale and staffed by career forest pathologists, entomologist, geneticists, breeders, ecologists and economists.

Biological Control for Diseases of Vegetables Grown in Hydroponics Systems

Cecilia Chagas de Freitas (Ph.D. Presidential Fellow) and Christopher G. Taylor (Associate Professor)

Summary

CFAES researchers are developing biological control products for plant diseases in hydroponics systems, with a focus on crazy root disease, an economically important disease of greenhouse cucumbers and tomatoes. They have identified two strains of Pseudomonas bacteria that can reduce the incidence of crazy root disease by 80% on hydroponically grown tomatoes. Working with I-Corps@Ohio, the researchers have also documented strong commercialization potential for this and other biological control products for use in hydroponics systems.

Situation

The production of vegetables in hydroponics and greenhouse systems has increased to meet consumer desires for locally grown, fresh produce year-round. In the U.S., 60% of the tomatoes sold in retail stores are now produced via hydroponics, bringing a revenue of about $510 million yearly (IBISWorld US, 2018). However, diseases and insects can pose difficult challenges. Crazy Root is a common bacterial disease in hydroponic vegetables, affecting about approx. 60% of all tomato and cucumber-producing greenhouses in the U.S., Canada and Europe. The diseased plants overproduce roots, which reduce yield and also clog the hydroponics tubes. For plant bacterial diseases, there is generally no treatment or cure, and growers must remove and destroy infected plants at a significant economic loss. In hydroponic systems, the disease is particularly hard to control because the crazy root bacteria can circulate and spread in the system and there is no commercial tool that a grower can use to prevent or reduce its impact on their production system.

Response

Cecilia Chagas de Freitas and Christopher G. Taylor are investigating the use of biological control methods to suppress disease. Their work is focusing on selected strains of Pseudomonas bacteria for their ability to both help promote plant growth and produce antimicrobial compounds, which antagonize (suppress) a broad spectrum of plant pathogens.

Impact

The research team was also selected for I-Corps@Ohio, a state program that helps university researchers in Ohio validate the market potential of technologies towards product commercialization. Chagas de Freitas was a project team Entrepreneurial Lead to do market research on hydroponic grower needs. Through this work, which involved interviewing 101 hydroponics growers, industry representatives and regulatory professionals, they were able to determine strong need and commercialization potential for the product.

Over 50 strains of *Pseudomonas* isolated from soil, water and plant samples from the U.S. were tested for effectiveness against *Agrobacterium rhizogenes*, the bacterial pathogen that causes the crazy root disease. They have identified two strains that can reduce the incidence of disease by >80% on hydroponically grown tomatoes. This is the first reported evidence for Pseudomonas control of crazy-root disease. Chagas de Freitas is currently working to determine how the Pseudomonas should be best applied as well as determine its longevity in hydroponic systems and impact on yield. She is also working on formulation and application requirements that will be necessary for production development and commercialization.

The goal is to establish a platform to develop new plant-associated microbial bioproducts using Pseudomonas. This work is generating interest from multiple university programs and the private sector groups. Based on their market research, nearly 95% of growers and consumers surveyed favored the use of biocontrols for limiting plant diseases over the conventual use of chemical pesticides (if even available). Additionally, the I-Corps@Ohio market research documented “promising commercial potential” for the global hydroponics industry globally and expanding industry partnerships for disease management and improved crop production.

Viruses in Ohio Wheat

Brian Hodge (Ph.D. student) and Pierce A. Paul (Professor); Lucy Stewart (USDA ARS Research Molecular Biologist and Associate Adjunct Professor)

Summary

Plant pathology and USDA researchers conducted a multi-year, statewide survey of viruses in Ohio wheat. The research group identified two new viruses in their surveys. Significantly, the group also discovered that Brome mosaic virus, which was previously not considered a problem, can cause up to 60% yield loss, clearly making this a high priority for farmers and opening new research on disease management.

Situation

Ohio is the largest producer of soft red winter wheat in the U.S., with an estimated 500,000-700,000 acres planted per year, primarily used for specialty cookies, crackers and other baked goods. Although most of

the modern soft red winter wheat cultivars grown in Ohio have the potential to yield close to 100 bushels/acre, growing conditions, pests and diseases often prevent most cultivars from reaching their full yield potential. Viruses in wheat can cause significant reductions in grain quality and yield, and there is no treatment or cure. Often, viruses go undetected or the yield loss is attributed to other factors, such as nutritional deficiency or adverse weather conditions.

Response

Hodge and the CFAES-USDA research team conducted a multi-year survey of Ohio wheat fields. This was the first comprehensive virus survey of Ohio wheat fields in four decades. This involved sampling wheat fields throughout the state, using state-of-the molecular and conventional approaches to identify and characterize viruses, and employed contemporary statistical methods to quantified associations among virus presence, severity, and crop production practices

Impact

The multi-year statewide surveys yielded new and critical information for wheat management. Hodge and the team discovered two viruses never before reported in Ohio wheat - Cocksfoot mottle virus and Agropyron mosaic virus. Biological validation tests were completed and Hodge et al. published peer-reviewed first reports for each of these viruses.

In addition, a comprehensive catalog of fully sequenced viruses in Ohio wheat was published, including viruses detected within different counties over time, and statistical analyses of detection patterns within fields, which can provide insight into how the different viruses are spread.

A surprising finding is that Brome mosaic virus, or BMV, is a significant pathogen of Ohio wheat. BMV has not been previously considered to be of economic importance in wheat, and there is little known about disease management. Subsequent work in the greenhouse and field has demonstrated that BMV infection can cause up to 60% yield loss, clearly making this a high priority for farmers and opening new research on disease management. This work was published in the international journal, *Plant Disease*.

Brian's work has direct impact on agriculture and growers' ability to manage virus diseases in a global food staple crop. His work has led to grower recommendations on monitoring for specific viruses, formulating sanitation procedures, insect vector management guidelines to curb spread, and recommendations on disease-resistant wheat varieties.

Education

Plant pathology is a strong academic discipline at Ohio State. It is traditionally a graduate-level discipline, and graduate education is a critically important part of the mission of this department. Additionally, our undergraduate program is very important for the education of Plant Health Management (PHM) and Plant Pathology majors, Horticulture and Crop Science majors, as well as non-majors. It is one of the few dedicated undergraduate plant pathology programs in the country.

Because undergraduate General Education (GE) curriculum at Ohio State is currently undergoing restructuring, we are in the process of revising Plant Pathology GE course offerings to better fit with University-wide themes and learning outcomes.

The Department currently administers seven academic programs: the undergraduate majors of Plant Pathology and Plant Health Management (PHM); the undergraduate minor in Plant Pathology; two Master of Science Programs (M.S.; thesis and non-thesis); a professional Master in Plant Health

Management (joint with Entomology; MPHM); and the doctor of Philosophy (Ph.D.) program. In addition, the department is in the final stages of developing a proposal for a university-wide interdisciplinary minor in Mycology.

Undergraduate programs

The undergraduate program is administered by the department's Academic Affairs (AA) committee, which consists of faculty, academic staff, and a graduate student representative. Membership in the AA committee is described in the Pattern of Administration (see plantpath.osu.edu/review). The AA committee oversees and coordinates instructional programs and academic policies of the department, including academic advising, course offerings, and curricula.

The undergraduate major in Plant Protection was established in 1976 as part of an interdisciplinary major and evolved into the PHM major in 1994. In 2012, PHM became jointly administered with the Department of Entomology, and Plant Pathology was added as a new (separate) major. Undergraduate student enrollment within the majors and minor offered in the department is shown in Table 5. Since 2011, undergraduate enrollment has averaged 15 students (two majors combined), 50% greater than average enrollment prior to 2011. The small size of our undergraduate program enables us to provide one-on-one attention to students, and it is evident that students thrive because of this support. In the past 9 years, the department graduated 38 undergraduate students, with a population comprised of 37% male, 63% female, 8% U.S. minority, and 5% international students. Undergraduate enrollment peaked in 2016, and in 2019 it was greater than the previous two years. Since 2011, 71 students have completed the Plant Pathology minor.

