Christopher D. Muir

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Born: July 2, 1984 — Reston, Virginia
Nationality: USA

Current position

2019 - *Assistant Professor*
Interim Director - Joseph F. Rock Herbarium
School of Life Sciences
University of Hawai'i at Mānoa
Honolulu, Hawai'i, USA

Graduate Faculty member in Ecology, Evolution, and Conservation Biology program
Cooperating Graduate Faculty member of Tropical Plant and Soil Sciences

Areas of specialization

Evolutionary Biology; Plant Ecophysiology; Quantitative Biology

Past Appointments

2017 - 2018 *Scientist* – Biological Statistics for Global Agronomy
Novozymes Inc.
Durham, North Carolina, USA

Novozymes develops biological solutions to improve yield and make crops more sustainable. I lead data science for the global field trial program to commercialize new agricultural products. I developed computational workflows to process, analyze, and interpret large datasets for stakeholders.

2017 *Computational Biologist*
Poisson Consulting Ltd.
Vancouver, Canada

I helped conserve natural resources in Canada through statistical consulting for industrial and government clients. I developed open source software in R to analyze and make sense of large ecological datasets using Bayesian statistical approaches.

2015 - 2017 *Postdoctoral Researcher*
Departments of Botany and Zoology
University of British Columbia
Vancouver, Canada

2013 - 2015 *Biodiversity Postdoctoral Fellow*
Biodiversity Research Centre
University of British Columbia
Vancouver, Canada

As a postdoctoral researcher I studied fundamental problems in the evolution and ecology of biodiversity. My funding provided extraordinary independence to develop and pursue my research interests in evolutionary physiology using theory, computational approaches, phylogenetic comparative methods, and field experiments.

Education

2013 PhD in Evolutionary Biology (Geology minor)
Indiana University
Bloomington, Indiana, USA

2006 BS in Biology (Economics minor)
College of William and Mary
Williamsburg, Virginia, USA

Grants, Awards, & Fellowships

Major Grants and Fellowships

Awarded

2023 NIH COBRE Integrative Center for Environmental Microbiomes and Human Health Pilot Project

"An experimental system to test how aerosols and leaf anatomy shape the plant microbiome" PI **Muir** ($61,296)

2022–2025 NSF DEB Bridging Ecology and Evolution

"Collaborative Research: BEE: Integrating evolutionary genetics and population ecology to detect contemporary adaptation to climate change across a species range" with lead PI Seema Sheth, PI **Muir**, PI Lluvia Flores-Renteria, PI Jason Sexton, and PI Jeff Diez. $1,452,695 ($220,404 to UHM)

2022–2025 NSF DBI

"Preserving Rare and Endemic Hawaiian Specimens in the Joseph F. Rock Herbarium Through Digitization." PI **Muir** (originally awarded to Karolina Heyduk). $148,882.

2020–2022 NSF EPSCoR RII Track 4

"Penetrating the inner lives of leaves to breed water-wise crops using math, 3D imaging, and experiments." PI **Muir**, $133,971

2013 - 2015 Biodiversity Postdoctoral Fellowship (UBC, $100,000)
2008 - 2012 NSF Graduate Research Fellowship ($120,000)

Awards

2020 Emerging Leader Award (Botanical Society of America)
Early Career Open Science Award (*Annals of Botany PLANTS*)

Small Grants and Fellowships

2022 UHM UROP Faculty Mentoring Award ($9,380)
2021 SEED Inclusion, Diversity, Equity, Access and Success ($1,000)
2020 Test proposal at the Paul Scherrer Institute, Switzerland ($22,000)
UHM UROP Faculty Mentoring Award ($4,452)
UHM Office of Vice Chancellor of Research Faculty Travel Award ($1,779)
2019 UHM Office of Vice Chancellor of Research Faculty Travel Award ($2,000)
pre-2019 Total of $48,100

Publications (34 peer-reviewed publications; 18 as (co-)first or corresponding author; 2 in-review)

Peer-reviewed Publications

2023 **Muir CD***, MÀ Conesa, J Galmés, VA Pathare, P Rivera, R López, T Terrazas, D Xiong. How important are functional and developmental constraints on phenotypic evolution? An empirical test with the stomatal anatomy of flowering plants. Accepted at *The American Naturalist*. article preprint code data

