Zoe G. Cardon

Senior Scientist, The Ecosystems Center
Marine Biological Laboratory
7 MBL Street, Woods Hole, MA 02543

Phone: 508 289 7473
FAX: 508 457 1548
e-mail: zcardon@mbl.edu

I am an ecosystems ecologist with roots in mechanistic plant physiology. For two decades, I have striven to understand controls over dynamic interactions among plants, microbes, and soils, particularly in the fundamental terrestrial commodities exchange -- the rhizosphere. In the rhizosphere, organic carbon (from plants) fuels recycling of mineral nutrients (by microbes), maintaining the productivity on which ecosystems and humanity depend. My work combines organismal, hydrologic, soil physical, and ecosystems perspectives and aims to identify commonalities across systems in how organism-initiated flow (of water) and physical (soil) structure constrain, and promote, resource exchange. Such commonalities should extend to any system where interacting macro- and microorganisms (microbiomes) are embedded in, evolving in, and creating or shaping their complex physical environment. My work is interdisciplinary and collaborative, combining development of genetically engineered microbiosensors, *in situ* imaging, and new stable isotope techniques, with emerging systems modeling, organismal, and "omics" approaches.

EDUCATION AND POSTDOCTORAL TRAINING

DOE Global Change Distinguished Postdoctoral Fellow, UC Berkeley, F. S. Chapin III advisor (1994-96)
Ph.D., Department of Biological Sciences, Stanford University, 1994. *Cellular and Physiological Investigations of Stomatal Regulation*, Joseph Berry advisor.
B.S. Biology, B.A. Spanish, Utah State University, 1988; College of Science valedictorian; graduation *Magna Cum Laude*.

PROFESSIONAL POSITIONS

Senior Scientist, The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA (2008-)
Faculty Associate (MBL), The Microbiome Center, University of Chicago, Chicago, IL (2016-)
Professor (MBL), Dept. of Ecology and Evolutionary Biology, and, Dept. of Earth, Environmental, and Planetary Sciences, Brown University, Providence, RI (2010-)
Adjunct Associate Scientist, Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA (2006- 2007)
University of Connecticut, Center for Integrative Geosciences, Storrs, CT
Associate Director (2005-2007)
Graduate Program Director (2005-2007)
Visiting scientist, Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA (Fall 2003)
Sarah Blaffer Hrdy Fellow in Conservation Biology, Organismic and Evolutionary Biology Department, Harvard University (Fall Semester, 2002)
University of Connecticut, Department of Ecology and Evolutionary Biology, Storrs, CT
Associate Professor (2003-2007)
Head, Biology Honors Program (Departments of Ecology and Evolutionary Biology, Physiology and Neurobiology, and Molecular and Cell Biology) (2003-2005)
Assistant Professor (1997-2003)
Assistant Professor, Biology Department, Bowdoin College, Brunswick, ME (1996-1997)

SELECTED HONORS

Elected Fellow of the Ecological Society of America (2018)
White House Office of Science and Technology Policy, invited participant, announcement of the "National Microbiome Initiative", Washington, DC., (2016)
White House Office of Science and Technology Policy, invited forum, "Microbiome Innovation:

Roadmap to the Future", Washington, DC., (2015)
White House Office of Science and Technology Policy, invited workshop, "The Microbiome: Developing a Roadmap for Discovery", Washington, DC., (2015)
Kavli Futures Symposium, invited participant, "Cracking the Microbiome: Developing Experimental Tools to Understand Microbial Function" Washington, D.C. (2015)
American Academy of Microbiology, invited workshop, "Incorporating microbes into climate models", Dallas, TX. (2011)
University of Connecticut University-wide Outstanding Faculty Advisor (1999)
Department of Energy Global Change Distinguished Postdoctoral Fellowship (1993-95)
National Defense Science and Engineering Graduate Fellowship (1990-93)
National Science Foundation Graduate Fellowship (1988-90)
Phi Kappa Phi James R. Slater Fellow, for excellence in plant sciences (1988-89)
National Merit Scholar (1983-87)
Presidential Scholar (1983)

INVITED SYMPOSIA AND DEPARTMENTAL TALKS

Symposia (last 5 years):

Invited keynote speaker, Goldschmidt Conference, session 12d "Interactions between Soil and Biota as Controls on Ecosystem Function from Canopy to Rhizosphere", Geochemical Society and the European Association of Geochemistry, Boston, MA (2018)
Invited speaker, Goldschmidt Conference, session 12f "Identifying and Modeling Mechanistic Drivers of Elemental Cycles Across the Critical Zone", Geochemical Society and the European Association of Geochemistry, Boston, MA (2018)
Invited speaker, Hydrology Section and Biogeosciences Section session "Hydrobiogeochemical interactions among plants, soil and microorganisms at molecular to single plant scales." American Geophysical Union (AGU) Fall Meeting, San Francisco, CA, (2016)
Invited speaker, Ignite Session organized by the Ecological Society of America's overall Science Committee: "Advances, Frontiers, Applications, and Challenges within and across Ecological Disciplines: a Celebration of ESA's Centennial, and a Roadmap for the Next 100 Years", 100th annual Ecological Society of America meeting, Baltimore, Maryland, (2015)
Invited speaker, Harvard University Plant Biology Initiative Symposium, "Plants and Climate Change: From Leaves to Ecosystems", (2015)
Invited speaker, MBL Celebration of Discovery, (2015)
Invited speaker, American Geophysical Union (AGU) session "B32D: Ideas in Terrestrial Biogeochemistry: Tell the Story", San Francisco, CA, (2014)
Invited speaker, 5th ASM Conference on Beneficial Microbes, invited main talk for "Ecology of Host-Microbial Interactions" session. Washington DC, (2014)
Invited Plenary Speaker, DOE TES/SBR Joint Investigators Meeting, Plenary Session IIII "Plant Genomics to Ecosystem Function", Washington DC, (2014)
Invited Plenary Speaker, DOE Environmental Molecular Sciences Laboratory meeting "Plants, Microbes, and their Interactions", (2013)