Table 5. Undergraduate Enrollment (majors/minors), Department of Plant Pathology

	2011	2012	2013	2014	2015	2016	2017	2018	2019
Plant Health Management major	8	11	9	7	7	5	1	1	5
Plant Pathology major	*	2	13	12	15	20	10	10	11
Total undergraduate students	**8**	**13**	**22**	**19**	**23**	**25**	**11**	**11**	**15**
Plant Pathology Minors	19	14	13	12	14	10	7	4	7

*Plant Pathology major established in 2012.

Since 2011, 48% of the graduates entered graduate school in plant pathology and related fields. Other graduates work in the public and private sector as lab technicians, sales and technical representatives in industry, and in greenhouse or farm management. We have a near 100% placement record. **Appendix 7** presents a table of Plant Pathology and PHM graduates since 2011 and their current location and selected awards and other recognitions.

Plant Pathology and Plant Health Management Majors

The Department has traditionally observed two cohorts of students in our majors: those interested in working as plant health practitioners, and those interested in pursuing research and graduate study. As part of the university's conversion from a quarter to semester system in 2012, undergraduate curricula

were reviewed and updated. During this process, we established the Plant Pathology undergraduate major to meet the needs of students primarily interested in research and graduate study; this major provides a foundation in chemistry, genetics, microbiology and plant biology. The PHM major is designed for those primarily interested in working in the plant-health industries after graduation. The PHM major curriculum was updated to emphasize strong interdisciplinary training in plant health management. As one would expect, there is overlap in some of the requirements for the two majors.

Students majoring in Plant Pathology and PHM must complete the B.S. in Agriculture curriculum that includes General Education courses and required and elective courses specific to each major. Students must also complete an approved internship experience, usually between the junior and senior year, and a minor of the student's choice (the internship and minor requirements are specific to the B.S. Agriculture program). Students in the Honors program must also complete an Honors thesis, usually during their senior year. Requirements for the undergraduate degrees are provided in **Appendix 8** (Plant Pathology) and **Appendix 9** (PHM).

The Plant Pathology minor requires 13-15 credit hours (see **Appendix 10** for Plant Pathology minor requirements). Most students pursuing Plant Pathology minors are Sustainable Plant Systems majors (from the Department of Horticulture and Crop Science), with others from majors such as Agribusiness or Environmental Science. Minor enrollment has decreased in the past few years, mainly due to changes in the Sustainable Plant Systems curriculum that has added specified courses (in lieu of a minor requirement).

Undergraduate Credit Hours

Credit hours taught (at the undergraduate and graduate level) have a direct impact on our funding by the university RBB business model for General Funds (Academic Programs). The formula is complex but is weighted by the level of the course. Number of majors is not the issue for funding, but rather the number of credit hours taught. Within the period 2014-2019, undergraduate credit hours per year fluctuated between 794-1,025. There was a 14% increase in undergraduate credit hours from fiscal year (FY) 2018 to FY 2019 (Table 6).

COVID Impact – While the full numbers of undergraduate students who will be taking our classes on-line is still not known, we do know that three undergraduate/graduate courses will not fill and will have to be cancelled. However, our new course in Psychedelics is fully enrolled and we will plant on a second offering in the Spring Semester.

Table 6. Undergraduate and Graduate Credit Hours per year, Department of Plant Pathology

	2014	2015	2016	2017	2018	2019
Undergraduate	986	1,025	924	957	794	909
Graduate	951	1,045	1,205	1,070	949	923

Strategies for recruitment

Recruitment and enrollment are big challenges for the Department of Plant Pathology, and more generally for the undergraduate major courses of study in CFAES. While we have an excellent group of students, it has been a challenge to increase enrollment because of several factors, many of which are common to plant pathology across the country:

- Little awareness about plant pathology and career opportunities, possibly until very late in an undergraduate program in a biological field, if at all. This often occurs at a point where changing

their major will add significant time and cost to graduation.

- Our lack of access to biology and microbiology majors, where students have little exposure to the plant sciences or mycology in any of their coursework, and no expectation that they will learn anything in these areas for their degree.
- Students interested in the plant sciences have several major options across departments and colleges (e.g. Sustainable Plant Systems, Molecular Genetics, Environmental Science, Evolution and Ecology)
- Decline in industry demand in certain areas, for example, in turfgrass science.

Many of our students transfer from other colleges/universities or the Agricultural Technical Institute (ATI, OSU's 2-year associate-degree technical college on the Wooster campus).

As a Department, we participate in recruitment initiatives organized at the College level. These include, for instance, an initiative in collaboration with CFAES Student Affairs to educate high school students about agriculture and related activities relevant to the field (e.g. FFA, 4H). In addition, the College has been making concerted outreach efforts with admissions personnel through CFAES tours as well as at venues such as Ohio's State Fair. CFAES also provides individualized visits for prospective students and their families, which is unique to the university.

The Department also participates in CFAES and university-wide education and outreach events and provides a variety of activities designed to be engaging in order to expose students and the public to plant pathology. Examples of these yearly events include FFA tours of the Columbus campus, Science of Agriculture Day in Wooster, and Farm Science Review in London, Ohio.

Another good recruitment strategy is to offer general education (GE) courses of interest to freshmen and sophomores. Currently, Tom Mitchell teaches a natural science GE course—Mold, Mushrooms and Mankind—which generates a lot of interest on campus with 40-50 students per semester; several students have changed majors to Plant Pathology after taking that course. In addition, two courses – Sick Plants in a Hungry World (PLNTPTH 2001) and Contemporary Issues: Pesticides, Genetic Engineering and the Environment (PLNTPTH 4597) – are both offered online every semester and reach non-majors. With the impending revision of Ohio State's GE curriculum, new opportunities will be available to develop courses that will attract potential students into our program.

Providing financial assistance to students through scholarships is a high priority in CFAES, with over $2.1 million offered annually in the college. Plant Pathology offers merit-based scholarships – typically totaling $3,000-$6,000 annually, through endowments (such as the Plant Protection Endowment) and departmental funds. We also offer the A. J. Hoffman award in recognition of an outstanding undergraduate student(s), which includes a $1,500 scholarship.

The undergraduate student organization in our department is Plant Health And Resource Management, or PHARM. The organization provides leadership opportunities (e.g., club officers, event planning). It is a good way for our undergraduate students to become engaged in department activities and plant pathology outreach. Monica Lewandowski and Dominique Tate are the club advisors.

Undergraduate student involvement in research

Internship programs play a major role in departmental outreach and recruitment. Each year the department hosts several undergraduate and a few high school students, mostly in the summer. A few undergraduate students get involved in research as assistants in individual labs during the school year or

the summer months. The department has an established summer internship program (since 2003) called the Summer Research Internship in Plant Pathology (SRIPP), funded by faculty programs with additional support from a department endowment. We also host interns through the OARDC Research Internship Program (now the CFAES Internship Program) and the Summer Research Opportunity Program (SROP), the latter targeting talented underrepresented minorities for graduate study (SROP interns are funded by the Graduate School). These internships involve professional development opportunities, presentation of research outcomes and involvement in social events and networking at both the Wooster and Columbus campuses. A summary highlighting the number of interns in the recent years is presented in Table 7.

Table 7. Undergraduate summer interns and student assistants

Year	OARDC/CFAES Internship Program (Wooster location)	Summer Research Opportunity Program	Summer Research Internship Program in Plant Pathology	Total*
2011	3	2	4-7 per year are supported by faculty, with $800 contribution from the department	**≈ 30 Summer Undergraduate Student Assistants and interns are hired each year on the Columbus and Wooster campuses**
2012	9	0		
2013	3	4		
2014	5	3		
2015	3	5		
2016	5	3		
2017	2	0		
2018	3	0		
2019	2	2		

* Including USDA, Center for Applied Plant Sciences, College of Wooster Independent Study students, and student assistants

COVID-19 Impact – We were not able to hire any undergraduate students this summer to the determent of our research programs for good reason. We are concerned about the practical training of our undergraduate students and are working to get them placed in OSU labs or industry as soon as possible.

