# Kathryn E. Bushley

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**Position:** Molecular Biologist/Curator ARSEF

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**EDUCATION/TRAINING**

Oregon State University Postdoctoral Fellow Mycology/Genomics 2009-2013

Chinese Academy of Sciences Postdoctoral Fellow Mycology 2011-2012

Cornell University PhD Molecular Plant Pathology 2001-2009

Duke University MEM Forestry/Resource Ecology 1995-1997

Oberlin College BA Biology /Anthropology 1986-1991

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**APPOINTMENTS**

**Molecular Biologist/Curator ARSEF,** USDA-ARS Emerging Pests and Pathogens Unit, Ithaca, NY and **Courtesy Assistant Professor**, SIPS, PPPMB Section, Cornell University. April 2021-present.

Lead laboratory focused on biotic interactions and taxonomic and functional diversity of fungi associated with insects and other invertebrate (nematode, arachnid) hosts and manage and curate ARS entomopathogenic fungi collection. Research on the ARSEF collection is focused on potential use of these fungi or their secondary metabolites for control of invertebrate plant pathogens in agriculture. Mentored postdoctoral scholar, graduate, and undergraduate students.

**Assistant Professor,** Dept. of Plant and Microbial Biology, University of Minnesota, Jan. 2014-March 2021.

Led laboratory focused on characterization of evolution and comparative genomics of fungi investigating the roles of secondary metabolites in host-fungal interactions. Emphasis on root endophytes and insect pathogenic and nematode parasitic fungi. Mentored postdoctoral scholar, graduate, and undergraduate students.

**Postdoctoral scholar**, Dept. of Botany and Plant Pathology, Oregon State University, Nov. 2009 – Jan. 2011, and Jan. 2012 - Dec. 2013. Mentor: Dr. Joseph Spatafora.

Lead researcher on genome sequencing of the insect pathogen and cyclosporin producer *Tolypocladium inflatum.* Designed, performed, and supervised all aspects of the project from genomic DNA isolation and sequencing to transcriptomics and integration of metabolomics data. Researcher on AFTOL II and other NSF funded project investigating phylogenomics of Hypocreales and analysis of CAZymes and proteases across the order.

**NSF International Fellow**, Institute of Microbiology, CAS/Oregon State University, Jan. 2011 – Dec. 2012. Mentor: Dr. Yijian Yao and Dr. Joseph W. Spatafora.

Postdoctoral NSF Fellowship to study mating system and population biology of the endangered Himalayan fungus *Ophiocordyceps sinensis* used in traditional Chinese Medicine. Cloned the *MAT1-1* mating type idiomorph, demonstrating homothallism in this fungus and applied SNP genotyping method for characterizing population diversity and substructure.

**Graduate Research and Teaching Assistant**, Dept. of Plant Pathology and Plant-Microbe Interactions and Dept. of Ecology and Evolution, Sept. 2001- Aug. 2009. Laboratory of Dr. B. Gillian Turgeon.

*Dissertation research* – Evolution of nonribosomal peptide synthetases and secondary metabolism in fungi. Cloned and performed high-throughput sequencing of *NPS* gene fragments from closely related *Cochliobolus* species, created bioinformatics tools and pipelines to data mine and annotate *NPS* genes from public databases, performed transformation of fungal strains using protoplasting and homologous recombination to knock out putative *NPS* genes and analyzed mutants using plant bioassays.

**Research Technician II**, Dept. of Radiology, Center for In Vivo Microscopy, Duke University, Nov. 1997- Aug. 2000. Supervisor: Dr. Janet MacFall.

Research technician for study of the amelioration of aluminum toxicity in *Pinus taeda* by the ectomycorrhizal fungus *Pisolithus tinctorius.* Grew mycorrhizal and non-mycorrhizal pine seedling for *in vivo* MRI experiments to nondestructively measure root growth and architecture and assisted in NMR experiments to analyze aluminum complexes in mycorrhizal versus non-mycorrhizal roots.

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**PEER-REVIEWED PUBLICATIONS**