Departmental or Series Seminars (last 5 years):

Cornell University, IGERT: Cross-Scale Biogeochemistry and Climate (March 2017)
University of Chicago, Department of Ecology and Evolution (2016)
University of Massachusetts, Amherst, Plant Biology Graduate Program (2016)
University of Maryland, Dept of Plant Science and Landscape Architecture (2015)
Stonybrook University, Ecology and Evolution Department (2014)
University of Massachusetts, Amherst, Microbiology Department (2013)

SELECTED SERVICE ON NATIONAL COMMITTEES AND INSTITUTIONAL BOARDS

Invited member, sub-committee of the Department of Energy's Biological and Environmental Research Advisory Committee (BERAC), charged with evaluating current and future utilization of DOE's National User Facilities for research aligned with BER's *Grand Challenges*. (2017-2018)

Invited NSF-funded workshop, University of Chicago, "*The Subterranean Macroscope: Sensor Networks for Understanding, Modeling, and Managing Soil Processes*" (2017)

Invited workshop, Environmental Molecular Sciences Laboratory, Pacific Northwest National Laboratory, "Breakthrough Science & Technologies (BS&T) Workshop", (2017)

Invited forum, White House Office of Science and Technology Policy, "Microbiome Innovation: Roadmap to the Future", Washington, DC., (2015)

Invited workshop, White House Office of Science and Technology Policy, "The Microbiome: Developing a Roadmap for Discovery", Washington, DC., (2015)

U.S. Department of Energy triennial review panel, Oak Ridge National Laboratory (2015)

U.S. Department of Energy triennial review panel, Joint Genome Institute (2014)

Invited workshop, "Belowground Carbon Cycling Processes at the Molecular Scale: New Tools for User Research", Environmental Molecular Sciences Laboratory at Pacific Northwest National Lab, Richland, WA (2013)

Organizer, Ecological Society of America Annual Meeting, final meeting-wide evening event, a fund-raising concert at the Moody Theatre, Austin, TX, to showcase and honor efforts of local Austin environmental groups. 20 groups created table displays and talked with concert patrons throughout the evening to raise environmental awareness. (2011)

Invited workshop, American Academy of Microbiology colloquium "Incorporating microbes into climate models", Dallas, TX (2011)

President (elected), Physiological Ecology Section, Ecological Society of America (2009-2011)

Invited member of Program Leaders Committee for NSF-funded SAMSI program emphasizing statistics for control of wireless sensing networks and analysis of data streams (2007-2008)

Invited member of nominating committee to establish the Board of Directors for the National iPlant Collaborative (http://www.iplantcollaborative.org/) (2008)

Invited workshop, NSF "Frontiers in Belowground Carbon Cycling Research" (2003)

<u>Grant Review Panelist and Journal Review Service:</u>

DOE Environmental Molecular Sciences Laboratory Terrestrial & Subsurface Ecosystems panel

DOE Joint Genome Institute Small-scale microbial/metagenome program panel

National Science Foundation, grant review panel member (multiple panels, some repeated over time):
- Ecology
- Ecology and Evolutionary Physiology
- Ecosystems
- Doctoral Dissertation Improvement Grants
- IGERT
- Integrative Organismal Systems
- TECO (Terrestrial Ecology and Global Change)

U.S. Department of Energy (DOE) Alexander Hollaender Postdoctoral Fellowships panel

Ad hoc reviewer for grant proposals from European Research Council (Brussels), NSF, NASA, NERC, DOE, University of Connecticut, USDA, Utah State University

Reviewer for *American Naturalist*, *Biogeochemistry*, *Biology Letters*, *Ecological Applications*, *Ecology*, *Ecosystems*, *Global Change Biology*, *Journal of Ecology*, *Journal of Environmental Quality*, *Journal of Geophysical Research Biogeosciences*, *Journal of Theoretical Biology*, *Nature Microbiology*, *New Phytologist*, *Oecologia*, *Physiologia Plantarum*, *Plant and Soil*, *Plant Cell and Environment*, *PNAS*, *Science*, *Soil Biology and Biochemistry*, *Wetlands*

Editorial Board
Oecologia (2004-2012)

SOCIETY MEMBERSHIPS

American Association for the Advancement of Science; American Geophysical Union; American Society for Microbiology; Ecological Society of America

PUBLICATIONS

Publications emphasizing larger implications of microbiomes research:

Blaser MJ, **Cardon ZG**, Cho MK, Dangl JL, Donohue TJ, Green JL, Knight R, Maxon ME, Northen TR, Pollard KS, Brodie EL. (2016) Towards a predictive understanding of Earth's microbiomes to address 21st Century challenges. ***mBio***. 7:e00714-16. doi: 10.1128/mBio.00714-16

Biteen JS, Blainey PC, **Cardon ZG**, Chun M, Church G, Dorrestein PC, Fraser SE, Gilbert J, Jansson JK, Knight R, Miller JF, Ozcan A, Prather KA, Taha S, Ven den Engh G, Quake S, Ruby EG, Silver P, Weiss PS, Wong GCL, Wright AT, Xie XS, Young TD (2016) Tools for the Microbiome: Nano and Beyond. ***ACS Nano***, 10:6-37. DOI: 10.1021/acsnano.5b07826. (Most read *ACS Nano* paper of 2016.)