Graduate programs

Graduate education is a pillar of the department. Graduate students take courses and conduct research, and they also bring new approaches and ideas, and challenge us to look at the discipline in new and refreshing ways. Most importantly, graduate education allows us to pass on our knowledge of plant disease and plant-microbe interactions to the next generation of plant pathologists and plant health professionals and educators.

Graduate degree programs at OSU are administered by the Graduate School and the Graduate Studies Committee (GSC) of the individual graduate programs. The graduate program in Plant Pathology is operated by a GSC consisting of four graduate faculty members from our department and one graduate student. The faculty members on the committee are elected by the faculty and serve 4-year terms (renewable); the graduate student (also chosen by the faculty) serves for a 1-year term. Faculty from both campuses are always represented on the committee. The GSC is responsible for the conduct and administration of the program. In particular, the GSC: evaluates applicants and makes decisions regarding admission; coordinates offers of associateships (assistantships), approves student petitions for submission to the Graduate School; oversees annual performance reviews of students; selects student recipients of the

C. C. Allison Award for excellence in graduate student research and service (our highest honor for a graduate student); nominates students for university and college fellowships and special competitive associateships; and monitors the progress of all graduate students. The GSC chair has additional responsibilities, such as representing Plant Pathology at Graduate School meetings and resolving issues. The GSC chair, the Graduate Program Coordinator (clinical faculty member), and the administrative and fiscal staff spend considerable time managing the graduate student appointments, and, together with the Chair of the department, make strategic plans for student financial support in the coming years.

In most cases, newly admitted graduate students are assigned an advisor before they arrive. This is partly because most students are financially supported entirely or at least partially by their advisor. Although GSC has overall responsibility for the program, specific oversight responsibility for each student is given to a Student Advisory Committee (SAC), which is chaired by the advisor and includes at least two additional members. Generally, SAC members serve as the major part of the examining committees for Ph.D. students participating in both the candidacy and final examinations. The SAC can choose to modify Departmental course requirements to meet the academic and professional needs of the students.

Degrees and Degree Requirements

The department offers an M.S. and a Ph.D. in Plant Pathology. Three types of M.S. degrees are currently possible: Plan A (thesis), Plan B (non-thesis, which is rare), and Plan “G" (awarded on the basis of passing the doctoral candidacy exam for those students who do not have an M.S. degree in the same field from OSU or elsewhere). In addition, we have the professional MPHM program (described in its own section below).

The graduate program curriculum went through a significant revision in the recent years. Incoming students in 2018 are under the new curriculum. Major revisions include reduction in the number of specified courses, to allow for more flexibility in course selection, as well as incorporation of more laboratory/hands-on practice, as requested by the graduate students during program re-envisioning. The M.S. and Ph.D. suggested courses of study are presented in **Appendix 11A** (M.S.) and **11B** (Ph.D.), with the course list in **Appendix 12**.

Graduate students are encouraged to participate in teaching within our department, and Ph.D. students are required to gain teaching experience. Students with department financial support may be expected to provide additional assistance in teaching. Students may obtain credit for teaching (PLNTPTH 8901) or Extension outreach (PLNTPTH 8902) by developing and executing a plan with designated mentors. Students must demonstrate a substantial intellectual contribution to the course or Extension program to obtain graduate credit. Because funding for M.S./Ph.D. grad students is for research in the department, it is an ongoing challenge to obtain a sufficient number of TAs for courses.

Graduate student demographics and trends

By fall 2019, 58 graduate students were enrolled in our department, across the three graduate programs, with 29 Ph.D. students, 9 M.S. students and 20 MPHM students (Table 8), with a gender distribution 43% male, 57% female. Within the period from 2011-2019, a total of 23 Ph.D. and 43 M.S. students graduated, representing 19 countries plus the U.S. The quality of graduate training and the quality of enrollees are evidenced by almost 100% placement in positions related to plant pathology, plant biology, and

biotechnology, and also by student achievements such as prestigious fellowships and awards (**Appendix 5 and 6**).

Table 8. Graduate enrollment (number of students) 2011-2018.

Program	2011	2012	2013	2014	2015	2016	2017	2018	2019
M.S.	11	11	12	7	10	9	9	8	9
Ph.D.	24	22	19	25	28	31	26	26	29
MPHM	*	1	5	14	11	16	21	17	20
Total	**35**	**34**	**36**	**46**	**49**	**56**	**56**	**51**	**58**

*The MPHM program was established in 2012. The online program was approved in 2014.

Graduate credit hours

As with undergraduate credit hours, graduate credit hours impact departmental funding in our General Funds (teaching) budget. The greatest weight in the OSU RBB Business Model is for graduate-level courses, especially the graduate research course (8999). Within the period 2014-2019, graduate credit hours fluctuated between 923-1,205 annually, with a peak in 2015. See Table 6 for details on the credit-hour counts. It should be pointed out that the number of Ph.D. students can give a misleading view of the number of graduate credit hours taught. At OSU, once a student passes their Ph.D. candidacy exam, they are only allowed to register for 3 credit hours per semester. On the one hand, this is a cost savings because of much lower tuition and fees for those post-candidacy students, but this also represents a reduced appropriation of funds to our unit in the RBB Business Model.

Graduate student funding comes from various sources. About 45% of the funding comes from grants to faculty. Department funds are allocated for graduate student support (≈ 30%), but that is often cost-shared with faculty advisors. CFAES provides ≈ $110,000 for tuition/fees, and faculty can also apply for Graduate School matching tuition/fee awards (for grants if tuition/fees are not funded). We have been successful in obtaining competitive fellowships from the Graduate School and CFAES (≈ 18% of our graduate support). About 7% of the support comes from external fellowships such as Fulbright, Brazil Science Without Borders, Beachell-Borlaug International Scholar program (Monsanto, now Bayer) and government scholarships (e.g., Thailand) (**Appendix 5**). In addition, Plant Pathology faculty also advise students in the Translational Plant Sciences Ph.D. program (2-3 students) and the Environmental Sciences Graduate Program (1-2 students). These programs also provide partial graduate support.

We strongly encourage student participation in professional meetings, particularly APS, MSA and ASV. Ohio State and CFAES host annual conferences that are excellent in-state opportunities to present research. Travel funds come from faculty grants, the Plant Protection and other endowments, PPGSA (see below), and other competitive travel awards or fellowships.

Graduate recruitment

Graduate recruitment is done at several levels. Our faculty and staff build and maintain relationships with colleagues and programs around the world to facilitate graduate student recruitment. We invest time in personal contacts, networking and our department website. We try to increase our visibility so that students interested in plant pathology will explore our department. We are actively engaged in internship and other recruitment programs. Every year, we invite selected applicants to visit the department (expenses paid for by department and/or host PI funds), which is crucial to recruiting excellent students.

Plant Pathology Graduate Student Association (PPGSA)

The PPGSA is an active part of the department. The group organizes events and fundraisers and coordinates visits for guest speakers. Students can become involved in the department by becoming PPGSA officers and serving on department committees. The PPGSA president and vice-president often represent the department at college, university and APS functions. Another important function of PPGSA is to foster professional and social interaction between students through regular meetings and social events, including an annual weekend retreat.

PPGSA helps welcome new graduate students and organizes an annual spring symposium (where first-year students present their research proposals). One very successful activity is the student exchange with Penn State, Cornell, and Michigan State. where graduate students from each institution have the opportunity to visit one of the other campuses and present a departmental seminar.

Two of PPGSA's biggest fundraisers involve raising plants (native plants in Columbus; vegetable seedlings in Wooster) for large public plant sales held on each campus every spring. These events raise a $2000-$4000 each year. Through this, PPGSA provides travel grants that are matched by the department and the Plant Protection Endowment. A big service to the department is PPGSA's involvement in outreach activities such as Science of Agriculture (Wooster, K-12) and FFA campus tours.

Master in Plant Health Management (MPHM)

The MPHM program, administered by the Departments of Plant Pathology and Entomology, is a professional degree established to meet a growing workforce need for plant health expertise. The program is course and internship/project based, with no research thesis requirement. Since 2012, the program has graduated a total of 21 individuals and enrolment has grown to stabilize at over 20 students annually. Most students are part-time. MPHM was Ohio State's first graduate program to achieve the Professional Science Master's affiliation, with the incorporation of professional and business coursework and training in a science-based discipline (**Appendix 13**).

