



## Leif Richardson, Ph.D. / Senior Ecologist



Leif brings over 15 years of experience in diverse aspects of applied ecological and environmental science. He recently completed a Postdoctoral Research Fellowship at the Gund Institute for Ecological Economics (UVM) where he examined how multiple mutualisms influence crop yield, and how floral resources on farms affect bee pollinators. Based on this work, he recently led a successful grant proposal by growers and researchers to develop novel pollination systems for specialty crops. Leif previously worked for a decade as an ecologist with the Vermont ANR, and has extensive natural resource management expertise, including in land cover mapping, forestry, and game species management.

### Years of Experience / 16

### Years of Experience at Stone / 1

#### Education

Ph.D., Dartmouth College, Ecology and Evolutionary Biology, 2014

M.S., University of Arizona, Ecology and Evolutionary Biology, 1999

B.A., Earlham College, Biology, 1994

#### Expertise

Terrestrial Ecology, Forestry, and Wildlife

Ecosystem Services to Agriculture

Biodiversity Conservation

Statistical and Data Management and Analysis

Climate Change Research

Plant and Insect Taxonomy

Software: Microsoft Office suite, FileMaker Pro, R Statistical Computing, JMP Statistical, GraphPad Prism, ArcGIS, Photoshop

French Proficiency

#### Honors and Awards

www.experiment.com crowdfunded gran, 2016: "Home sick: Effects of migratory beekeeping on honey bee disease." (\$6,000)

USDA NIFA Specialty Crop Block Grant, 2016: "Managing locally sourced native bees as alternative pollinators for Vermont specialty crops." (\$36,000)

USDA NIFA Postdoctoral Research Fellowship, 2014: "Multispecies interactions affect crop yield and pollinator health." (\$150,000)

#### Community Activities

Member, Vermont Pollinator Protection Committee (2016-present)

### Relevant Experience & Technical Accomplishments

#### Stone Environmental / Montpelier, Vermont Senior Ecologist / March 2017–present

#### Middlebury College, Biology Department / Middlebury, Vermont Visiting Instructor / January 2017

Dr. Richardson taught a Winter Term intensive course, *Experimental Approaches to the Ecology and Conservation of Bees*. Through reading, lectures, and independent research, students developed a foundational knowledge of topics in this field, including social behavior, pollination interactions, importance to agriculture, conservation status, and threats. Students developed research questions and conducted laboratory experiments with live bumble bees to test them.

#### Gund Institute for Ecological Economics, University of Vermont / Burlington, Vermont

#### Postdoctoral Research Fellow / 2015–2017

With faculty mentors Drs. Taylor Ricketts and Alison Brody, Dr. Richardson used field and lab experiments to examine how multiple mutualisms influence crop yield, and how floral resources on farms affect bee pollinators. He managed all aspects this research program, including experimental design, data analysis, manuscript preparation, and hiring and supervision of undergraduate technicians. His research demonstrated that yield of an important US crop, highbush blueberry, is increased by synergies among wild bee pollinators and beneficial mycorrhizal fungi, which alter aboveground plant traits.

#### Maine Department of Inland Fisheries and Wildlife, Maine Bumble Bee Survey / Bangor, Maine

#### Consultant / 2014–present

Dr. Richardson serves as technical advisor to a 5-year citizen science project designed to assess the status of Maine's native bee species. He provides technical assistance on many aspects of the project, and makes identifications of ~5,000 insect specimens collected each year.

#### Vermont Center for Ecostudies / White River Junction, Vermont

#### Consultant / 2012–2016

In a citizen science inventory of Vermont's bumble bee species, Dr. Richardson databased 2,000 historical bee specimens, trained volunteers, and identified more than 10,000 insect specimens collected by volunteers. He is

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preparing a manuscript for publication that documents extensive declines of Vermont's native bee fauna.