Alivisatos AP et al. (2015) A unified initiative to harness Earth's microbiomes. ***Science*** 350:507-508. (45 authors in Unified Microbiome Initiative Consortium.)

Rhizosphere-specific publications

Fu C, Wang G, Bible K, Goulden ML, Saleska SR, Scott RL, **Cardon ZG**. (2018) Hydraulic redistribution affects modeled carbon cycling via soil microbial activity and suppressed fire. ***Global Change Biology***.24(8):3472-3485. DOI: 10.1111/gcb.14164

Espeleta JF, **Cardon ZG,** Mayer KU, Neumann RB. (2016) Diel plant water use and competitive soil cation exchange interact to enhance NH_4^+ and K^+ availability in the rhizosphere. ***Plant and Soil***. 414:33. doi: 10.1007/s11104-016-3089-5

Fu C, Wang G, Goulden ML, Scott RL, Bible K, and **Cardon ZG**. (2016) Modeling the hydrological impact of hydraulic redistribution using CLM4.5 at eight AmeriFlux Sites. ***Hydrology and Earth System Sciences*** 20:2001-2018. doi:10.5194/hess-20-2001-2016

Thomas F, Giblin AE, **Cardon ZG**, Sievert SM. (2014) Rhizosphere heterogeneity shapes abundance and activity of sulfur-oxidizing bacteria in vegetated salt marsh sediments. ***Frontiers in Microbiology*** 5:309 doi: 10.3389/fmicb.2014.00309.

Neumann R, **Cardon ZG**, Teshera-Levye J, Rockwell F, Zwieniecki M, Holbrook NM. (2014) Modeled hydraulic redistribution by sunflower (*Helianthus annuus* L.) matches observed data only after including nighttime transpiration. ***Plant Cell and Environment*** 37:899-910

Cardon ZG, Stark JM, Herron PM, Rasmussen JA. (2013) Sagebrush carrying out hydraulic lift enhances surface soil nitrogen cycling and nitrogen uptake into inflorescences. ***Proceedings of the National Academy of Sciences of the United States of America*** 110(47):18988-18993.

Herron PM, Gage DJ, Arango Pinedo C, Haider ZK and **Cardon ZG** (2013) Better to light a candle than curse the darkness: illuminating spatial localization and temporal dynamics of rapid microbial growth in the rhizosphere. ***Frontiers in Plant Science*** 4:323. doi: 10.3389/fpls.2013.00323

Neumann, R.B. and **Z.G. Cardon** (2012). The magnitude of hydraulic redistribution by plant roots: a review and synthesis of empirical and modeling studies. ***New Phytologist*** 194:337-352.

Herron, P.M., Gage, D.J., and **Cardon, Z.G**. (2010) Micro-scale water potential gradients visualized in soil around plant root tips using microbiosensors. ***Plant, Cell, and Environment***, 33:199-210.

Herron, P.M., Stark, J.M., Holt, C., Hooker, T., and **Cardon, Z.G.** (2009) Microbial growth efficiencies across a soil moisture gradient assessed using ^{13}C-acetic acid vapor and ^{15}N-ammonia gas. ***Soil Biology and Biochemistry*** 41:1262-1269.

Gage, D.J., Herron, P.M., Arango Pinedo, C., and **Cardon, Z.G.** (2008) Live reports from the soil grain – the promise and challenge of microbiosensors. ***Functional Ecology*** 22: 983-989.

Cardon,Z.G. and Gage, D.J. (2006) Resource exchange in the rhizosphere – molecular tools and the microbial perspective. ***Annual Review of Ecology, Evolution, and Systematics***, 37: 459-88.

Cardon, Z. G., Czaja, A. D., Funk, J. L., and Vitt, P. L. (2002) Periodic carbon flushing to roots of *Quercus rubra* saplings affects soil respiration and rhizosphere microbial biomass. ***Oecologia***, 133: 215-223.

Bringhurst, R. M., **Cardon, Z. G.**, and Gage, D. J. (2001) Galactosides in the rhizosphere: utilization by *Sinorhizobium meliloti* and development of a biosensor. ***Proceedings of the National Academy of Sciences***, 98(8): 4540-4545.

Cardon, Z.G. (1996) Effects of root exudation and rhizodeposition on ecosystem carbon storage under elevated CO_2. ***Plant and Soil***. 87(2):277-288.

Publications focused on soil microbes and/or soil carbon processing and storage.

Graves CJ, Makrides E, Schmidt V, Giblin A, **Cardon ZG**, Rand D. (2016) Functional responses of salt marsh microbial communities to long-term nutrient enrichment. ***Applied and Environmental Microbiology*** 82:2862-2871.

Xia, LC, Steele, JA, Cram, JA, **Cardon, ZG**, Simmons, SL, Vallino, JJ, Fuhrman, JA, Sun, F (2011) Extended local similarity analysis (eLSA) of microbial community and other time series data with replicates. ***BMC Systems Biology***, 5(Suppl 2):S15.

Skogen, K.A., Holsinger, K.E., and **Cardon, Z.G.** (2011) Nitrogen deposition and the decline of a regionally threatened legume, *Desmodium cuspidatum*. ***Oecologia,*** 165:261–269.