* Jianghua Sun, Tuuli-Marjaana Koski, Jacob D. Wickham, Yuri N. Baranchikov, **Kathryn E. Bushley**. Emerald Ash Borer Management and Research: Decades of Damage and Still Expanding. 2024. Annual Review of Entomology, Vol. 69 (Volume publication January 2024). Published online September 14, 2023. <https://doi.org/10.1146/annurev-ento-012323-032231>.
* Monica Watson, Georgiana May, **Kathryn E. Bushley**. 2023. Sources of fungal symbionts in the microbiome of a mobile insect host, *Spodoptera frugiperda*. Microbial Ecology. 2023 Aug; 86(2): [900-913https://link.springer.com/article/10.1007/s00248-022-02140-3](900-913.%20https:/link.springer.com/article/10.1007/s00248-022-02140-3).
* Rodrigo A. Olarte, Rebecca Hall, Javier F. Tabima, Dean Malvick, **Kathryn E. Bushley**. 2022. Genetic Diversity and Aggressiveness of *Fusarium virguliforme* Isolates Across the Midwestern United States. Phytopathology. Vol. 112 (6), <https://apsjournals.apsnet.org/doi/10.1094/PHYTO-05-21-0191-R>.
* Deepak Haarith, Dong-gyu Kim, Senyu Chen, **Kathryn E. Bushley**. 2021. Growth chamber and greenhouse screening of promising in vitro fungal biological control candidates for the soybean cyst nematode (*Heterodera glycines*). Biological Control. Vol. 160: Article 104635. [<https://doi.org/10.1016/j.biocontrol.2021.104635>](https://doi.org/10.1016/j.biocontrol.2021.104635)
* Benjamin W. Held, Sofia Simeto, Nickolas N. Rajtar, Alissa J. Cotton, David N. Showalter, **Kathryn E. Bushley**, Robert A. Blanchette. 2021. Fungi associated with galleries of the emerald ash borer. Fungal Biology, Vol. 125 (7): 551-559. [<https://doi.org/10.1016/j.funbio.2021.02.004>](https://doi.org/10.1016/j.funbio.2021.02.004)
* Emile Gluck-Thaler, Sajeet Haridas, Manfred Binder, Igor V. Grigoriev, Pedro W. Crous, Joseph W. Spatafora, **Kathryn E. Bushley**, Jason C. Slot. 2020. Molecular Biology and Evolution, 37 (10): 2838–2856. <http://doi.org/10.1093/molbev/msaa122>.
* Deepak Haarith, Dong-gyu Kim, Noah B. Strom, Senyu Chen, and **Kathryn E. Bushley**. 2020. In-vitro Screening of a Culturable Soybean Cyst Nematode Cyst Mycobiome for Potential Biological Control Agents and Biopesticides. Phytopathology. Vol. 10 (8): 1388-1397. <https://doi.org/10.1094/PHYTO-01-20-0015-R>.
* Yong-Hu Wang, Sayaka Ban, Wen-Jing Wang, Yi Li, Ke Wang, Paul Kirk, **Kathryn E. Bushley**, and Yi-Jian Yao. *Pleurocordyceps* gen. nov. for the group of fungi previously named under *Polycephalomyces* based on both molecular phylogeny and morphology. Journal of Systematics and Evolution. Published online 09 November 2020. <https://doi.org/10.1111/jse.12705>.
* David Geiser, Abdullah Al-Hatmi…**Kathryn E. Bushley**…and [Xue Zhang](https://pubmed.ncbi.nlm.nih.gov/?term=Zhang+X&cauthor_id=33200960). 2020. Phylogenomic analysis of a 55.1 kb 19-gene dataset resolves a monophyletic *Fusarium* that includes the *Fusarium solani* species complex. Phytopathology. Published online 17, November 2020. [http://doi: 10.1094/PHYTO-08-20-0330-LE.](http://doi:%2010.1094/PHYTO-08-20-0330-LE.)
* Yi Li, Lan Jiang, Ke Wang, Hai-Jun Wu, Rui-Heng Yang, Yu-Jing Yan, **Kathryn E. Bushley**, David L. Hawksworth, Zujian Wu, and Yi-Jian Yao. RIP mutated ITS genes in populations of *Ophiocordyceps sinensis* and their implications for molecular systematics. 2020. IMA Fungus. 11: Article18. <https://doi.org/10.1186/s43008-020-00040-0>.
* Mudassir Iqbal, Martin Broberg, Deepak Haarith, Anders Broberg, **Kathryn E. Bushley**, Maria Viketoft, Dan Funck Jensen, Mukesh Dubey, and Magnus Karlsson. 2020. Genome-wide association study for in vitro antagonism of *Pratylenchus penetrans* nematodes identifies non-ribosomal peptide synthetases as biocontrol factors in the fungus *Clonostachys rosea*. Evolutionary Applications, 13 (9): 2264-2283. <https://doi.org/10.1111/eva.13001>.
* Zhang, Wei, Yu, Haiying, Lu, Yunxue, **Bushley, Kathryn**, Wickham, Jacob, Gao, Shenghan, Hu, Songnian, Zhao, Lilin, and Sun, Jianghua. 2020. Gene family expansion of pinewood nematode to detoxify its host defense chemicals. Molecular Ecology, 29 (5): 940-955. <https://doi.org/10.1111/mec.15378>.
* Strom, Noah, Hu, Weiming, Haarith, Deepak, Chen, Senyu, and **Bushley, Kathryn E.** 2020. Interactions between soil properties, fungal communities, the soybean cyst nematode, and crop yield under continuous corn and soybean monoculture. Applied Soil Ecology 147: Article 103388. <https://doi.org/10.1016/j.apsoil.2019.103388>.
* Hu, Weiming, Strom, Noah, Haarith, Deepak, Bushley, Chen, Senyu, and **Bushley, Kathryn E.** 2019. Seasonal variation and crop sequences shape the structure of bacterial communities in cysts of soybean cyst nematode. Frontiers in Microbiology. Front. Microbiology, 21 November 2019. [doi.org/10.3389/fmicb.2019.02671](https://doi.org/10.3389/fmicb.2019.02671).
* Strom, Noah, Hu, Weiming, Chen, Senyu, **Bushley, Kathryn E.** 2019.Corn and soybean host root endophytic fungi with toxicity towards the soybean cyst nematode. Phytopathology. Published Online 21 Oct 2019. [doi.org/10.1094/PHYTO-07-19-0243-R](https://doi.org/10.1094/PHYTO-07-19-0243-R).
* Strom, Noah, Hu, Weiming, Chen, Senyu, **Bushley, Kathryn E.** 2019. Continuous Monoculture Shapes Root and Rhizosphere Fungal Communities of Corn and Soybean Cyst Infested Soil. Phytobiomes. 5 November 2019. [doi.org/10.1094/PBIOMES-05-19-0024-R](https://doi.org/10.1094/PBIOMES-05-19-0024-R).
* Haarith, Deepak, Hu, Weiming, Kim, Dong-gyu, Showalter, David, Chen, Senyu, **Bushley, Kathryn E**. 2019. Culturable mycobiome of soya bean cyst nematode (Heterodera glycines) cysts from a long-term soya bean-corn rotation system is dominated by Fusarium. Volume 42, December 2019, 100857. [doi.org/10.1016/j.funeco.2019.08.001](https://doi.org/10.1016/j.funeco.2019.08.001).