### **Dartmouth College / Hanover, New Hampshire Ph.D. Candidate / 2010–2014**

Dr. Richardson completed a doctoral degree, including design and implementation of field and lab experiments on the chemical ecology of interactions among plants, bee pollinators, and parasites of bees. His research demonstrated that naturally occurring chemicals present in the nectar and pollen of plants can reduce bee parasite load, and that bees seek out these chemicals when parasitized. The novel results of this research appear in peer-reviewed publications, and were featured in more than 500 news stories, including those in the *BBC*, *New York Times*, *Scientific American*, and *Times of London*.

### **Committee on the Status of Endangered Wildlife in Canada / Québec, Canada Consultant / 2011–2014**

Dr. Richardson researched and wrote species assessments for three rare bee species to support listing decisions by the Canadian federal government, resulting in legal protection for all three.

### **Xerces Society for Invertebrate Conservation / Portland, Oregon Consultant / 2011 –2014**

In this work, Dr. Richardson worked with colleagues to produce status assessments of 48 bumble bee species found in North America for the International Union for the Conservation of Nature's Red List of Threatened Species. This document informed the US Fish and Wildlife Service's assessment and proposed listing of one species, rusty patched bumble bee, as federally endangered.

### **Vermont Agency of Natural Resources / Montpelier, Vermont State Lands Ecologist / 2001–2010**

In this position, Dr. Richardson performed a variety of roles in natural resource management, including inventory of natural communities; documentation and monitoring rare, threatened, and endangered species populations; management of budgets and consultant contracts; management of GIS and other spatial data on public lands natural resources; review and implementation of forest management activities on state lands; statistical and aerial estimation of population size of deer and moose, and management of game wildlife hunting seasons.

### **Middlebury College / Middlebury, Vermont Visiting Instructor / 2009**

Dr. Richardson created curriculum and taught a one-month Winter Term course on the ecology, identification, and conservation of native bee species.

### **Princeton University Press / Princeton, New Jersey Contracted Writer / 2011 –2014**

With colleagues, Dr. Richardson was contracted to write a book, *Bumble Bees of North America: An Identification Guide*. To support this effort, he assembled a database of ~300,000 historical specimen records, from which he produced figures depicting species distributions and seasonal phenology. He participated in all other aspects of the project, including photography, writing, and editing. This often-cited work won the American Library Association's Outstanding Reference Source Award, and has become a standard manual on these animals in North America.

## **Publications and Presentations**

### **Peer-Reviewed Publications**

Sonter, L.J., T.H. Ricketts, B. Fisher, C.N. Nicholson, J.A. Johnson, K.B. Watson, and L.L. Richardson. Multi-site interactions: Understanding the offsite impacts of land use change on the use and supply of ecosystem services. *Ecosystem Services* 23:158-164.

Ricketts, T.H., K.B. Watson, I. Koh, A.M. Ellis, C.C. Nicholson, S. Posner, L.L. Richardson, and L.J. Sonter. 2016. Disaggregating the evidence linking biodiversity and ecosystem services. *Nature Communications*: 7:13106.

de Keyzer, C.W., S.R. Colla, C.F. Kent, N.E. Rafferty, L.L. Richardson, and J.D. Thomson. 2016. Delving deeper: Questioning the decline of long-tongued bumble bees, Long-tubed flowers and their mutualisms with climate change. *Journal of Pollination Ecology* 18 (6): 36–42.