Gartner, T.L. and **Cardon, Z.G.** (2006) Site of leaf origin affects how mixed litter decomposes. ***Soil Biology and Biochemistry***, 38: 2307-2317.

Hooker, B.A., Morris, T. F., Peters, R., and **Cardon, Z.G.** (2005) Long-term effects of tillage and corn stalk return on soil carbon dynamics. ***Soil Science Society of America Journal***, 69 (1) : 188-196.

Venterea, R.T., Rolston, D.E., and **Cardon, Z.G**. (2005) Effects of soil moisture, physical, and chemical characteristics on abiotic nitric oxide production. ***Nutrient Cycling in Agroecosystems*** 72:27-40.

Johnston, C. A., Groffman, P., Breshears, D. D., **Cardon, Z. G.**, Currie, W., Emanuel, W., Gaudinski, J., Jackson, R. B., Lajtha, K., Nadelhoffer, K., Nelson Jr., D., Post, W. M., Retalack, G., and Wielopski, L. (2004) Carbon cycling in soil. ***Frontiers in Ecology and the Environment***, 2(10): 522-528.

Gartner, T. B. and **Cardon, Z. G.** (2004) Decomposition dynamics in mixed-species leaf litter — a review. ***Oikos*** 104: 230-246.

Cardon, Z. G., Hungate, B. A., Cambardella, C. A., Chapin III, F. S., Field, C. B., Holland, E. A., and Mooney, H. A. (2001) Contrasting effects of elevated CO_2 on old and new soil carbon pools. ***Soil Biology and Biochemistry***, 33: 365-373.

Publications focused on photosynthesis in microbiotic crust organisms and/or higher plants.

Cardon ZG, Peredo EL, Dohnalkova AC, Gershone HL, Bezanilla M. A model suite of green algae within the Scenedesmaceae for investigating contrasting desiccation tolerance and morphology. ***Journal of Cell Science***. 131: jcs212233 doi: 10.1242/jcs.212233 (Work used as cover photo, and paper included in the "Research Highlights" section of issue 131.)

Lunch, CK, LaFountain, AM, Thomas, S, Frank, HA, Lewis, LA, **Cardon, ZG.** (2013) The xanthophyll cycle and NPQ in diverse desert and aquatic green algae. ***Photosynthesis Research*** 115:139–151.

Cardon, Z.G., Gray, D.W., and Lewis, L. A. (2008) The green algal underground – evolutionary secrets of desert cells. ***Bioscience*** 58(2): 114-122.

Gray, D.W., Lewis, L.A., and **Cardon, Z.G.** (2007) Photosynthetic recovery following desiccation of desert green algae (Chlorophyta) and their aquatic relatives. ***Plant, Cell, and Environment***, 30:1240-1255. (Journal cover image is from our work.)

Gray, D.W., **Cardon, Z.G**., and Lewis, L. A. (2006) Simultaneous collection of rapid chlorophyll fluorescence induction kinetics, fluorescence quenching parameters, and environmental data using an

automated PAM-2000/CR10X data logging system. ***Photosynthesis Research***, 87:295-301.

Zanne, A.E., Lower, S.S., **Cardon, Z.G.**, and Orians, C.M. (2006) ^{15}N fertilization of tomatoes: vascular constraints vs. tissue demand. ***Functional Plant Biology*** 33:457-64.

Jones, C.S, **Cardon, Z.G**., and Czaja, A.D. (2003) A phylogenetic view of low level CAM in *Pelargonium* (Geraniaceae). ***American Journal of Botany,*** 90:135-142.

Hooper, D. U., **Cardon, Z. G**., Chapin III, F. S., and Durant, M. (2002) Corrected calculations for whole ecosystem measurements of CO_2 flux using the LI-COR 6200 portable photosynthesis system. ***Oecologia***, 132: 1-11.

Lodding, C. C., Behling, J., and **Cardon, Z. G.** (2000) Water relations of *Betula cordifolia* and *Betula allegheniensis* rooted together on landslides in Franconia Notch, NH. ***American Midland Naturalist***, 143:321-329.

Tsionsky, M., **Cardon, Z.G.,** Bard, A.J., and Jackson, R.B. (1997) Photosynthetic electron transport in single guard cells as measured by scanning electrochemical microscopy. ***Plant Physiology***. 113(3):895-901

Cardon, Z.G., Berry, J.A., and Woodrow, I.E. (1995). Fluctuating [CO_2] drives species-specific changes in water use efficiency. ***Journal of Biogeography*** 22:203-208.

Jackson, R.B., Luo, Y., **Cardon, Z.G**., Chiariello, N.R., Sala, O.E., Field, C.B., and Mooney, H. A. (1995). Photosynthesis, growth, and density for the dominant species in a CO_2-enriched grassland. ***Journal of Biogeography***. 22:221-225.

Cardon, Z.G., Berry, J.A., and Woodrow, I.E. (1994a). Dependence of the extent and direction of average stomatal response in *Zea mays* and *Phaseolus vulgaris* on the frequency of fluctuations in environmental stimuli. ***Plant Physiology*** 105:1007-1013.

Cardon, Z.G., Mott, K.A., and Berry, J.A. (1994b) Dynamics of patchy stomatal movements, and their contribution to steady-state and oscillating stomatal conductance calculated with gas-exchange techniques. ***Plant, Cell, and Environment.*** 17:995-1007.

Mott, K.A., **Cardon, Z.G**., and Berry, J.A. (1993). Asymmetric patchy stomatal closure for the two surfaces of *Xanthium strumarium* L. leaves at low humidity. ***Plant, Cell, and Environment***. 16:25-34.