The program was established as an in-person program, but it was apparent that an online program would fit the needs of working professionals. In 2014, the MPHM-Online option was approved. Initially, online or distance options for our in-person core courses were developed. Over time, more courses have been converted to online format, with many courses still offered in-person.

The MPHM program, particularly with the online program option, has enabled us to expand the student population and increase enrollment in departmental courses. The program serves mostly non-traditional, part-time and online students seeking to advance in their careers or change careers. Students are mostly on self-support or use employer tuition benefits, but both the Departments of Plant Pathology and Entomology provide some funding support through Graduate Teaching Associateships or hire student assistants for class support. We also provide a limited number of travel grants and funds for supplies through the recently established Master in Plant Health Management Grad Studies Support Fund. In addition, OSU Extension typically supports one MPHM student annually to work with the OSU Pesticides Safety and Education Program.

All 21 MPHM graduates obtained employment in agriculture and related fields that include the greenhouse/controlled environment industry, state Extension programs, academia, and government agencies (**Appendix 6**). Further, many of our graduates have landed higher-level positions after earning their degree. Growth of the MPHM program is shown by enrollment (previously shown in Table 8) and revenue stream (**Appendix 14**).

In the past seven years, the success of the program has relied heavily on faculty involvement and commitment through curriculum development, mentoring, teaching, and collaboration with stakeholders. While the program initially accepted students with a background in plant health, it has expanded to included students with a variety of backgrounds. As a result, faculty involvement has expanded beyond the Departments of Plant Pathology and Entomology. Starting in 2015, faculty members have been working with university course designers to convert material to an online format, which include improvements in video recording and course management systems. Over the past seven years, MPMH administrators and faculty members have built collaborations with external and internal stakeholders, including Scotts Miracle-Gro Co., The Davey Tree Expert Co., Bayer CropScience and OSU Extension, to help students pursue internship projects in different areas of research, such as precision agriculture, urban farming and landscaping, and pollinator health.

The proof of concept for the MPHM program is complete and it has been shown to be a success. We are expecting to grow student number by at least double now that the entire program can be taken online, if we can hire a dedicated MPHM Director.

As shown in **Appendix 14**, in the 5-year period from 2013-2017, the program generated $514,352 in total revenue between Plant Pathology and Entomology. After 24% CFAES and13% OSU central taxes, net program revenue equates to $324,041, split roughly evenly between the two departments. With 716 credits yielding roughly $1,134 per credit, depending on the subsidy rate (which varies with the level of the course), the program has generated a total of $811,944 with $194,867 going to CFAES in taxes. These numbers need to be interpreted in light of the fact that in the first couple years of the program, 2013 and 2014, there were only 2 and 6 students enrolled, respectively. We attribute the dramatic increase in credits taken in 2015, and consequently jump in revenue, to the fact that it was the first year that the program was offered online. Our goal is to increase enrollment to 45 students by 2024. With 45 students, we forecast that the program will gross ~$400K per year before central and college taxes. Over the next 5 years, during the growth of enrollment from 20 to 45 students, we project the program to gross ~$1.5M.

To accomplish the goal of growing the program enrollment, creating stronger ties with industry partners, and creating more quality internship opportunities, the ***department feels that it is urgent to hire a new MPHM Director***. This person would have the title of Assistant Professor of Professional Practice (clinical faculty; not tenure track). The director will be expected to develop a course to serve students within and outside the MPHM program. By teaching a new course and increasing enrollment, we forecast that the director will be generating the revenue needed to support their salary and benefits by within the first three years of being hired, as well as generate significant revenue for the Departments of Plant Pathology and Entomology. The success and especially the sustainability of the program does depend heavily on our hiring a full-time director. Otherwise, the burden on our current faculty will become too great.

Curriculum Assessment

Curriculum assessment based on learning goals for degree programs has been the norm for the past 8 years at OSU. The Department of Plant Pathology is viewed as the standard for curricular assessment programs in CFAES since the college began implementing assessment requirements in 2012. The learning goals for the B.S., M.S., Ph.D., and MPHM programs are listed below. Also shown are the numerical results for the learning goals for the two undergraduate majors (Figures 1 and 2).

Learning Goals – B.S. Plant Pathology

1) Understand the importance of plant pathology and the impacts of plant disease in agricultural and natural ecosystems;
2) Remember causes of plant diseases and the basis of plant-pathogen interactions;
3) Remember laboratory techniques to study plant-associated microbes;
4) Apply the principles of plant pathology to field and laboratory studies;
5) Create environmentally-sound disease and insect management strategies by using current informational resources; and
6) Develop components needed for career development.

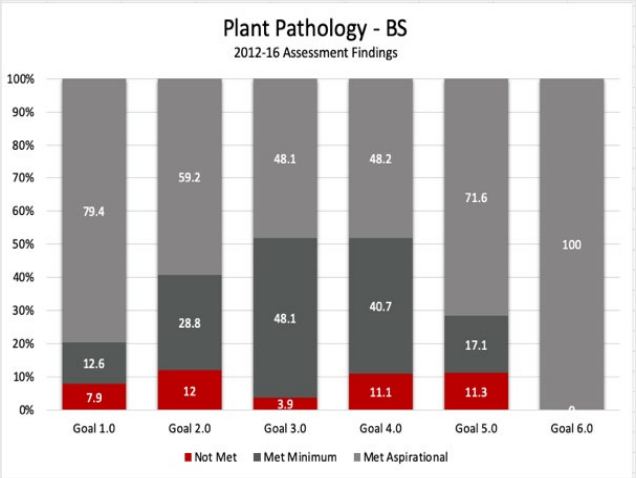

Figure 1 – B.S. Plant Pathology Measurement of Learning Goals.

Learning Goals – B.S. Plant Health Management

1) Understand the importance of plant health and the impacts of plant pests in agricultural and natural ecosystems;
2) Understand biotic and abiotic factors that influence plant health;
3) Apply the principles of plant health management to field and laboratory studies
4) Create environmentally-sound disease and insect management strategies by using current informational resources; and
5) Develop components needed for career development.

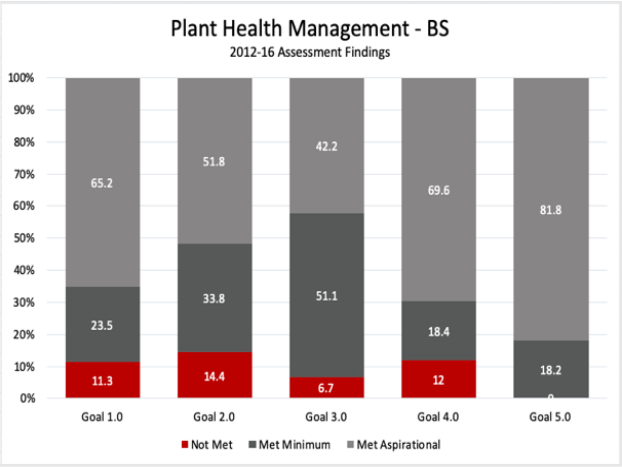

Figure 2 – B.S. Plant Health Management Measurement of Learning Goals.

Learning Goals – M.S. Plant Pathology

1) Learn how to think critically when reviewing and conducting research and solving problems;
2) Understand effective communication strategies, including oral and written communication skills, using current informational resources;
3) Understand the fundamental and advanced applications of the scientific method as it relates to plant pathology research;
4) Understand ethical issues in academia and industry;
5) Understand the importance of plant pathology and the impacts of plant disease in agriculture and natural ecosystems;
6) Understand the fundamental tenets and practice of plant pathology, plant health management, and experimental design.

Learning Goals – Ph.D. Plant Pathology

1) Apply critical thinking when reviewing and solving problems;
2) Implement effective communication strategies, including oral and written communication skills, using current informational resources;

3) Apply the fundamental and advanced applications of the scientific method as it relates to plant pathology research;
4) Understand ethical issues in academia and industry;
5) Understand the importance of plant pathology and the impacts of plant disease in agriculture and natural ecosystems;
6) Understand the fundamental tenets and practice of plant pathology, plant health management, and experimental design; and
7) Apply their knowledge in the classroom through teaching techniques.