* Olarte, R.A., Menke, J., Zhang Y., Sullivan, S., Slot, J. C., Huang, Y, J., Badalamenti, J. P., Quandt A.C., Spatafora, J.W., and **Bushley, K.E.** 2019. Chromosome Rearrangements Shape the Diversification of Secondary Metabolism in the Cyclosporin Producing Fungus Tolypocladium inflatum. BMC Genomics. 20, Article number: 120. [doi.org/10.1186/s12864-018-5399-x](https://bmcgenomics.biomedcentral.com/articles/10.1186/s12864-018-5399-x)
* Bajaj, Ruchika, Huang, Yinyin, Gebrechristos, Sebhat, Mikolajczyk, Brian, Brown, Heather, Prasad, Ram, Varma, Ajit, **Bushley, Kathryn E**. 2018. Transcriptional responses of soybean roots to colonization with the root endophytic fungus Piriformospora indica reveals altered phenylpropanoid and secondary metabolism. 2018. Nature Scientific Reports. 8(1); 10227. doi.org:10.1038/s41598-018-26809-3.
* Weiming Hu, Noah Strom, Deepak Haarith, Senyu Chen, and **Kathryn E. Bushley.** 2018. Mycobiome of Cysts of the Soybean Cyst Nematode Under Long Term Crop Rotation. Frontiers in Microbiology. [doi.org/10.3389/fmicb.2018.00386](https://doi.org/10.3389/fmicb.2018.00386).
* Yang, X. Q., Feng, P., Yin, Y., **Bushley, K.** Spatafora, J. W. Wang, C. S.  2018. Cyclosporine Biosynthesis in Tolypocladium inflatum Benefits Fungal Adaptation to the Environment. Mbio: 9(5): 14. doi.org:10.1128/mBio.01211-18.
* Siddhanta, S. Paidi, S., **Bushley, K.**, Prasad, R., Barman, I. 2017. Exploring morphological and biochemical linkages in fungal growth with label-free light sheet microscopy and Raman spectroscopy.  ChemPhysChem 18(1): 72-78. [doi.org/full/10.1002/cphc.201601386](https://onlinelibrary.wiley.com/doi/full/10.1002/cphc.201601386).
* Castell-Miller, C.V., Gutierrez-Gonzelez, J.J., Jin Tu, Z., **Bushley, K.E.,** Hainaut, M., Henrissat, B., Samac, D.A.. 2016. Genome Assembly of the Fungus Cochliobolus miyabeanus, and Transcriptome Analysis during Early Stages of Infection on American Wildrice (Zizania palustris L.).  PloS One 11 (6):e0154122. [doi.org/10.1371/journal.pone.0154122](https://doi.org/10.1371/journal.pone.0154122).
* Strom, N. and **Bushley, K.E**. 2016. Two genomes are better than one: history, genetics, and biotechnological applications of fungal heterokaryons. ﻿Fungal Biol Biotechnol 3:4. [doi.org/10.1186/s40694-016-0022-x](https://doi.org/10.1186/s40694-016-0022-x).
* Quandt, A.C., **Bushley, K. E.**, and Spatafora, J.W.  2015. The genome of the truffle-parasite Tolypocladium ophioglossoides and the evolution of antifungal peptiabiotics.  BMC Genomics, 16:553. [doi.org/10.1186/s12864-015-1777-9](https://bmcgenomics.biomedcentral.com/articles/10.1186/s12864-015-1777-9).
* Spatafora, J.W. and **Bushley, Kathryn E**. 2015. Phylogenomics and evolution of secondary metabolism in plant-associated fungi.  Current Opinion in Plant Biology, 26-37-44. [doi.org/10.1016/j.pbi.2015.05.030](https://doi.org/10.1016/j.pbi.2015.05.030).
* Bajaj, Ruchika, Hu, Weiming, Huang, Yin Yin, Chen, Senyu, Prasad, Ram, Varma, Ajit, **Bushley, Kathryn E.** 2015. The beneficial root endophyte Piriformospora indica reduces egg density of the soybean cyst nematode.  Biological Control 90: 193-199. [doi.org/10.1016/j.biocontrol.2015.05.021](https://doi.org/10.1016/j.biocontrol.2015.05.021).
* Yiling Lai, Keke Liu, Xinyu Zhang, Xiaoling Zhang, Kuan Li, Niuniu Wang, Chi Shu, Yunpeng Wu, Chengshu Wang, **Kathryn E. Bushley**, Meichun Xiang, Xingzhong Liu. 2014. Comparative genomics and transcriptomics analyses reveal divergent lifestyle features of nematode endoparasitic fungus Hirsutella minnesotensis.  Genome Biology and Evolution 6 (11): 3077-3093. doi.org: [10.1093/gbe/evu241](https://dx.doi.org/10.1093%2Fgbe%2Fevu241).
* **Kathryn E. Bushley**, Rajani Raja, Pankaj Jaiswal, Jason S. Cumbie, Mariko Nonogaki, Alexander E. Boyd, C. Alisha Owensby, Brian J. Knaus, Justin Elser, Daniel Miller, Yanming Di, Kerry L. McPhail, Joseph W. Spatafora. 2013. The Genome of Tolypocladium inflatum: Evolution, Organization and Expression of the Cyclosporin Biosynthetic Gene Cluster.  PLoS Genetics 9(6): e1003496. [doi.org/10.1371/journal.pgen.1003496](https://doi.org/10.1371/journal.pgen.1003496).
* **Kathryn E. Bushley**, Wenjing Wang, Yi Li, Xiao-liang Wang, Joseph W. Spatafora, and Yijian Yao.  2013. Isolation and characterization of the MAT1-1 mating type locus and evidence for selfing in the Chinese medicinal fungus Ophiocordyceps sinensis. Fungal Biology 117(9): 599-610. doi.org: 10.1016/j.funbio.2013.06.001.
* Bradford J. Condon, Yueqiang Leng, Dongliang Wu, **Kathryn E. Bushley**, Robin A. Ohm, Robert Otillar, Joel Martin, Wendy Schackwitz, Jane Grimwood, NurAinIzzati MohdZainudin, Chunsheng Xue, Rui Wang, Viola A. Manning, Braham Dhillon, Zheng Jin Tu, Brian J. Steffenson, Asaf Salamov, Hui Sun, Steve Lowry, Kurt LaButti, James Han, Alex Copeland, Erika Lindquist, Kerrie Barry, Jeremy Schmutz, Scott Baker, Lynda M. Ciuffetti, Igor V. Grigoriev, Shaobin Zhong, and B. Gillian Turgeon. 2013. Comparative genome structure, secondary metabolite, and effector coding capacity across Cochliobolus pathogens.  PLoS Genetics 9(1). doi.org: 10.1371/journal.pgen.1003233.
* **Bushley, Kathryn E.**and Turgeon, B. Gillian**.**2010. Phylogenomics reveals subfamilies of fungal nonribosomal peptide synthetases and their evolutionary relationships.  Evolutionary Biology 10:26. doi.org: 10.1186/1471-2148-10-26.
* **Bushley, Kathryn E.** and B. Gillian Turgeon.  2008. Module evolution and substrate specificity of fungal intracellular siderophore NRPS synthetases. [doi.org/10.1186/1471-2148-8-328](https://doi.org/10.1186/1471-2148-8-328).
* B. Gillian Turgeon, Shinichi Oide, **Kathryn E. Bushley**.  2008. Creating and screening Cochliobolus heterostrophus non-ribosomal peptide synthetase mutants. Mycological Research. 2008 Feb;112(Pt 2):200-6. [doi: 10.1016/j.mycres.2007.10.012](doi:%2010.1016/j.mycres.2007.10.012).