Cardon, Z.G., and Berry, J.A. (1992). Effects of O_2 and CO_2 concentration on the steady-state fluorescence yield of single guard cell pairs in intact leaf discs of *Tradescantia albiflora*. Evidence for Rubisco-mediated CO_2 fixation and photorespiration in guard cells. ***Plant Physiology*** 99:1238-1244.

Cardon, Z.G., and Mott, K.A. (1989). Evidence that ribulose 1,5-bisphosphate (RuBP) binds to inactive sites of RuBP carboxylase *in vivo* and an estimate of the rate constant for dissociation. ***Plant Physiology*** 89:1253-1257.

Volumes Edited, and Peer-Reviewed Contributions to Edited Volumes:

Cardon, Z.G. and Whitbeck, J.L. (eds) (2007) *The Rhizosphere: an Ecological Perspective*. Elsevier.

Whitbeck, J.L. and **Cardon, Z.G.** Introduction. (2007) IN: *The Rhizosphere: an Ecological Perspective*. Cardon, Z.G. and Whitbeck, J.L. (eds). Elsevier, San Diego. Pp. xv-xix.

Cardon, Z. G., and Herron, P. M. Sweeping water, oozing carbon: long distance transport and patterns of rhizosphere resource exchange. (2005) IN: *Vascular Transport in Plants*. Holbrook, N.M. and Zwieniecki, M.A. (eds). Academic Press, San Diego. Pp. 257-276.

Cottingham, K. L., **Cardon, Z. G**., D'Antonio, C. M., Dent, C. L., Findlay, S. E. G., Lauenroth, W. K., LoGiudice, K. M., Stelzer, R. S., Strayer, D. L. (2003) Increasing modeling savvy: strategies to advance quantitative modeling skills for professionals within ecology. In: *Models in Ecosystem Science*. 9th Cary Conference volume, Canham, C., Cole, J. and Lauenroth, W., eds. pp. 428-436.

FUNDING

Research grants:

NSF Sensors in the Soil (SitS) Program," EAGER SitS: Developing a Next Generation Modeling Approach for Predicting Microbial Processes in Soil", Joe Vallino (PI) and **Cardon** (co-I). Jan 1 2019-Dec 31 2020. Recommended ($300,000)

DOE Terrestrial Ecosystem Science (TES) Program, "Sticky roots – implications of widespread, cryptic, viral infection of plants in natural and managed ecosystems for soil carbon processing in the rhizosphere." Cardon (PI), Keiluweit M and Malmstrom C (co-Is). Oct 1 2018 – Sept 30 2019. Recommended ($294,999).

DOE Subsurface Biogeochemical Reactions (SBR) Program, "Root Influences on Mobilization and Export of Mineral-Bound Soil Organic Matter." Keiluweit M (PI), **Cardon** (co-I), Oct 1 2018 – Sept 30 2019. Recommended ($200,000, $44,000 to MBL).

DOE Environmental Molecular Sciences Laboratory (EMSL) Science Theme Project 50268, "The Root of the Matter: Soil Carbon Mobilization in the Rhizosphere" Keiluweit, M (PI); **Cardon** and Malmstrom, C **(coPIs)**. EMSL : Lipton, Chu. Oct 1 2018 – Sept 30 2020.

Bailey Wildlife Foundation, "Developing a novel, low-cost, flexible sensor platform for quantifying environmental conditions using imaging of immobilized dyes." **Cardon** (PI), Zhang X. and Guha S. (UChicago and ANL, co-Is). 2018. $80,000.

University of Wyoming, "Wyoming Algae for Unconventional Bioconversion Processes", J. Oakey (PI), **Cardon** (co-I), Peter Stahl(co-I), and Magdalena Bezanilla(co-I). May 1 2017-April 30 2018. $102,194.

Anonymous donor, Current Use Research Supplements to "Women in Ecological Science" at MBL, recurrent contributions of $25000, $25000, $25000, $50000, $36000, $45000, $16500, $12500, $12500, $12500, $34103, $26000, $26000, $26,000, $26,000, $26,000 (most recent: 2/1//2018), 2009-2017. **Cardon (PI).**

DOE JGI Community Science Program, "Protecting photosynthesis during desiccation: do the genomes of desert-derived and aquatic *Scenedesmus* species hold the key to understanding extreme desiccation tolerance among green algae?", Elena Lopez Peredo (PI) and **Cardon (co-I)**. 2016-18.Sequencing genomes of four green algae, two desert-derived, and two sister aquatic.

DOE Environmental Molecular Sciences Laboratory (EMSL) Science Theme Project, "Does Chloroplast Thylakoid Membrane Organization Influence Desiccation Tolerance in Green Algae?" **Cardon (PI)**. EMSL Co-I: Galya Orr, EMSL and PNNL. Oct. 2015-Sept. 2017.

DOE Joint Genome Institute – Environmental Molecular Sciences Laboratory (JGI-EMSL) Collaborative Science, "3D Reality Check: Developing Structural Support for Predicting Microbial Function and Interpreting Microbial 'Omics' Data" **. Cardon (PI).** Co-Is: Joe Vallino and Gretta Serres. EMSL collaborator: Tim Scheibe, EMSL and PNNL. Oct. 2015-Sept. 2017.

Anonymous donor, "A novel low-waste, low-maintenance system for microbial generation of methane from algal biomass." **Cardon (PI)** Co-I Joe Vallino. Oct.2014 – Sept. 2016. $302,393.