Learning Goals - MPHM

1) Apply critical thinking when reviewing and solving problems;
2) Implement effective communication strategies, including oral and written communication skills, using current informational resources;
3) Understand ethical issues in academia and industry;
4) Understand the adverse effects of pathogens and pests on plant health; and
5) Analyze plant health management strategies in agricultural, urban, and natural ecosystems.

Both the M.S./Ph.D. and the MPHM curricular assessments have been recognized as exemplary since their implementation. In fact, our approach has been used as a model for other academic units. In 2017, the Plant Pathology M.S./Ph.D. programs were awarded the CFAES Learning Outcomes Assessment–Award of Distinction for executing innovative changes in our curricular design and delivery, based on the findings from our learning outcomes assessment. In 2019, we were presented with this award for our work in revising the MPHM program. By analyzing the results from our curricular assessments, we have been able to make modifications to improve student learning and workforce preparation**.**

The first assessment cycle for our undergraduate programs has come to a close. This means that we are currently reviewing the assessment data and considering revisions in the curricula and program requirements, as well as our assessment measures and process. With a major restructuring of the university's general education (GE) curriculum planned for a target date of Autumn 2022, we expect to undergo the assessment review process again within a few years. In light of this, we anticipate that our undergraduate learning goals and outcomes will undergo very little revision until the new GE is in place. Once the GE is established, we plan to evaluate the undergraduate programs with a similar collaborative process used to improve our graduate programs.

Extension

The department considers outreach and engagement an integral part of its program. Extension focus areas include Crop Health, One Health, Educational Programming, and Diagnostics. The goals of the Extension faculty and Program Specialists in the department are to deliver evidence-informed plant disease diagnoses and disease management and produce safety recommendations that are effective, cost-efficient, and sustainable. Research and outreach activities are stakeholder driven, encouraging stakeholder decision-makers to be responsive to research findings, with our faculty conducting studies and developing programming that can be translated, in a meaningful way, into better decision-making by stakeholders. We strive to deliver research findings to stakeholders using their preferred method of delivery and develop programs and materials that recognize the range of cultural and economic diversity within the state.

Evidence-informed plant disease and produce safety recommendations are vital to preventing plant diseases, foodborne diseases due to human pathogens or mycotoxins, and antimicrobial resistance development. Our Extension faculty and Program Specialists are committed to providing our stakeholders with the best available science, and delivering this information in a way that will improve disease management and public health, enhance product quality and safety, and benefit the environment and our stakeholders. A list of our current OSU Extension faculty and Program Specialists, their program area, and FTE is provided in Table 9.

COVID-19 Impact – As with most colleges and universities with an Extension expectation, OSU Extension has experienced a large disruption. There is no clear path back to supporting the stakeholders in the state, nation, or internationally. However, we are working to develop the best support via electronic media using all the tools and technology at our disposal.

Table 9. Plant Pathology Extension Faculty and Program Specialists.

Name	Program Area	OSU Extension FTE
Francesca Peduto Hand	Ornamental Crops	0.30
Pierce Paul	Field Crops	0.40
Melanie Lewis Ivey	Fruit, Hop, and Nut Crops; Produce Safety	0.50
Sally Miller	Vegetable Crops	0.40
	Total Faculty FTE	**1.60**

(Note: this does not include the recently vacated Soybean position, which has been 0.40 FTE)

Name	Program Area	OSU Extension FTE
Joe Rimelspach, Program Specialist	Turfgrass Pathology	0.50
Joy Pierzynski, Clinic Director	Disease diagnostics	1.00
	Total Program Specialist FTE	**1.75**

One Health

A One Health approach brings together diverse disciplines to address the spread of disease, promote health and emphasize the connections among humans, animals, plants, and the environment. Faculty in the department extend knowledge locally, nationally and globally on: 1) prevention and control of foodborne pathogens (i.e., *Listeria monocytogenes*, *Salmonella* spp., norovirus, Shiga toxin-producing *E. coli*) and mycotoxins (e.g., deoxynivalenol) associated with food crops; 2) environmental and biological risk factors that impact agricultural food systems including pesticide stewardship and antimicrobial resistance; and 3) good agricultural practices to mitigate preharvest plant disease and food safety risks.

We collaborate with interdisciplinary programs within the university, such as the Fresh Produce Safety Team, Center for Foodborne Illness Research and Prevention, and Global One Health Initiative, regional centers for food safety training, outreach, and technical assistance, state (Ohio Department of Agriculture) and federal (Food and Drug Administration) regulatory agencies, and non-profit organizations, including the FAO of the United Nations, to translate research into practical practices and evidence-based policies that can effect change. New knowledge is disseminated through handbooks and guides, workshops, trainings, white papers, presentations, news briefs, etc.

Educational Programming

Our primary approach for outreach and engagement with stakeholders is through our Extension educational programming. Program delivery takes many forms, from distance education (webinars, online courses, etc.), social media (Facebook, Twitter, etc.) and other online platforms (blogs, program websites, etc.), to traditional face-to-face meetings (in-services, grower meetings, field days, etc.), factsheets (traditional and interactive), and a variety of printed publications. Although our focus remains in Ohio, our educational programs are not limited to Ohio or the United States. For example, in view of reduced Extension resources across the country, we participate in regional initiatives to create bulletins, production guides, fungicide manuals, handbooks related to pest and disease identification and management, etc., that can serve multiple cooperating states. Within Ohio, we work closely with county Extension educators, independent and company-based crop advisors and consultants, Ohio-based seed companies, agricultural business associations, large producers as well as Plain (i.e. Amish) communities.

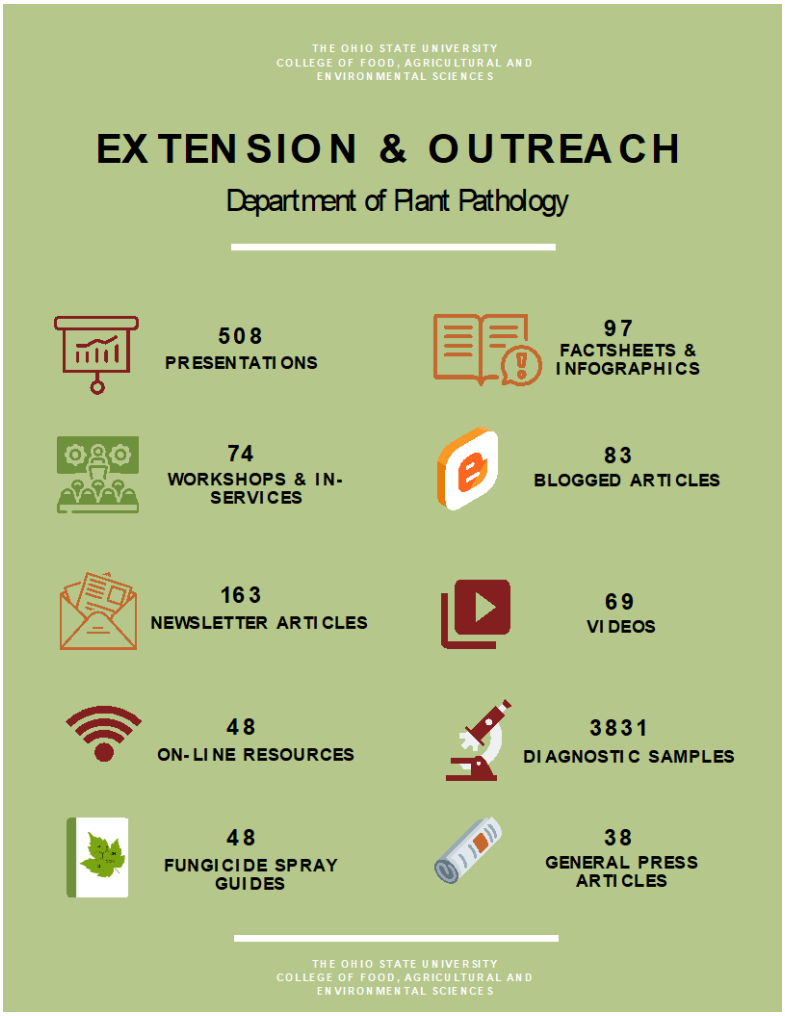

Figure 3. Extension and Outreach delivery tools, 2015-2019.