**MANUSCRIPTS IN REVIEW:**

* Tuuli-Marjaana Koski, Bin Zhang, Judith Mogouong, Hualing Wang, Zhenzhu Chen, Huiping Li, **Kathryn E. Bushley**, Jianghua Sun. Fungal community and metabolomic investigations reveal distinct ash metabolites shaping phloem fungal communities in ash trees (*Fraxinus* spp.) resistant and susceptible against highly invasive emerald ash borer (*Agrilus planipennis*). In review - New Phytologist.
* Hua-Ling Wang, Teng Lei, Xiao-Wei Wang, Stephen Cameron, Jesús Navas-Castillo, Yin-Quan Liu, M.N. Maruthi, **Kathryn E. Bushley**, John Colvin, Shu-Shen Liu. A comprehensive framework for the delimitation of species within the *Bemisia tabaci* cryptic complex, a global pest-species group. In review - Systematic Entomology.
* Stephen Rehner, Stephen, **Kathryn E. Bushley**, Allen Cavan. Lectotypification and epitypification of the insect pathogen *Metarhizium anisopliae*. In review - Taxon.
* Andrii P. Gryganskyi, Ann E. Hajek, Nataliya Voloshchuk, Alexander Idnurm, Jørgen Eilenberg, Romina Guadalupe Manfrino, **Kathryn E. Bushley**, Liudmyla Kava, Vira B. Kutovenko, Felicia Anike, Nie Yong. Potential use of species in the Erynioideae for biological control and biotechnology. In review - Microorganisms.

**BOOK CHAPTERS**

* Ruchika Bajaj, Ram Prasad, Ajit Varma, and **Kathryn E. Bushley.**  2017. The Role of Arbuscular Mycorrhizal Fungi and the Mycorrhizal-Like Fungus Piriformospora indica in Biocontrol of Plant Parasitic Nematodes in Mycorrhiza - Eco-Physiology, Secondary Metabolites, Nanomaterials, edited Ajit Varma, Ram Prasad, and Narendra Tuteja, Springer International Publishing, pp. 43-56.
* Turgeon, B. Gillian and **Bushley, Kathryn E.**  2009. Secondary metabolism. In Cellular and Molecular Biology of Filamentous Fungi, edited by K. Borkovich, D. Ebbole, M. Momany. ASM press pp. 376-395.