Muir CD*. Technical comment on 'Negative-assortative mating for color in wolves'. *Evolution* 77(2):627-632. article preprint code

2022 **Muir CD***, CL Van Den Elzen, AL Angert. Selection on early survival does not explain germination rate clines in *Mimulus cardinalis*. *The American Journal of Botany* 109(11):1811-1821. article preprint code data

Gorné LD, *et al.* (author 6 of 13). The acquisitive-conservative axis of leaf trait variation emerges even in homogeneous environments. *Annals of Botany* 129(6):709-722. article

Kajihara KT, CP Egan, SOI Swift, CB Wall, **CD Muir**, NA Hynson. Core arbuscular mycorrhizal fungi are predicted by their high abundance occupancy relationship while host specialists are rare and geographically structured. *New Phytologist* 234(4): 1464-1476. article code

2021 Stinziano JR, C Roback, D Gamble, BK Murphy, PJ Hudson, **CD Muir***. Principles of resilient coding for plant ecophysiologists. *AoB PLANTS* 13(5):plab059. article preprint cran (* corresponding author)

Neto-Bradley BM, **CD Muir**, J Whitton, MW Pennell. Phylogenetic history of vascular plant metabolism revealed using a macroevolutionary common garden. *Proc R Soc B* 288: 20210605. article code data

Egan CP, J Koko, **CD Muir**, G Zahn, SOI Swift, AS Amend, NA Hynson. Restoration of the mycobiome of the endangered Hawaiian mint *Phyllostegia kaalaensis* increases its pathogen resistance. *Fungal Ecology* 52: 101070. article code

Bontrager M, T Usui, JA Lee-Yaw, DN Anstett, HA Branch, AL Hargreaves, **CD Muir**, AL Angert. Adaptation across geographic ranges is consistent with strong selection in marginal climates and legacies of range expansion. *Evolution* 75: 1316-1333. article preprint data

Nelson TC*, **CD Muir***, A Stathos*, DD Vanderpool, K Anderson, AL Angert, L Fishman. Quantitative trait locus mapping reveals an independent genetic basis for joint divergence in leaf function, life-history, and floral traits between scarlet monkeyflower (*Mimulus cardinalis*) populations. *American Journal of Botany* 108: 844-856. article preprint (* equal contribution)

Richardson AD, DM Aubrecht, D Basler, K Hufkens, **CD Muir**, L Hanssen. Developmental changes in the reflectance spectra of temperate deciduous tree leaves, and implications for thermal emissivity and leaf temperature. *New Phytologist* 229: 791-804. article

2020 **Muir CD**. A stomatal model of anatomical tradeoffs between gas exchange and pathogen colonization. *Frontiers in Plant Science* 11: 518991. article preprint code

Conesa MÀ, **CD Muir**, A Molins, J Galmés. Stomatal anatomy coordinates leaf size with Rubisco kinetics in the Balearic *Limonium*). *AoB PLANTS*. 12: plz050. article code

Kattge J *et al.* (author 447 of 724). TRY plant trait database - enhanced coverage and open access. *Global Change Biology* 26: 119-188. article

2019 **Muir CD**. tealeaves: an R package for modelling leaf temperature using energy budgets. *AoB PLANTS*. 11: plz054. article preprint code cran

Lowry DB *et al.* (author 23 of 37). The case for the continued use of the genus name *Mimulus* for all monkeyflowers. *Taxon* 68: 617-623. article

Muir CD. Is amphistomy an adaptation to high light? Optimality models of stomatal traits along light gradients. *Integrative & Comparative Biology* 59: 571–584. article preprint code

Bontrager M, **CD Muir**, AL Angert. Geographic and climatic drivers of reproductive assurance in *Clarkia pulchella*. *Oecologia* 190: 59-67. article preprint code

2018 **Muir CD**. Light and growth form interact to shape stomatal ratio among British angiosperms. *New Phytologist* 218: 242-52. article preprint code data

2017 **Muir CD** & AL Angert. Grow with the flow: a latitudinal cline in physiology is associated with more variable precipitation in *Erythranthe cardinalis*. *Journal of Evolutionary Biology* 30: 2189-203. article preprint code data