In addition, we partner with OSU/CFAES/OSU Extension interdisciplinary Commodity Teams, such as the Agronomics Crop Team, Vegetable Crops Team, Fruit Crops Team, Extension Nursery Landscape and Turf Team (ENLTT), and IPM Center Working Groups such as the Great Lakes Fruit Workers (GLFW), Great Lakes Vegetables, and Great Lakes Hops, and the Greenhouse Industry Roundtable of the Midwest (GIRM). These collaborations keep us appraised of issues and enable us to integrate plant pathology into broader Extension programming. Important examples of outputs of these interactions are the Crop Observation and Recommendation Network (C.O.R.N.) online Newsletter, the VegNet blog, Ohio Fruit News (OFN), and the Buckeye Yard and Garden on Line (BYGL) website, among others. A more detailed list of programming outputs can be found in Figure 3.

The department is committed to conducting applied research and diagnostics and extending new knowledge to enhance crop and human health in Ohio. We do this by developing management programs to mitigate the economic impact of plant diseases and foodborne illnesses, assisting producers in diagnosing and managing diseases, addressing issues related to emerging plant and human pathogens and climate change, training producers in best disease management and food safety practices, and developing and delivering dynamic educational materials to producers, backyard gardeners, students, regulators, educators, agrochemical companies, and the general public.

Plant Disease Diagnostics

Plant disease diagnostic services are provided across the state to commercial producers and backyard gardeners. Diagnostic services and education programs are supported using funds from a wide range of sources, including state commodity associations, USDA National Institute of Food and Agriculture awards, Ohio Department of Agriculture Specialty Crop Block Program awards, USDA Animal and Plant Inspection Service, National Plant Disease Network awards, and client fees. Our diagnostic services are strengthened through collaborations with the Ohio Plant Disease Network and North Central Integrated Pest Management Working Groups (i.e., Midwest Fruits, Great Lakes Vegetables, Great Lakes Hops).

A combination of classical and state-of-the-art molecular techniques are used to diagnose diseases. Services are centered at the C. Wayne Ellett Plant Disease and Pest Diagnostic Clinic (ppdc.osu/edu), Reynoldsburg, Ohio, and directed by Joy Pierzynski. The C. Wayne Ellett Plant Disease and Pest Diagnostic Clinic specializes in commercial ornamental and forest tree disease diagnostics, as well as vegetable and fruit disease diagnostics for backyard gardeners, and also any commercial field-crop samples that are submitted. Diagnostic services for turf diseases are provided by Program Specialist Joe Rimelspach within the department of Plant Pathology-Columbus Campus, as part of the Diagnostic Clinic. Vegetable, fruit, nut and hop, soybean, and cereal crop disease diagnostics for commercial producers are conducted within the department of Plant Pathology-Wooster Campus and are directed by Extension faculty members Sally Miller, Melanie L. Ivey, Anne Dorrance (now vacant position), and Pierce Paul, respectively, and senior support staff. Vegetable, fruit, nut, and hop producers are specifically requested to submit samples to the Wooster programs. In addition to traditional diagnostic services, the Field Crops Program (Dorrance and Paul) and the Fruit Crop Program (Ivey) conduct disease/pathogen specific surveys across the state to assess pathogen diversity, fungicide resistance development, and population shifts to assist producers with making informed disease management decisions. Our diagnostic programs have resulted in 19 published reports of new diseases or disease-causing agents in the state. **Table 10** provides a breakdown of the number of diagnostic samples per year that our programs have processed from 2015 to 2019.

In addition to disease diagnostics, our services include plant health, disease, and fungicide resistance management recommendations. Further, Program and Extension Specialists educate Extension

Educators, producers, backyard gardeners, students, and Master Gardener volunteers through workshops and trainings focused on accurate and rapid diagnoses.

Table 10. **Diagnostic Samples (2015-2019)**

Program Area	Number of Samples
Plant & Pest Diagnostic Clinic (includes turf, ornamentals, insect pests)	790
Vegetable Pathology Program	400
Fruit Pathology Program	245
Cereal Pathology Program (tar Spot & ear rot survey)	30
Soybean Pathology Program	15
Soybean Pathology Program (soybean cyst nematode survey)	250
Soybean Pathology Program (soybean *Phytophthora* survey)	400

International Programming

Globalization of agriculture has mandated that research and outreach efforts in Land Grant Universities place some emphasis on work outside the United States. Globalization of our programs and curriculum has long been a goal in CFAES, and the Department of Plant Pathology fully embraces this commitment to international research, development, teaching and outreach. All faculty members in Plant Pathology have directed some of their program into the international arena, either by advising international graduate students, collaborating with international scientists, speaking at international symposia or in foreign countries, or by participating in—or leading—collaborative international programs.

The department has identified two broad international programming objectives.

1. Train and collaborate with international students, postdoctoral scientists and scholars through our undergraduate and graduate programs, international exchange programs, training workshops, and joint research projects. Utilize technology to bring educational opportunities to new audiences.

2. Continue to develop linkages and partnerships between programs and individuals in developed and developing countries, for the purpose of development and human-capital capacity building in less developed countries.

The involvement of our faculty at international venues has greatly enhanced our visibility, having worked in 45 countries in the past five years. Figure 4 (Global Map) is an infographic world heat map depicting where faculty members in the department have worked with regards to funded projects, co-authored publications, and student/scholar exchanges. The deeper the color, the more activity in that country. As shown, the department faculty members collectively are globally engaged, with strong collaborative activity in Asia, South America, Sub-Saharan Africa, and the European Union. In the past five years our faculty members have overseen 25 student exchanges, mentored 36 international visiting scholars and postdocs, participated in 49 funded international research projects and 41 collaborative programs not funded by a specific grant. We have provided a sampling of faculty collaborative projects over the past 5-years (**Appendix 13**) and international publications (**Appendix 14**)

We continually strive to develop and enhance our global reputation as a leader in plant pathology to leverage resources and expand our international network. Looking forward, we see the department involvement growing in several regions of the world due to the hiring of recent faculty members. For instance, Soledad Benitez-Ponce is expanding work in Latin America; Ye Xia is working with several institutions in Asia; and Jonathan Jacobs is working in the European Union and Africa.