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**GRANT FUNDING**

***Current:***

**Agency:** NY Corn and Soybean Growers

**Title:** Harnessing Endophytic, Rhizosphere, and Nematode-colonizing Fungi for Control of the Soybean Cyst Nematode.

**PI:** Kathryn E. Bushley**, Co-PIs:** Xiaohong Wang

**Dates:** 11/01/2023 – 08/30/2024

**Total costs:** $79,950

**Agency:** USDA-NIFA – Agricultural Microbiomes.

**Title:** Microbial Interactions in the Soybean Cyst Nematode Suppressive Soil Microbiome.

**PI:** Kathryn E. Bushley, **Co-PIs:** Christine Salomon, Senyu Chen

**Dates:**  05/01/2021 – 04/30/2025

**Total costs:** $749,921

**Agency:** National Science Foundation

**Title:** Dimensions U.S.–China: The Role of Symbiotic Microbes in the Invasion Process of Emerald Ash Borer and Red Turpentine Beetle

**PI:** Kathryn Bushley, **Co-PIs:** Bob Blanchette, Brian Aukema

**Dates:** 01/01/2021 – 12/31/2025

**Total costs:** $1,443,950

**Agency:** Joint Genome Institute

**Title:** Defensive Mutualism of Fungal Root Endophytes of Soybean

**PI:** Kathryn Bushley

**Dates:** 11/01/2019-12/30/2025

**Direct/Total costs:** In kind genome, transcriptome, and metabolomics services

***Past:***

**Agency:** USDA Specialty Crops

Title: Developing novel tools to combat devastating potato pathogens

PI: Bob Blanchette, Co-PIs: Kathryn Bushley (USDA), Walter De Jong (Cornell), Louise-Marie Dandurand, Joanna Kud, Alexander Karasev (University of Idaho)

Dates: 06/01/2018 – 05/29/2022

**Direct/Total costs:** $37,000

**Agency:** Minnesota Terrestrial Invasive Plants and Pests Institute

Title: Studies of Fungi Associated with the Emerald Ash Borer: Finding effective biocontrol agents and elucidating the role of fungi during ash decline and mortality

PI: Bob Blanchette, Co-PIs: Kathryn Bushley

Dates: 06/01/2018 – 05/29/2021

**Direct/Total costs:** $499,629

**Agency:** Forever Green Initiative

**Co-PIs:** Kathryn Bushley and Senyu Chen

**Title:** Pennycress and Soybean Cyst Nematode: A Solution Oriented Approach

**Dates:** 05/01/2020 – 04/30/2021

**Total costs:** $184,717

**Agency:** Minnesota Terrestrial Invasive Plants and Pests Institute

Title: Distribution and Traits of the Fungal Pathogen *Fusarium virguliforme* that Influence Current and Future Risk to Soybean and other Legumes in Minnesota

**PI:** Dean Malvick, **Co-PIs:** Kathryn E. Bushley

**Dates:** 05/01/2017 – 04/30/2020

**Direct/Total costs:** $412,000

**Agency:** Forever Green Initiative

**Co-PIs:** Kathryn Bushley and Senyu Chen

**Title:** Pennycress and Soybean Cyst Nematode: A Solution Oriented Approach

**Dates:** 05/01/2020 – 04/30/2021

**Total costs:** $184,717

**Agency:** USDA-NIFA

**Title:** Characterization of microbial communities associated with cysts of the soybean cyst nematode (SCN) under long-term crop rotations.

**PI:** Kathryn E. Bushley, **Co-PIs:** Senyu Chen

**Dates:** 05/01/2015 – 04/30/2018

**Total costs:** $454,712

**PI:** Joseph W. Spatafora, **CoPIs:** Kathryn E. Bushley, Kerry McPhail, Mark Zabrinski

**Agency:** NSF Evolutionary Processes

**Title:** Understanding evolutionary similarity and diversification of complex pathways of soil fungi to synthesize compounds with diverse ecological, biological, and pharmaceutical functions.

**Dates:** 07/01/2014 – 06/30/2017

**Total costs:** $476,609

**Agency:** Minnesota Soybean Research & Promotion Council

Title: Development of Biocontrol Agents and Biopesticides for Control of SCN and SDS

PI: Kathryn E. Bushley, Co-PIs: Senyu Chen

Dates: 05/01/2019 – 04/30/2020

**Direct/Total costs:** $65,000

**Agency:** Minnesota Soybean Growers Association

**Title:** Development of Biocontrol agents and Biopesticides for control of SCN and SDS

**Name of PI:** Kathryn Bushley, **Co-PIs:** Senyu Chen

**Dates:** 05/01/2018-04/30/2019

**Direct/Total costs:** $65,000

**Agency:** Minnesota Soybean Research & Promotion Council

Title: Nematode Egg Parasites and Endophytes as Antagonists of Soybean Cyst Nematode and Sudden Death Syndrome