Conesa MÀ, **CD Muir**, EJ Roldán, A Molins, JA Perdomo, J Galmés. Growth capacity in wild tomatoes and relatives correlates with original climate in arid and semi-arid species. *Environmental and Experimental Botany* 141: 181–90. article

Guerrero RF, **CD Muir**, S Josway, LC Moyle. Pervasive antagonistic interactions among hybrid incompatibility loci. *PLoS Genetics* 13: e1006817. article preprint

Muir CD, MÀ Conesa, EJ Roldán, A Molins, J Galmés. Weak coordination between leaf structure and function among closely related tomato species. *New Phytologist* 213: 1642-53. article preprint data

2015 **Muir CD** & M Thomas-Huebner (undergraduate coauthor). Constraint around quarter-power allometric scaling in wild tomatoes (*Solanum* sect. *Lycopersicon*; Solanaceae). *The American Naturalist* 186: 421-33. article data

Muir CD. Making pore choices: repeated regime shifts in stomatal ratio. *Proc R Soc B* 282: 20151498. article preprint data

2014 **Muir CD** & MW Hahn. The limited contribution of reciprocal gene loss to increased speciation rates following whole genome duplication. *The American Naturalist* 185: 70-86. article data

Muir CD, JB Pease, LC Moyle. Quantitative genetic analysis indicates natural selection on leaf phenotypes across wild tomato species (*Solanum* sect. *Lycopersicon*; Solanaceae). *Genetics* 198: 1629-43. article data

Muir CD, RP Hangarter, LC Moyle, PA Davis. Morphological and anatomical determinants of mesophyll conductance in wild relatives of tomato (*Solanum* sect. *Lycopersicon* and sect. *Lycopersicoides*). *Plant, Cell &Environment* 37: 1415-26. article

2013 **Muir CD**. How did the Swiss cheese plant get its holes? *The American Naturalist* 181: 273-81. article

2012 Hahn MW, BJ White, **CD Muir**, NJ Besansky. No evidence for biased co- transmission of speciation islands in Anopheles gambiae. *Phil. Trans. R. Soc. B* 367: 374-84. article

2010 Moyle LC & **CD Muir**. Reciprocal insights into adaptation from agricultural and evolutionary studies in tomato. *Evolutionary Applications* 3: 409-21. article

Moyle LC, **CD Muir**, MV Han, MW Hahn. The contribution of gene movement to the 'Two Rules of Speciation'. *Evolution* 64: 1541-57. article

2009 **Muir CD** & LC Moyle. Antagonistic epistasis for ecophysiological trait differences between *Solanum* species. *New Phytologist* 183: 789-802. article

Wilczek AM *et al.* (author 7 of 18). Effects of genetic perturbation on seasonal life history plasticity. *Science* 323: 930-4. article

Preprints

Liu C*, **CD Muir***, Y Li, J Zhang, G Yu, L Xu, M Li, Z Zhang, HJ de Boer, L Sack, X Han, N He. Scaling between stomatal size and density in forest plants. In revision. RX preprint (* equal contribution)

Bontrager M, **CD Muir**, C Mahony, DE Gamble, RM Germain, AL Hargreaves, EJ Kleynhans, KA Thompson, AL Angert. Climate warming weakens local adaptation. In revision. RX preprint

Open-source Software

tealeaves: Solve for Leaf Temperature Using Energy Balance
github cran

photosynthesis: Model C_3 Photosynthesis
github cran

gunit: Converts Conductance Units
github cran

smbr: R package to facilitate analyses using STAN
github

Talks

Invited Seminars (29 since 2012)

2023 University of Wisconsin, Madison, Botany, *Adaptation past and present: lessons from stomatal macroevolution and contemporary responses to climate change*.

California State University, Chico, Biological Sciences, *Adaptation past and present: lessons from stomatal macroevolution and contemporary responses to climate change*.

2021 University of Richmond, Department of Biology, *Global syntheses of stomatal evolution and local adaptation*.

University of California, Davis, Department of Plant Biology, *Global syntheses of stomatal evolution and local adaptation*.

University of Mississippi, *Global syntheses of stomatal evolution and local adaptation*.

Carleton University, *Global syntheses of stomatal evolution and local adaptation*.

University of Hawai'i at Mānoa, Department of Natural Resources and Environmental Management, *Global patterns of stomatal evolution and local adaptation*.