Environmental Molecular Sciences Laboratory (EMSL) science theme project, "Integration of Pore-Scale Simulations and Multi-Omics Data to Develop Insights into Functional Heterogeneity in Microbial Communities". **Cardon (PI)** Co-Is: Joe Vallino, Gretta Serres, and computer scientist Tim Scheibe (EMSL). Oct. 2014-Oct. 2015.

NSF, "Photoprotection in Diverse, Desiccation-Tolerant, Desert Green Algae and Their Close Aquatic Relatives"; **Cardon (PI).** 6/15/2014-6/14/2017. $629,975

DOE Terrestrial Ecosystems, "Hydraulic redistribution of water through plant roots – implications for carbon cycling and energy flux at multiple scales"; **Cardon (PI)**, Daniel Gage and Guiling Wang (UConn, Co-Is), Rebecca Neumann (Univ. WA, Co-I). 4/2012-4/2016. $1,048,327.

Brown-MBL Faculty Seed Grant, "Linking long- and short-term controls on terrestrial phosphorus cycling"; **Cardon (PI)**, Stephen Porder and Laura Schreeg (Brown co-Is). 10/2011-9/2012. $49,949.

NSF, "Collaborative Research: MSB: The Role of Sulfur Oxidizing Bacteria in Salt Marsh C and N Cycling" ; **Cardon (PI),** Giblin (co-I); Sievert (PI) from WHOI. 8/2011 – 7/2016. $1,200,326 total ($510,333 to MBL, $689,993 to WHOI)

NASA Exobiology, "Leaping to Land – Physiology and Phylogenetics of Desert Green Algae", **Cardon (PI)**, Louise Lewis and Harry Frank (Co-Is), 9/2008-9/2012, $531,978.

Recipient of long-term, targeted support from anonymous, quasi-endowment to MBL to support "Women in Ecological Science", 3/08, $1,200,000.

Anonymous grant, "Hydraulic Redistribution of Water in Western Landscapes: Effects on Plant Fitness and Rhizosphere Function", **Cardon (PI)**. 3/08. $300,000.

DOI USGS Office of Groundwater Research, Branch of Geophysics, "USGS OGW BG-UCONN Cooperative Agreement", **Cardon (co-I)**. 8/2007-8/2012. $220,632.

Connecticut Institute of Water Resources Grant, "Development of a New Generation of Sensitive, Fluorescence-based Nitrate Sensors for Use in Soil and Water", **Cardon (co-I)** with PI Shawn Burdette. 9/1/07-8/31/09. $36,994.

UConn Research Foundation Large Faculty Grant, "Desiccation Tolerance in Desert Green Algae", **Cardon (PI).** 1/06 – 1/07. $16,677.

NSF DDIG, Population Dynamics Program, "Nitrogen Deposition and Population Dynamics of a Declining Nitrogen-fixing Plant Species", **Cardon (co-PI)**, co-PI Krissa Skogen (student proposal) and PI Kent Holsinger, 6/1/06-7/31/08, $11,993.

NSF Ecosystems Program, "Desert Microbial Activity in the Rhizosphere Oasis", **Cardon (PI)**, co-PIs Daniel Gage and John Stark. 7/1/04 – 7/1/07. $529,625.

NSF REU supplements, summers of 2005, 2006, 2007, $6000 each summer.

NSF International Supplement, with Dr. Vit Gloser, Czech Republic, 7/04-'07, $25,472.

NSF DDIG, Ecosystems Program, "Dissertation Research: Does Hydraulic Redistribution Increase Microbial Activity in the Rhizosphere?", **Cardon (PI)**, co-PI Patrick Herron (student written proposal), 7/1/04-7/1/06, $12,000.

NASA Exobiology, "Phylogenetic diversity and comparative physiology of independently-evolved lineages of desert green algae (Chlorophyta)", **Cardon (co-PI)**,L.A. Lewis, PI, 2003-06 $380,876.

NSF Ecosystems Program, SGER, "Developing a New Miniaturized Sensor for Detecting Glucose in Soil", **Cardon (PI)**, F. Moussy (co-PI), 5/02-5/03, $25,053

UConn Research Foundation Large Faculty Grant, "Effect of tillage and carbon input levels on soil organic carbon distribution" **Cardon (PI)**, T. Morris (co-I). 1/01-1/02, $7881

Andrew W. Mellon Foundation Grant, "Carbon fluxes from plant roots to soils -- how timing, quality, and quantity of fluxes affect rhizosphere microbial activity." **Cardon (PI)** 3/00-12/04, $350,000

UConn Research Foundation Large Faculty Grant, "Does Plant Phenology Influence Microbial Activity in the Rhizosphere? " **Cardon (PI)**, 6/98-5/99, $17,609

Andrew W. Mellon Foundation Grant, "Influence of Root Exudation and Rhizodeposition on Rhizosphere Processes in Natural Soils." **Cardon (PI)**, 4/96-12/99, $180,000

<u>Teaching and Graduate Training Grants:</u>

NSF IGERT, "Reverse Ecology: Computational Integration of Genomes, Organisms and Environments", David Rand PI, Zoe **Cardon**, Mitch Sogin, Annie Schmitt, Sorin Istrail **co-Is**, $2,920,540, 8/2010-8/2015 (extended to 2016)

NSF Instrumentation and Laboratory Improvement, "Analytical and Quantitative Understanding of Integrative Plant Biology through Coursework and Independent Student Research" 6/97-6/00, $17,520