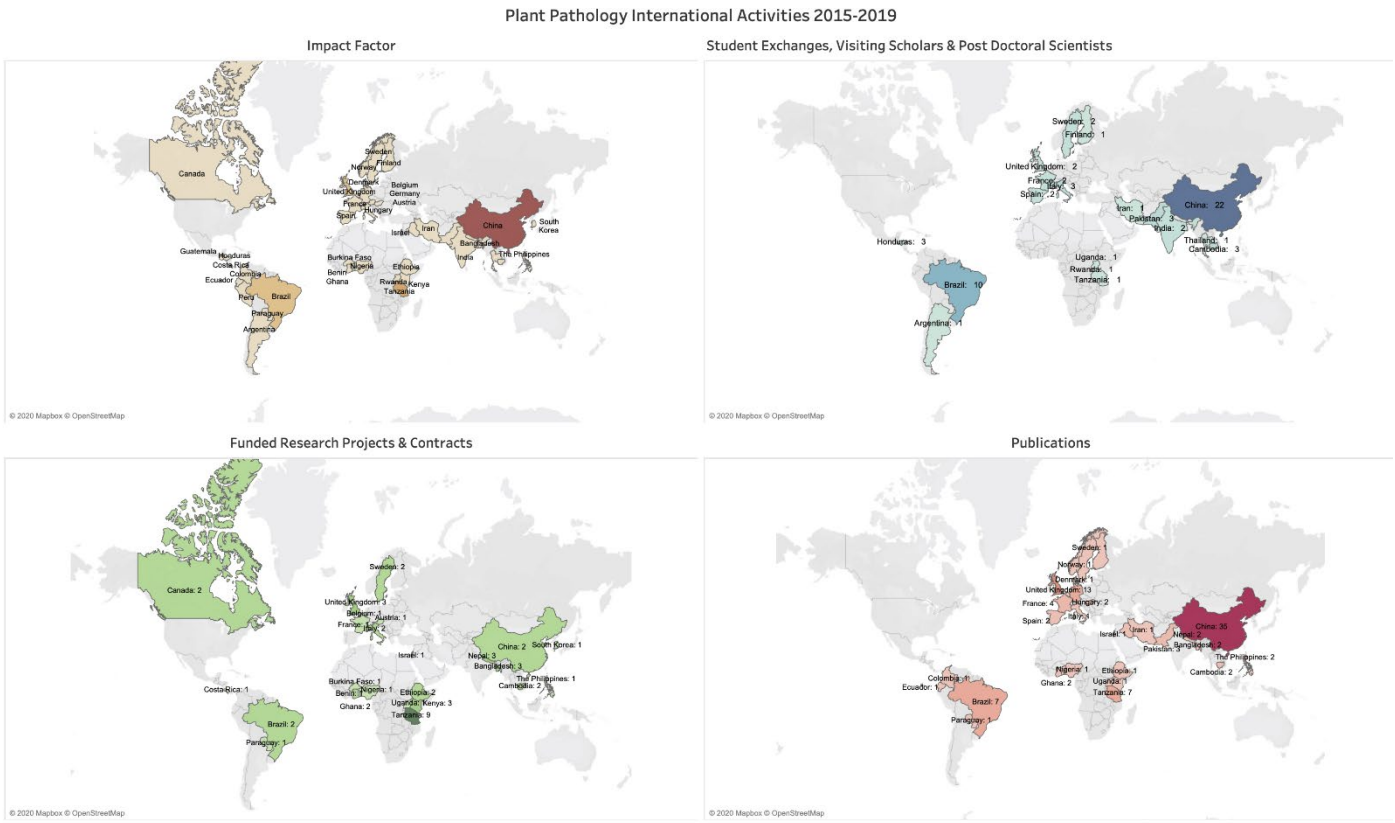

Figure 4. International activities by department faculty members in the areas of funded projects and contracts, co-authored publications, and student exchanges in the past 5-years. "Impact Factor" is a weighted score that shows the combination of all these factors. The deeper the color, the more activities have taken place.

Facilities - Columbus Campus

Laboratory Space

All Columbus-based faculty have office and laboratory space in Kottman Hall, primarily on the third or fourth floor. Four faculty laboratories on the fourth floor are standard size (approximately 700 sq ft). There is also a small faculty lab with an adjoining prep room and another smaller lab being used by a research scientist. There are two labs on the third floor, of 437 and 823 sq ft. The third-floor labs are part of a wing of molecular biology laboratories, which allows ready sharing of molecular biology related resources. There is also a lab on the second floor that was used by the turf pathology program for several years and more recently by nematology; this is part of a suite of rooms, including offices and a student social-gathering space. There are three common equipment labs, including two on the fourth floor and one on the third floor. The third-floor common lab is shared with the Department of Horticulture and

Crop Science (HCS) as part of the molecular biology equipment suite. The common labs on the fourth floor include a walk-in cold room, common equipment and spill-over space for programmatic incubators, freezers, etc. On the fourth floor, there is also a small lunchroom. Finally, there is a standard sized laboratory on the fourth floor that is being used by "MCIC Columbus," a unit of the OARDC Molecular and Cellular Imaging Center (MCIC) established in Columbus (see below). This lab houses additional common molecular biology, chromatography and imaging equipment, provided as a general service, but primarily used by Plant Pathology. Finally, a new BSL2P (BSL2-plus) laboratory and greenhouse space is proceeding through the final stages of approval by the USDA for research being done by Dr. Jacobs on USDA Plant Protection and Quarantine (PPQ) Select Agents.

Overall, laboratory space is adequate in Columbus and we foresee no immediate problems as current vacant positions are replaced.

Diagnostic Clinic and Ohio Department of Agriculture Facilities

The C. Wayne Ellett Plant Pest and Diagnostic Clinic (PPDC) traditionally has operated in lab and office space on the 1st floor of Kottman Hall in Columbus. However, to increase cooperation with the plant diagnostic efforts at the Ohio Department of Agriculture (ODA), the PPDC moved to new lab and office facilities at the ODA Headquarters at Reynoldsburg (30 miles east of the Columbus campus). The PPDC occupies part of a 3000-sq ft lab/office complex at the Division of Plant Health of ODA; the new facilities are state of the art for diagnostic (and other) laboratory work. The former clinic in Kottman Hall is still used for diagnostic work and some classes.

Teaching Space

Most Plant Pathology courses are taught in the two laboratory classrooms on the 4th floor of Kottman Hall. The department has complete schedule control of these two teaching rooms, although one is primarily used for Entomology classes (with our full cooperation). For larger undergraduate courses or lecture courses for non-majors, we utilize lecture rooms under the scheduling control of the college or university, and compete for space. The teaching facilities are generally sufficient for all of our courses at this time. However, we could not afford to lose any of these rooms if our curriculum and course content continues to grow, especially for laboratory classes.

All graduate-level courses in Plant Pathology are taught through the videolink facilities on the Columbus and Wooster campuses. At a minimum, the lecture-recitation-discussion parts of the courses are completely taught this way; and for courses without labs, the entire course is usually taught in this manner. Both fourth-floor teaching labs and the second-floor conference room have complete videolink facilities. For several years, our college has been using Polycom technology for video conferences, which is a hardware-based platform for conferencing. We have been using Zoom software platform more frequently in the last year or two, and the college is transitioning completely away from Polycom for the future. This is good, because placing Zoom on top of Polycom creates many technical problems. We are in the middle of the conversion of teaching and conference rooms to Zoom right now (with the capability of also using Skype or Business if the need arises).

Although teaching labs are sufficient, we have inadequate storage for equipment and supplies, and a shortage of greenhouse and phytotron space to support the teaching program. Maintenance of teaching equipment, including videoconferencing equipment, is a continuing challenge. The switch to Zoom should help a lot.

Office and Meeting Space

Individual office space is available for all faculty, research scientists, and senior staff members. Other members of the department (students, post-docs and technicians) usually share office space. We have strived to have one programmatic desk (in a shared office) per faculty member that can be used for a technician, post-doc or visiting scientist. Graduate students have priority on the remaining office space. Recent renovations of two rooms on the 4th floor have allowed us to accommodate all graduate students with modern furniture.

The suite in 201 Kottman has office space for the Chair, two office associates, and a reception desk (staffed by a temporary student worker, as needed). This suite also has a conference room that is heavily used for committee meetings, teaching, and other events. It will be receiving new video conferencing capabilities as part of the above-listed upgrade. The second floor of Kottman also has a suite of offices (associated with the one second floor lab) that is used for turf pathology staff and academic coordinators and advisors. This area also has casual meeting space for students and student activities; this area comes in very handy for frequent overflow problems, when the conference room in 201 is occupied.

Equipment

Through the past decade, we have relied very heavily on the annual OARDC Equipment Competition for the acquisition of new equipment and repair of existing equipment. The use of this fund is always highly matched by faculty and departmental contributions. However, major needs still occur and put a strain on department funds. Further, the new model for the financing of computing resources, implemented in 2019, has proven to be costly to the department as well as to individual PIs. Computers are now effectively leased to users and an annual fee is assessed; this applies to both campuses (see Research section for discussion and department policy).

Plant Growth Facilities

All plant growth facilities (growth chambers and greenhouse space) and the headhouse are under the management of the Department of Plant Pathology and managed by a facilities manager who oversees operations, repairs and maintenance, and handles user fees. While greenhouse space in Kottman Hall was expanded somewhat by an NSF facilities grant in the early 1990's, it is barely adequate for existing programs. New growth chambers are urgently needed to keep up with the growing research programs in Kottman Hall.