**PI:** Kathryn E. Bushley, **Co-PIs:** Senyu Chen

**Dates:** 05/01/2017 – 04/30/2018

**Direct/Total costs:** $65,000

**Agency:** Minnesota Soybean Research & Promotion Council

Title: Endophytic, Rhizosphere, and Nematode-colonizing Fungi for Control of the Soybean Cyst Nematode and Sudden Death Syndrome

**PI:** Kathryn E. Bushley, **Co-PIs:** Senyu Chen

**Dates:** 09/01/2016 – 08/31/2017

**Direct/Total costs:** $65,000

**PI:** Kathryn E. Bushley

**External Agency:** NSF Postdoctoral Fellowship

**Project title and Dates:** Towards Conservation and Sustainable Use: Genetic Diversity and Reproductive Mode of the Endangered Himalayan Fungus *Ophiocordyceps sinensis.*

**Dates:** 01/2011- 12/2013.

**Direct costs:** $141,100

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**AWARDS AND HONORS**

**NSF Postdoctoral International Research Fellowship** (Jan 2011 – Dec. 2013)

**NNEMS EPA Fellow** (Summer 1995)

**TEACHING**

**Cornell University**

Filamentous Fungal Genetics and Genomics PLPPM 6380 **–** 4 week module on fungal genomics (2022)

**University of Minnesota**

Genetics 4003- Spring 2016 and 2017, Fall 2017 – Fall 2020 (3 credits)

Freshman Seminar- Microbiomes (Fall 2014, 1 credit)

**Oregon State University**

Honor’s Seminar: Microbiomes and Host-Microbe Interactions (Fall 2013; 1 credit)

**Xishuangbanna Tropical Botanical Garden, Chinese Academy of Science**

Module on fungal ecology for Program for Field Studies in Tropical Asia **(**Fall 2011)

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**ADVISING AND MENTORING**

**Postdoctoral Researchers:**

` Jon Menke, 09/2014 – 12/2015, (Senior Research Scientist, Rebiotix, Roseville, MN)

Weiming Hu, 08/2015 – 10/2017, (Bioinformatician, The Children's Hospital of Philadelphia, Philadelphia, PA).

Ruchika Bajaj, 08/2016 – 05/2017 (Visiting Scientist from India)

David Showalter, 02/2018 – 06/2020 (State Initiatives Grant Coordinator, Oregon Department of Forestry, Salem, OR)

Noah Strom, 01/2020 – 12/2020 (Bioinformatics Team Lead, Diversigen, Brighton, MN)

Rodrigo Olarte, 05/2016 – 05/2021.

Judith Mogouong, 01/2022 – present

Emily Green, 03/2022 - present

**Graduate Students:** *Doctoral Students*: Claire Yager (2021- present), Noah Strom (2015 – 2019), Deepak Rajendran (Co-Advised with Dr. Senyu Chen - 2015-2020), Sean O’Mara (Co-Advised with Dr. Corby Kistler – 2014-2020), Monica Watson (Co-Advised with Dr. Georgiana May – 2014 - 2020), Ruchika Bajaj (PhD 2017, Amity University, India – External co-advisor). *Masters’ students*: Sebhat Gebrechristos, Dong-gyu Kim, Rebecca Hall (Co-Advised with Dr. Dean Malvick)

**Undergraduate Students:** Supervised two honors student theses and eleven undergraduate directed research or undergraduate research opportunity projects. A Cornell have supervised five undergraduate researchers.

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**INVITED TALKS**

***Conference Proceedings***

Donggyu Kim, Deepak Haarith, Noah Strom, Dong, Zhou, **Kathryn E. Bushley**. Killing them softly: putting the fungal squeeze on cyst nematodes. 91st Annual Meeting of the Mycological Society of America, Flagstaff, AZ, July 30-Aug. 2, 2023.

Donggyu Kim, Deepak Haarith, Noah Strom, Christine Salomon, **Kathryn E. Bushley**. Nematode Parasitic Fungi for Biological Control of Soybean Cyst Nematode. National Soybean Cyst Nematode Conference, Savannah, Georgia, Dec. 14-16, 2022.

David Showalter, Stephen Rehner, **Kathryn E. Bushley**. Comparative genomics of the entomopathogenic genus Beauveria. Annual Meetings of the Mycological Society of America. Gainesville, Florida. July 10-14, 2022.

**Kathryn E. Bushley** and Joseph W. Spatafora. The non-model insect pathogenic fungus *Tolypocladium inflatum* as a platform for discovery of novel pharmaceuticals, agrochemicals, and chitin and alkane degrading enzymes. Society for Industrial Microbiology and Biotechnology. Society of Industrial Microbiology and Biotechnology, Austin, Texas (Virtual). 08/11/2021.

Rajiv Darnipragada, Ruchika Bajaj, and **Kathryn E. Bushley**.Infection of *Spodoptera frugiperda* with the entomopathogenic fungus *Beauveria bassiana*. 06/29/21. Society for Invertebrate Pathology International Congress on Invertebrate Pathology and Microbial Control. Virtual. 06/29/2021.

Rodrigo Olarte\*, Jon Menke\*, Ying Zhang, Shawn Sullivan, Jason Slot, Yinyin Huang, Jonathan Badalamenti, Alisha Quandt, Joseph Spatafora and **Kathryn E. Bushley.** Chromosomal rearrangements drive evolution of secondary metabolic gene clusters in the Entomopathogenic Fungus *Tolypocladium inflatum.* Plant and Animal Genomes XXVIII, San Diego, CA. 01/12/2020.