2020 University of California, Berkeley, Botany Lunch Seminar, *Global patterns of stomatal evolution and local adaptation*

2019 University of Hawai'i at Mānoa, Ecology, Evolution and Conservation Biology Evoluncheon Series, *Climate anomalies are altering local adaptation*.

University of Hawai'i at Mānoa, Department of Tropical Plant and Soil Sciences, *Global patterns of stomatal evolution and local adaptation*.

University of Hawai'i at Mānoa, Department of Tropical Plant and Soil Sciences, *Synthesizing evolution and ecophysiology using leaves, trees, and math*.

2018 University of Hawai'i at Mānoa, Department of Botany, *Synthesizing evolution and ecophysiology using leaves, trees, and math*.

Michigan State University, *Evolving resilience: Lessons from the ecophysiology of crop cousins and other wild plants*.

2017 University of Virginia, *How and Why? Synthesizing Evolution and Physiology*.
Rice University, *How and Why? Synthesizing Evolution and Physiology*.
Purdue University, *How and Why? Synthesizing Evolution and Physiology*.

2016 University of Arizona, *How and Why? Synthesizing Evolution and Physiology*.
University of Arkansas, *How and Why? Synthesizing Evolution and Physiology*.
University of Wyoming, *How and Why? Synthesizing Evolution and Physiology*.
University of Pittsburgh, *How and Why? Synthesizing Evolution and Physiology*.

2015 Virginia Tech, *How and Why? Synthesizing Evolution and Physiology*.
University of Texas, Arlington, *How and Why? Synthesizing Evolution and Physiology*.
University California, Davis, *How and Why? Synthesizing Evolution and Physiology*.
Purdue University, *Is it time for an evolutionary physiological synthesis, yet?*.

2014 ETH Zürich, *The physiology and genetics of adaptation*.
Simon Fraser University, *Phenotypic variation and constraint*.
Harvard University Herbarium, *Why do some plants have stomata on both leaf surfaces?*.
University of British Columbia, *Is it time for an evolutionary physiological synthesis, yet?*.
Michigan State University, *Is it time for an evolutionary physiological synthesis, yet?*.

2012 University of Virginia EEBio Seminar, *Through thick and thin: the adaptive significance of leaf trait variation in wild tomatoes*.

Invited Conference Presentations

2021 **Muir CD**. *Emerging Leader Lecture: Eons of pore decisions: how selection shapes the stomatal morphospace*. *Botany*. Virtual!

2019 **Muir CD**. *Synthesizing evolution and ecophysiology using leaves, trees, and math*. Society for Integrative and Comparative Biology, Tampa, Florida, USA.

2016 **Muir CD**. *What is evolutionary physiology?*. Evolution, Austin, Texas, USA.

2012 **Muir CD**. *Functional and genetic analysis of leaf traits associated with drought in wild tomatoes* (Poster). Ecological Genomics Symposium, Kansas City, Missouri, USA.

Contributed Conference Presentations

2022 Bonn-Savage, MA, **CD Muir**, KE Barton. Genetic variation in ontogenetic patterns in leaf anatomical traits in a long-term field experiment. *Botany*. Anchorage, Alaska.

Muir CD, A Bonnin, TN Buckley, MÀ Conesa, J Galmés, S McKlin, DA Rippner, M Schmeltz, G Théroux-Rancourt. Finding genes responsible for evolution of complex 3D leaf anatomy using tomographic microscopy. *Botany*. Anchorage, Alaska.

2021 **Muir CD**, SN Sheth, AL Angert. How will climate change affect the variance in fitness? An empirical test in the perennial herb *Mimulus cardinalis*. *Society for Integrative and Comparative Biology*. Virtual!

2020 **Muir CD**. Independent evolution of ab-and adaxial stomatal density enables adaptation. *Botany*. Virtual!

Bontrager M, **CD Muir**, C Mahony, DE Gamble, RM Germain, AL Hargreaves, EJ Kleynhans, KA Thompson, AL Angert. Climate anomalies are altering local adaptation. *Society for Integrative and Comparative Biology*. Austin, Texas.

2019 **Muir CD**. Open source computational tools for plant ecophysiology. *SACNAS*. Honolulu, Hawai'i.