UConn Institute for Teaching and Learning Grant, "Biology as a quantitative science--easing the path to computational ability and conceptual thinking." 6/99, $6000

SELECTED SERVICE ON MBL COMMITTEES

MBL strategic planning:

Search committee, Bell Center faculty search, 2018

Co-Leader (appointed), "PRO-Microbes" vision meeting (23 invited attendees, 9 from MBL). New research and education linking dynamic microbial response with shifting ecosystem function in the short-term (with global change) and over evolutionary time. (2015)

Co-Leader (appointed), MBL "Vision Team IV: Microbial diversity, ecology, evolution and microbiomes" (12 invited attendees, 5 from MBL, 5 from University of Chicago). Development of new strategic MBL theme in research and education focused on microbiomes. (2015)

Science Council (elected, 2010 – 2013, 2014 - ongoing) (Highest advisory committee to the MBL Director on research and education strategy at the MBL)

Institutional Committee (appointed 2009 – 2010) (Advisory committee to the MBL Director on resident research at the MBL)

Implementation -University of Chicago affiliation:

MBL Affiliation Committee (appointed 2014) (providing guidance for new MBL-UChicago affiliation)

Head (appointed), Organizing Committee, first UChicago-MBL faculty retreat (2014)

Day-to-day operations: MBL Research Services (2013 -); MBL Biosafety (2009 -); Head, Ecosystems Center Facilities (2009 -); Head, MBL Research Greenhouse (2009 -); Stable Isotope Laboratory (2008 -); Bell Center Search (2011, 2017); Friday Evening Seminar speaker series planning committee (2017); two Bay Paul Center searches (2008 - 2009) ; Weekly seminar organizer, Ecosystems Center (Fall 2008, Fall 2009, Spring 2010);

TEACHING

MBL

Co-Organizer and webmaster, weekly MBL "MicroEco" discussion group, a cross-Center group exploring links between microbial activity, diversity and ecosystem function (2008 – ongoing; http://ecosystems.mbl.edu/mbl_micro_eco/)

Semester in Environmental Science (fall 2011, fall 2014, fall 2015, fall 2016, fall 2017). Four lectures each fall, and supervision of 5-week independent student research projects. The SES program (http://www.mbl.edu/ses/) is a hands-on field- and lab-intensive, semester-long course, drawing up to 24 juniors and seniors from a consortium of over 60 liberal arts colleges and universities.

Organizer, weekly "Chlorophyll Fluorescence" discussion group at MBL and WHOI, a cross-institution group examining what information chlorophyll fluorescence signatures (detected directly from samples or remotely at distance) can give about photosynthetic activity (2009 – 2010)

UChicago-MBL

UChicago, BIOS 27720: Microbiomes Across Environments. One-hour lecture, Sept. 2017.

UChicago, Invited contributor , third annual Quantitative Methods in Biology Bootcamp at MBL, for incoming biological sciences graduate students at the University of Chicago. Sept. 2017.

UChicago, BIOS 15123 – The Microbiome in Human and Environmental Health. One lecture, at UChicago, May, 2016.

UChicago, Invited contributor (afternoon seminar), first annual Quantitative Methods in Biology Bootcamp at MBL, for all incoming biological sciences graduate students at the University of Chicago (~100 students) September, 2015.

Brown-MBL

Co-taught (with Dr. David Rand) the IGERT "Core Course" for the Brown-MBL graduate training grant: "Reverse Ecology – Computational Integration of Genomes, Organisms, and Environments". http://brown.edu/Research/IGERT-reverse-ecology/. (2011-2017).

Intensive, year-long core course required of all incoming graduate students in the program.

Students were immersed in the ecology and history of an ecosystem, and they were introduced to genomic techniques that can be used to answer ecological and evolutionary questions. Students worked in groups to generate field site-specific hypotheses, planned and executed a sampling expedition, processed samples, generated amplicon or metagenomic libraries, obtained molecular data generated using Illumina sequencing, learned how to process and interpret those data to answer their questions, and wrote papers based on the results.

Participant in graduate Phenology seminar, EEB Department, Brown Univ., fall 2009.

University of Connecticut, regularly taught (1996-2007):
Introductory Biology (~300 first year students);
General Ecology "W" (~70-100 sophomores/juniors, writing intensive);
Organisms and Ecosystems (~10-20 seniors and graduate students);
Soil Degradation and Conservation (~10-15 seniors and graduate students)
Integrative Earth System Science (~6-10 graduate students, developed and taught this intensive core course for first-year students in the new interdisciplinary Center for Integrative Geosciences)

University of Connecticut, irregularly taught (1996-2007):
Introduction to Undergraduate Research (~25-60 students)
Professional Development Seminar (~15 graduate students)
Seminars on The Rhizosphere, on Plant Evolution, on Plant Ecology, and on Plant Water Relations (~10-15 graduate students each)
Multiple independent study courses one-on-one with undergraduate and graduate students

Harvard University (fall, 2002):
Soil Degradation and Conservation (as Sarah Blaffer Hrdy Fellow in Conservation Biology)

TRAINING

Postdoctoral Advisor:

Elena Lopez Peredo (MBL 2014-). PhD 2008 from University of Oveido. Fullbright Scholar 2010-2012, University of Connecticut.

Or Shapira (MBL 2014-2016). Visiting postdoc from Robert H. Smith Institute of Plant Science and Genetics in Agriculture, The Hebrew University of Jerusalem, Israel. PhD 2013 from The Hebrew University of Jerusalem.