Field Research Facilities (Waterman Farm)

The Waterman Agriculture and Natural Resources Laboratory is a 288-acre multidisciplinary research and education facility under the college auspices located only several blocks from the OSU main campus. About 80% of the area is devoted to crop and pasture land supporting research in horticulture, agronomy and dairy science and a woodlot used by the School of Environment and Natural Resources. The remainder is a very modern turf research and education center with a field laboratory and excellent equipment. Additionally, the college is finalizing plans for a new Controlled Environment Plant Growth building in which Plant Pathology will be able to conduct research of various scales (for a fee).

Facilities - Wooster Campus

Laboratory Space

Selby Hall and attached greenhouses were constructed in 1971. Laboratories (675 sq. ft. each) are available to all faculty members, with some additional general laboratories or rooms dedicated to PCR, radioisotope, microbe-culturing or transfer work, and one 'dirty' lab for working with materials straight

from the field plots. Some of these extra rooms are the size of offices (114 sq. ft.). There is also general lab-support space for autoclaves, dishwashing, and related activities. Because of the size of their research programs, four faculty members currently use two labs each. Three USDA-ARS scientists (including two open positions to be filled soon) with adjunct faculty appointments in Plant Pathology also use labs in Selby. The Molecular and Cellular Imaging Center (MCIC) service facility for the college is located in the basement of Selby Hall. Lab space for plant pathology research is currently very tight in Selby Hall.

Selby Hall is clearly showing its age, as the wear and tear becomes more and more apparent, which includes many leaks and temperature issues. This past year we underwent a total overhaul of our wireless capabilities and Internet cabling within the building, headhouse and greenhouse areas. Phones were also upgraded to Skype for Business.

There is a BSL-3 building (Ralph Regula Plant and Animal Agrosecurity Research Facility) on the Wooster campus. We have access to the facility, on a fee basis. This is very useful to those who wish to work on pathogens which require this level of containment, and will allow us to compete for new biosecurity-type grants.

Teaching Space

Currently, we have videolink facilities in three rooms in Selby — 104 (“library”), 203 (conference room), and 213 (“teaching lab”). In the teaching lab, we also have video equipment to digitally link microscopes between sites. These rooms have aging Polycom video conferencing abilities (a hardware-software platform) and are being upgraded to Zoom capabilities (software platform, with desktop computer).

Office and Meeting Space

All Wooster faculty members have offices in Selby Hall (114 sq. ft). Senior staff members with broad responsibilities have or share offices. Grad students and postdocs share offices. Some original offices have been converted to specialized lab facilities, such as for BSL-2 containment and for culturing plants or microbes. As programs have grown in Wooster, office space for grad students and postdocs has become very tight. The biggest challenge is to provide office space to students and postdocs on the floors where their labs are located.

Seminar and meeting rooms are available in the building, as described under Teaching space (e.g., conference room, teaching lab, library). In addition, the “Buckeye Room” on the second floor is available for meetings and social gatherings.

The front office suite (102 Selby) has space for the Associate Chair (or Chair, if based in Wooster), an office associate, and one other office associate or departmental support person. The departmental “library” is also housed in this office complex (with videolink equipment).

Equipment

As in Columbus, maintaining common equipment is challenging for the operations of the department in Wooster. Faculty members purchase required equipment for their programs, or sometimes a few faculty members pool resources to purchase shared equipment. The department may contribute to purchases (on both campuses) on a cost-share basis. Moreover, as stated under Columbus facilities, the college has a new-equipment competition (across campuses) during most years, where proposals are considered for the purchasing of large “items” (such as a GC Mass Spectrometer, or a computer-controlled combine for field studies). Usually, proposals require a substantial cost share from the faculty and department. Even with a cost share, however, t*he department is always challenged by the high cost of major equipment, either for laboratory studies or field studies.*

Greenhouses and Plant Growth Facilities

The greenhouses that are attached to Selby Hall generally provide adequate space for the research of the OSU and ARS faculty in Plant Pathology. There are four wings, with a total of 12,700 sq. ft.

However, these are now 50 years old and in generally poor condition. Despite a moderate upgrade in 2016, many of *the climate control systems for the entire greenhouse complex are obsolete and insensitive, and cannot be automated to meet the needs of many programs.* Many experiments cannot be done in the summer months because of the high temperatures. The headhouse and soil mixing room for the greenhouses are very heavily used by many programs. Soil mixing is not mechanized and requires heavy hand labor to prepare appropriate potting mixes. Storage for blended soils is inadequate.

Of the four greenhouse wings, one is newer and has been renovated to meet BSL-2 containment specifications. This wing is primarily used by the virus group (USDA-ARS and OSU) and food safety program. The lack of containment in the other wings has been limiting our ability to do other research with APHIS-permitted pathogens. The Master Plan for the Wooster Campus calls for new greenhouse within the next 6 years or so. There is a strong possibility that the new facilities will be part of a wider (multi-department) state-of-the-art greenhouse operation for the campus. In particular, the new facility could be used for Plant Pathology and Entomology on a fee basis, and would not be exclusive to any department. We hope this construction does happen.

Eight years ago, our growth chambers were replaced with 16 state-of-the-art Conviron chambers, and more recently five additional Conviron chambers were added. Chambers are controlled by a centralized computer, operated by the building manager (Lee Wilson). These chambers allow us to conduct controlled-environment studies for many pathosystems. However, there is always competition for space in these chambers.

Molecular and Cellular Imaging Center (MCIC)

The MCIC (mcic.osu.edu) is a fee-based core facility located in Selby Hall on the Wooster campus, with a satellite laboratory located on the Columbus campus in Kottman Hall (see above). This is a service facility for the college, which can also perform work for those outside the college and university. Plant Pathology faculty, students, postdocs, and staff are frequent users of the MCIC.

The Wooster core houses equipment and provides services in the areas of microscopy, genomic and bioinformatics. Most of our genetics work centers around DNA sequencing and genotyping technologies. We provide different types of libraries preparation services for high throughput sequencing (Illumina, Nanopore), sequencing services on the Illumina MiSeq and Nanopore MinIon platforms, and low throughput capillary sequencing and fragment analysis. The microscopy laboratory is fully equipped to conduct research at the subcellular, structural and ultrastructural level. The MCIC houses light, confocal, transmission and scanning electron microscopes, and equipment for EDX elemental analysis. They also offer a variety of microscopy sample preparation techniques as a service.

The Columbus facility houses equipment for metabolomics research such as mass spectrometers and a UPLC system, and bioinformatics support (see above description for Kottman Hall).

Smaller molecular biology equipment, as real-time PCR machines, electrophoresis imaging equipment and microfluidic systems for DNA, RNA and protein analysis are available to users on both campuses.

The MCIC Computational Biology Laboratory (MCBL) has a dedicated computer lab and maintains software and pipelines for large genetic dataset analysis. Staff is available to train and guide users with data analysis and help customize bioinformatics tools and pipelines.

The MCIC also plays an important role in teaching and training. While most of the technologies are provided as a service, the MCIC staff also trains students in any of the technology housed at the center. Several staff member are also co-instructors or guest lecturers in courses and offer techniques classes.

MCIC users include faculty from our College (CFAES Wooster 53%, CFAES Columbus 26%), other OSU Colleges (10%), other universities and colleges (10%), and a few companies (0.3%) (2018). Faculty from the Department of Plant Pathology are heavy uses of the core, and in the past 5 years, they have contributed over $600,000 in user fees (Figure 5).

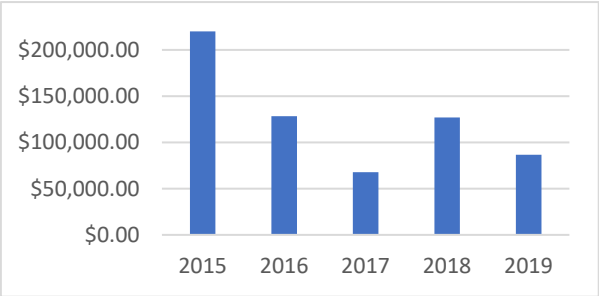

Figure 5. MCIC User Fees from Plant Pathology (2015-2019).