**Kathryn E. Bushley.** Comparative genomics of secondary metabolism in the entomopathogenic genus *Beauveria.* World Cordyceps Forum. Beijing, China. 05/30/2019.

**Kathryn E. Bushley.** Genomic signatures of nematode parasitism. Mycological Society of America Meetings. Minneapolis, MN. August 10-14, 2019.

**Kathryn E. Bushley.** Diversity and evolution of fungal parasites and symbionts of nematodes. Fungal Genetics Conference, Asilomar California. March 12-17, 2019.

**Kathryn E. Bushley.** Genetic mechanisms generating population level variation in secondary metabolism. International Mycological Congress. San Juan, Puerto Rico, July 16-21, 2018.

**Kathryn E. Bushley.** Comparative genomics of secondary metabolism in insect and nematode pathogens. Mycological Society of America Meeting, Athens, GA. July 16-19, 2017.

**Kathryn E. Bushley.** Evolution of secondary metabolism and host association in insect pathogens.Fungal Genetics Conference, Asilomar, CA. March 14-19, 2017.

**Kathryn E. Bushley**. Mechanisms of population genomic variation in secondary metabolism. Mycological Society of America, Berkeley, CA. August 7-11, 2016.

**Kathryn E. Bushley**. Fine-scale evolution of fungal secondary metabolism. Fungal Genetics Meetings, Asilomar, CA, USA. March 17-22, 2015.

**Kathryn E. Bushley**. The secondary metabolome of *Tolypocladium inflatum*: Roles in insect pathogenesis. International Mycological Congress, Bangkok, Thailand. August 3-8, 2014.

**Kathryn E. Bushley** and Joseph W. Spatafora, 2014. Secondary metabolites in fungi: Evolution of genes and clusters. Invited oral presentation. Mycological Society of America Annual Meeting. East Lansing, MI.

**Kathryn E. Bushley,** 2013. Fungal host-association as a driver of metabolic diversity. Asian Mycological Congress. August 19-23, 2013. Beijing, China.

**Kathryn E. Bushley** and Joseph W. Spatafora**,** 2012. Convergent and divergent evolution of nonribosomal peptide synthetases. Invited oral presentation. Mycological Society of America. New Haven, CN.

**Kathryn E. Bushley**. 2011. Genome sequencing of the cyclosporin producer *Tolypocladium inflatum.* Invited oral presentation. 2nd Meeting of the Chinese Fungal Genome Initiative. Kunming, China.

**Kathryn E**. **Bushley**, 2011. Hybrid genomes sequencing of the insect pathogen *Tolypocladium inflatum*. Invited Oral presentation. Asian Mycological Congress. Incheon, Korea.

**Kathryn E**. **Bushley** and Turgeon, B. Gillian, 2009. Evolution of fungal NRPSs: Generating chemical diversity. Invited oral presentation. Fungal Genetics Meeting. Asilomar, CA.

***Invited Seminars and Lectures at Academic or Other Institutions***

**Kathryn E. Bushley.** Invertebrate pathogens of the ARSEF culture collection, Invertebrate Pathology Course, Cornell University, Dept. of Entomology. 11/2022.

**Kathryn E. Bushley.** Genomic signatures of fungal parasitism of invertebrate hosts. Cornell University, PPPMB Seminar Series. 11/03/2021**.**

**Kathryn E. Bushley.** Of Beetles and (Wo)men: The evolution of immunosuppressants and virulence factors in fungal pathogens of invertebrates. University of Wisconsin, Medical Microbiology and Immunology Seminar Series. 03/26/2021**.**

**Kathryn E. Bushley.** Mining the genomes of nematode parasitic fungi for biological control. University of California, Riverside, Department of Nematology Seminar Series. 03/22/2021**.**

**Kathryn E. Bushley**. Mining the genomes of nematode parasitic fungi for biological control. Michigan State University, Molecular Plant Sciences Program Seminar Series. 11/30/2020.

**Kathryn E. Bushley.** Diversity of entomopathogenic fungi**. University of Minnesota, Fungal Biology course.** 04/23/2019.

**Kathryn E. Bushley.** Genomics of insect and nematode pathogens. Cornell University, Department of Plant Pathology Seminar Series. **11/01/2017.**

**Kathryn E Bushley.** Fungi for biocontrol of insect and nematode pathogens. University of Minnesota, Plant Pathology Seminar Series. **10/09/2017.**

**Kathryn E Bushley.** Genomics of insect pathogens. Institute of Microbiology, Chinese Academy of Sciences, Key Laboratory of Mycology, Beijing, China. 06/12/17.

**Kathryn E. Bushley.** Entomopathogenic fungi**. University of Minnesota, Fungal Biology course.** 04/06/2017.

**Kathryn E. Bushley,** 09/23/2016. Population variation in secondary metabolism in *Beauveria bassiana*. Indian River Research and Education Center, University of Florida.