This presentation is part of the symposium *Ahupua'a: From the mountains to the ocean. Desde la montaña hasta el océano* co-organized by Rosana Zenil-Ferguson, Emily Sessa, and myself.

Muir CD. Poster: Assimilation *in silico* and in practice: Open source computational tools for simulating CO_2 assimilation and fitting models to data. *Gordon Research Conference: CO_2 Assimilation in Plants from Genome to Biome*. Newry, Maine.

2017

Conesa MÀ, **CD Muir**, EJ Roldán, JJ Piguero-Pina, A Molins, J Galmés. Poster: Adaptive strategies in tomato wild relatives: sources to adapt tomato crop to more water-restrictive cultivation conditions. *XIV Solanaceae and 3rd Cucurbitaceae Joint Conference*. Barcelona, Spain.

2015 **Muir CD** & M Thomas-Huebner. Constraint around quarter-power allometric scaling in wild tomatoes. *Botany*, Edmonton, Alberta, Canada

2014 **Muir CD**, JB Pease, LC Moyle. Connecting macroevolution to the genetics of adaptation: a case study using stomatal ratio. *Evolution*, Raleigh, North Carolina, USA

Muir CD. Pore choices: the adaptive significance of stomatal ratio. *American Society of Naturalists*, Asilomar, California, USA

2013 **Muir CD**. Pore choices: the adaptive significance of stomatal ratio. *Evolution*, Snowbird, Utah, USA

Muir CD. Poster: Functional and genetic analysis of leaf traits associated with drought in wild tomatoes. *Society of Integrative and Comparative Biology*, San Francisco, California, USA

2012 **Muir CD**. Through thick and thin: the adaptive significance of leaf trait variation in wild tomatoes. *Evolution*, Ottawa, Ontario, Canada

2010 **Muir CD**. Genetics of drought adaptation in wild tomatoes. *Evolution*, Portland, Oregon, USA

2008 Evolution, Minneapolis, Minnesota, USA

2006 Evolution, Stony Brook, New York, USA

Professional Activities, Affiliations & Outreach

Editor

2016 - 2017 Axios Review

External Grant Reviews

2023 NSF BIO Integrative Organismal Systems (panelist)
NSF BIO Division of Environmental Biology (panelist)
French National Research Agency evaluation panel "Living earth" (ad hoc)
2017 NSF BIO Integrative Organismal Systems (ad hoc) Austrian Science Fund (FWF)
2016 NSF BIO Division of Environmental Biology (ad hoc)

Manuscript Reviews

American Journal of Botany; American Naturalist; Annals of Botany; AoB PLANTS; Applications in Plant Sciences; Botany; Current Biology; Ecology; Evolution; Global Ecology and Biogeography; International Journal of Plant Sciences; Journal of Evolutionary Biology; Methods in Ecology and Evolution; Molecular Biology and Evolution; Molecular Ecology; Nature Climate Change; Nature Ecology and Evolution; New Phytologist; Photosynthesis Research; Physiologia Plantarum; Plant, Cell & Environment; Plant Physiology; PLOS Biology; PLOS ONE; Proceedings B; Scientific Reports; Theoretical Population Biology

University Service

2023	Botany Graduate Admissions Committee
	Life Sciences Funding and Fellowship Committee Member
	Life Sciences Seminar Committee Member
	EECB Fellowship Reviewer
2022	Quantitative Biologist Faculty Search Committee
	Faculty Search Procedure
	Life Sciences Assessment Committee Member
	Life Sciences Funding and Fellowship Committee Member
	Life Sciences Seminar Committee Member
	EECB Fellowship Reviewer
2021	Life Sciences Assessment Committee Member
	Life Sciences Funding and Fellowship Committee Member
	EECB Fellowship Reviewer
2020	Life Sciences Diversity, Equity, and Inclusion Committee Member
	Life Sciences Workload Committee Member
	Global Change Botanist Faculty Search Committee
	Botany Graduate Admissions Committee
	Life Sciences Building Space Governance Committee
2019	School of Life Sciences Instructional Workload Survey Committee
	Botany department scholarship reviewer
2014 - 2015	Organized UBC Biodiversity Lunchtime Internal Seminar Series (BLISS)