Laura Schreeg (Brown-MBL 2011 – 2013, co-advisor with Stephen Porder). PhD 2011 from University of Florida. AAAS Science and Technology Postdoctoral Fellow 2013-2015. Currently Agricultural Resource Specialist at U.S. Department of Agriculture (USDA) and U.S. Agency for International Development (US AID), Washington, District Of Columbia.

Claire Lunch (MBL 2009-2012). PhD 2009 Stanford University. Currently Staff Scientist, Plant Physiology, Neon, Inc. Boulder, CO.

Dennis Gray (UConn 2004-2007) PhD 2003 from SUNY Stonybrook. Currently Assistant Professor of Biology, Saginaw Valley State University, University Center, MI.

Catalina Arango Pinedo (UConn 2007). PhD 2000 from UMass Amherst. Currently Assistant Professor, Department of Biology, Saint Joseph's University, Philadelphia, PA.

Pati Vitt (UConn 1998-1999). PhD University of Connecticut 1998. Currently Susan and Roger Stone Curator, Dixon National Tallgrass Prairie Seed Bank Conservation Scientist at the Chicago Botanic Garden, and Adjunct Assistant Professor, Plant Biology and Conservation, Northwestern University.

Jon Behling (Bowdoin College 1996-1997). Now organic farmer in Wisconsin.

Graduate Major Advisor, Department of Ecology and Evolutionary Biology, Univ. of Connecticut:

Patrick Herron, PhD 2007. NSF DDIG recipient and EPA STAR Fellow. Currently Deputy Director, Mystic River Watershed Association. Arlington, MA.

Bethanie Hooker, PhD 2006. EPA STAR Fellow and PEO Scholar. Currently Director of Food, Farm,

and Sustainability, Hampshire College, Amherst, MA.
Tracy Gartner, PhD 2004. NSF Graduate Research Fellow. Currently Director, Environmental Science Program; Associate Professor of Biology; Associate Professor of Geography and Earth Science. Carthage College, Kenosha, WI.

Graduate Major Co-Advisor, Center for Integrative Geosciences, Univ. of Connecticut:
David Hoover. MS 2008. Currently Postdoctoral researcher, USGS Canyonlands Research Station, Moab, UT

Graduate Committee Member, Various Institutions:
Joseph Vineis (Northeastern University, PhD expected 2022)
Brooke Osborne (Brown University, PhD expected May 2017)
Bo Pietraszkiewicz (University of Connecticut, Storrs, PhD 2010)
Kristina Catanese (University of Connecticut, MS 2009)
Shirley Micallef (University of Massachusetts, Boston, PhD 2008)
Krissa Skogen (University of Connecticut, PhD 2008)
Lindsay Bowerman (University of Connecticut, MS 2007)
Krista Fisk (University of Connecticut, MS 2007)
Courtney Hamler (University of Connecticut, MS 2007)
Robin Kodner (Harvard University, PhD 2007)
Sarina Lambert (University of Connecticut, MS 2007)
Corie Cann (University of Connecticut, MS 2006)
Stacey Leicht (University of Connecticut, PhD 2006)
Nava Tabak (University of Connecticut, MS 2005)
Robert Dunn (University of Connecticut, PhD 2003)
Michael Gavin (University of Connecticut, PhD 2003)
Nancy Ryan (University of Connecticut, MS 2003)
David Bryant (University of New Hampshire, PhD 2002)

Graduate Qualifying Exam Committee Member at Brown:
Brooke Osborne
Susanna Theroux

Post-undergraduate trainees:
Jordan Stark (MBL research assistant 2017-current. Semester in Environmental Science TA at MBL fall 2017.)
Elizabeth Forbes (MBL research assistant 2012-2014. Currently PhD student at University of California, Santa Barbara, CA with NSF Graduate Research Fellowship).
Jennifer Funk (UConn research assistant1997-1999). (Currently Associate Professor , Chapman University, Orange, CA.)

Undergraduate lab trainees:
At MBL:
Hannah Gershone (Mt. Holyoke) SES independent project advisor (2016)
Emily Geoghegan (Bryn Mawr) SES independent project co-advisor with Joe Vallino (2015)
Caroline Kanaskie (Dickinson College) SES independent project advisor (2015)
Tinsley Galyean (Hampshire College) SES independent project advisor (2015)
Ruby An (Univ. of Chicago Metcalf program),co-advisor with Joe Vallino (2015)
Hansen Johnson (Bates College), co-advised SES project with Ed Rastetter (2011) (Now graduate student, Dalhousie University, Department of Oceanography)
Adrien Hansen (Bowdoin College), co-advised with Anton Post (2011)
Jed Rasmussen (REU through UConn, graduate of Utah State University, 2008) (Now Assistant Professor, Biology, Snow College, Ephraim,Utah)

Kristina Catanese, honors thesis (2008)

At UConn:

Christine Quartararo, honors thesis
David Hoover, undergraduate researcher and post-graduate research assistant
Naomi Avery, honors thesis
Corie Cann, UConn BS/MS program in Conservation Biology
Andrew Czaja, honors (NSF and NDSEG graduate fellow, now Assistant Professor, University of Cincinnati, Dept. of Geology)
Jeremy Draghi (NSF graduate fellowship honorable mention, now Assistant Professor, Brooklyn College, Dept. of Biology);
Matthew Dunn, honors
Laura Pustell
Kristen Riley

At Bowdoin:

Cynthia Lodding, honors thesis
Erika Kiers (Now faculty at Vrije Universiteit, Amsterdam)

Multiple others for short-term projects in the lab, at Bowdoin, University of Connecticut, and MBL.