**Kathryn E. Bushley,** 04/23/2015. Entomopathogenic fungi**. University of Minnesota, Fungal Biology course.**

**Kathryn E. Bushley,** March 2015. Genomics of insect pathogenic fungi**. University of Minnesota, Ecology and Evolutionary Biology seminar series.**

**Kathryn E. Bushley,** 2011. **Genome sequence of an insect pathogenic fungus. Xishuangbanna Tropical Botanical Garden, CAS seminar series.**

**Kathryn E. Bushley**, 2010. Genomics of insect pathogenesis. Oregon State University. Department of Botany and Plant Pathology, Departmental Seminar.

**Kathryn E. Bushley**, 2008. Structural and functional evolution of nonribosomal peptide synthetases in fungi. Cornell University, Department of Plant Pathology, Departmental Seminar.

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**SYNERGISTIC ACTIVITY**

***Editorial and Reviewing***

Editor for Fungal Genetics and Biology and Frontiers in Microbiology.

Reviewer for PLoS Biology, PLoS Genetics, PLoS Pathogens, PLoS One, Nature Scientific Reports, New Phytologist, Biological Conservation, BMC Genomics, BMC Molecular Biology, FEMS Microbiology Letters, International Society of Microbial Ecology (ISME), Microbiome, Applied and Environmental Microbiology, Frontiers in Microbiology, Fungal Biology, Fungal Genetics and Biology, Molecular Plant-Microbe Interactions, Phytobiomes, Microbiology, Mycological Research, Mycologia, Canadian Journal of Microbiology, Current Opinion in Genetics and Development, Protoplasma, Symbiosis.

***Society Service and Committee memberships***

Specific Expertise Committee on Genetics & Cell Biology, Mycological Society of America (2014-2018)

Councilor, Genetics and Molecular Biology, Mycological Society of America (2015-2017) and (2019 -2021)

***Review panels for external funding agencies, foundations, etc.***

-JGI Community Science Program (CSP): New Investigators – Eukaryotes, December 1, 2023

***-***USDA-NIFA SBIR 8.2 Plant Production and Protection-Biology -- Panel B, January, 2023

*-*USDA-NIFA Agricultural Microbiomes, September, 2021

***-***DOE BER Sustainable Bioenergy Crop program, March 2015

-NSF-IOS Symbiosis and Self Defense pre-proposal panel (April, 2015) and ad-hoc reviewer for full panel (October, 2015)

***-***Ad-hoc reviewer for NSF-DEB - Biodiversity: Discovery &Analysis Panel (October 2016) and NSF-DEB IEP panel (Fall 2016).

-Science Themes Call at the Environmental Molecular Sciences Laboratory (EMSL) DOE facility, Richland, WA (May 2014)

***Outreach Activities***

***-*SYMBiota Website/Blog**. <https://blogs.cornell.edu/beetlebiome/>. Summer 2023 – present. Host a blogsite on our project investigating microbes associated with emerald ash borer.

**-Ithaca Farmer’s Market.** Ithaca, NY**.** July 15, 2023. Postdoc and graduate student in lab led an interactive table with specimens and one-page handouts on invasive forest insects.

-**Cornell Soil Health Day**, Senaca Falls, NY. July 13, 2023. Biological Control of the Soybean Cyst Nematode, An Emerging Pest in NY. Oral presentation to ~100 growers at NY Soil Health field day.

-**NY Invasive Species Week**, Ithaca, NY. June 10, 2023. Led an interpretive walk on the life-cycle and management of emerald ash borer at our field site in Stewart Park, Ithaca, NY.

-**Expanding Your Horizons (EYH).** Cornell University, Ithaca, NY. April 1, 2023. Hosted an interactive exhibit/table on fungal parasites of the soybean cyst nematode.

-**Ag-EXPO,** Mankato, MN. January 2017, 2019 and 2020.Presented poster and presented project investigating fungi parasitizing the SCN and live microscope display of nematode eggs to corn and soybean growers.

**-Waseca Field Days,** Waseca, MN.September 2018, 2019**.** Presented a poster, video, and live demonstrations of nematodes and potential fungal biocontrol agents to wider Waseca community and soybean growers.

-**Café Scientifique**. Bell Museum, St. Paul, MN. 10/18/2016. Presented “The Fungi Around Us – Diversity, Ecology, and Industrial Applications” with graduate student Kat Sweeney on wood degrading and insect pathogenic fungi. <https://www.youtube.com/watch?v=-fdg5OoSA0o>.

-**Bridge to Research Experiences for Undergraduates (REU).** Fall 2015**.** Faculty Mentor. Program of LSAMP North Star STEM Alliance designed to broaden participation of underrepresented students in science, technology, engineering, and mathematics by providing mentoring, tools, and guidance in contacting faculty and applying for undergraduate research opportunities.

**-Intel International Science and Engineering Fair** (<https://student.societyforscience.org/intel-isef>). Academic Year 2015-2016. Mentored a high school student to work on a project investigating infection of insects with the fungus *Beauveria bassiana.* He was selected to attend the state-wide competition and poster presentation and is currently a medical student at UM.

**-NSF-East Asia and Pacific Summer Institute (EAPSI).** Beijing, China**.** June 2017.Participated in orientation for graduate student summer fellows in June 2017 to share research fellowship experience and perspectives on living and working in China with incoming EAPSI summer fellows and served as a moderator for discussion session on “Building sustainable long-term collaborations between Chinese and U.S. young scholars for the **6th U.S.-China Young Scientist Forum**. Beijing, China. August 2014.