Professional Service

2022	Workshop on "Common methods in leaf gas-exchange research: an introduction to measurements, theory, and data analysis" at Botany 2022
	SICB Division of Botany Best Poster competition judge
2021	SICB Division of Botany Best Poster competition judge
	Botanical Society of America PLANTS Mentor
2019 - 2021	Secretary, Division of Botany, Society for Integrative and Comparative Biology (SICB)
2020	SICB Rising Star in Organismal Botany competition judge
2013 - 2015	Co-organizer SFU/UBC/UVic Ecology and Evolution Retreat

Professional Society Memberships

- Society for the Study of Evolution
- The American Society of Naturalists
- Botanical Society of America
- Society for Integrative and Comparative Biology

Mentorship & Teaching

Certificate in Effective Instruction

2023 Association of College and University Educators

This certificate signifies my completion of a 25-module course in effective teaching practices requiring the implementation of evidence-based instructional approaches. The credential is co-issued by the American Council on Education and distinguishes faculty for their commitment to educational excellence and student success.

Graduate Student Committees

Current

Dachuan (Frank) Wang (chair)
Kelvin Awori (UGA Crop & Soil Sciences, member)
Ana Flores (member)
Nathan Fumia (UH TPSS, member)
Allie Hall (member)
Francisca Rodriguez (member)

Former

Devon DeBevoise (member)
Caitlyn Genovese (member)
G Young Kim (interim member) Lauren Nerfa (interim member)
Ikenna Nometa (UH Mathematics, member)
Joani Viliunas (interim member)

Undergraduate Thesis Committees

Genevieve Triplett (chair)
Amanda Wong (member)

Undergraduate mentorship

2023 Luke Sparreo (UH Mānoa)
2022 Paul Yamane (UH Mānoa)
Awarded UHM UROP project funds ($3,000)
Lily Rogers (UH Mānoa)
Joana Kim (UH Mānoa)
Justin Alter (UH Mānoa)
Jenna Matsuyama (UH Mānoa)
Kai Yasuda (UH Mānoa)
2021 McKenna Bonn-Savage (UH Mānoa)
Ezikio Quintana (UH Mānoa)
Michelle Leano (UH Mānoa)
Jennifer Guo (UH Mānoa)
2020 Skylar Hara (UH Mānoa)
Daniel Trupp (UH Mānoa)
Genevieve Triplett (UH Mānoa)
Awarded UHM UROP project funds ($4,989)
2017 Selina Dhanani, Alyson Eng, Geety Hafizi, Curtis Logan, Emily Okun (UBC)
2016 Vicki Thill and Austin Koontz (Univ Nevada-Reno undergraduates)
2015 Courtney Van Den Elzen (UBC)
2014 Lisa Lin and Erin Warkman (UBC Work-learn students)
2012 Meret Thomas-Huebner (Indiana University NSF REU)

High schoool student mentorship

2022 Chani Chung (Punahou)

Teaching experience

Instructor of Record (University of Hawai'i)

2023-fall BOT 100: Freshman Seminar
BIOL / BOT 220: Biostatistics and R lab
2023-spring BIOL 470: Evolution
2022-fall BOT 100: Freshman Seminar
BIOL 172L: Introduction to Biology II Lab
2022-spring BIOL / BOT 220: Biostatistics and R lab
BIOL 470: Evolution
2021-fall BOT 100: Freshman Seminar
2021-spring BIOL / BOT 220: Biostatistics and R lab
2020-fall BIOL 470: Evolution
2020-spring BIOL 470: Evolution
BIOL / BOT 297: Biostatistics
2019-fall BIOL / BOT 455: Analysis of Biological Data

Open-source teaching resources

Shiny apps for Evolutionary Biology

Interviews and Press Coverage

Botany One: AoBP ECOS 2020 Awardee Chris Muir

Plantae: Faculty Job: Myths & Realities - an interview with Christopher Muir

Botany One: tealeaves: an R package for modelling leaf temperature using energy budgets

Discover: "Why Do Houseplants Have Holey Leaves?"
https://discovermagazine.com/2014/april/2-0-holey-leaf

New Phytologist: "Plant evolutionary ecology: molecular genetics, global warming and invasions, and the novel approaches we are using to study adaptations" https://dx.doi.org/10.1111/nph.12028