- Richardson, L.L., R.E. Irwin, and M.D. Bowers. 2016. Nectar chemistry mediates the behavior of parasitized bees: Consequences for plant fitness. *Ecology* 97(2): 325-337.
- Sheffield, C.S., L.L. Richardson, S. Cannings, H. Ngo, J. Heron, and P.H. Williams. Biogeography and designatable units of *Bombus occidentalis* Greene and *B. terricola* Kirby (Hymenoptera: Apidae) with implications for conservation status assessments. 2016. *Journal of Insect Conservation* 20(2): 189-199.
- Williams, P.H., A.M. Byvaltsev, B. Cederberg, M.V. Berezin, F. Ødegaard, C. Rasmussen, L.L. Richardson, J. Huan, C.S. Sheffield, and S.T. Williams. 2015. Genes suggest ancestral colour polymorphisms cut across morphologically cryptic species in Arctic bumblebees. *PLOS One* 10(12): e0144544.
- Richardson, L.L. and R.E. Irwin. 2015. Floral ecology of turtlehead (*Chelone glabra* L.; Plantaginaceae). *Journal of Pollination Ecology* 17(20): 132-144.
- Kerr, J.T., A. Pindar, P. Galpern, L. Packer, S.G. Potts, S.M. Roberts, P. Rasmont, O. Schweiger, S.R. Colla, L.L. Richardson, D.L. Wagner, L.F. Gall, D.S. Sikes, and A. Pantoja. 2015. Climate change impacts on bumblebees converge across continents. *Science* 349 (6244): 177-180.
- Richardson, L.L., L.S. Adler, A.S. Leonard, J. Andicoechea, K.H. Regan, W.E. Anthony, J.S. Manson, and R.E. Irwin. 2015. Secondary metabolites in floral nectar reduce parasite infections in bumblebees. *Proceedings of the Royal Society of London B: Biological Sciences* 282 (1803), 20142471.
- Irwin, R.E., L.L. Richardson, J.S. Manson, D.R. Gardner, and D. Cook. 2014. Secondary compounds in floral rewards: Impacts on pollinators. *Journal of Agricultural and Food Chemistry* 62(30): 7335-7344.
- Bowers, M.D. and L.L. Richardson. 2013. Use of two oviposition plants in populations of *Euphydryas phaeton* Drury (Nymphalidae). *Journal of the Lepidopterists' Society* 67(4): 299- 301.
- Colla, S.R., F. Gadallah, L.L. Richardson, D. Wagner, and L. Gall. 2012. Assessing declines of North American bumble bees (*Bombus* spp.) using museum specimens. *Biodiversity and Conservation* 21(14): 3585-3595.
- Richardson, L.L. and J.L. Bronstein. 2012. Reproductive biology of pointleaf manzanita (*Arctostaphylos pungens*) and the pollinator-nectar robber spectrum. *Journal of Pollination Ecology* 9(15): 115-123.
- Millette, T.L., D. Slaymaker, E. Marcano, C. Alexander, and L.L. Richardson. 2011. AIMS- thermal—a thermal and high resolution color camera system integrated with GIS for aerial moose and deer census in northeastern Vermont. *Alces* 47: 27-37.
- Irwin, R.E., J.L. Bronstein, J.S. Manson, and L.L. Richardson. 2010. Nectar robbing: Ecological and evolutionary perspectives. *Annual Review of Ecology and Systematics* 41: 271- 292.
- Books**
- Williams, P.H., R.W. Thorp, L.L. Richardson, and S.R. Colla. 2014. *Bumble bees of North America: An identification guide*. Princeton University Press. Princeton, NJ, USA. ISBN: 978-0- 691-15222-6. 208 pp.
- Letters, Non-Refereed Articles and Technical Reports**
- Kerr, J.T., A. Pindar, P. Galpern, L. Packer, S.G. Potts, S.M. Roberts, P. Rasmont, O. Schweiger, S.R. Colla, L.L. Richardson, D.L. Wagner, L.F. Gall, D.S. Sikes, and A. Pantoja. (2015). Relocation risky for bumblebee colonies—Response. *Science* 350, 287.
- Richardson, L.L. 2015. Flower pharmacies help bees fight parasites. *The Conversation*. Available online: [www.theconversation.com/flower-pharmacies-help-bees-fight-parasites-37614](http://www.theconversation.com/flower-pharmacies-help-bees-fight-parasites-37614).
- Colla, S.R., L.L. Richardson, and J. Heron. 2015. Status report on the yellow-banded bumble bee, *Bombus terricola*. Report to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Canadian Wildlife Service, Environment Canada. Ottawa, Ontario.
- Colla, S.R., M. Otterstatter, C.S. Sheffield, L.L. Richardson, and J. Heron. 2014. Status report on the western bumble bee, *Bombus occidentalis*. Report to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Canadian Wildlife Service, Environment Canada. Ottawa, Ontario.

Colla, S.R., C.S. Sheffield, and L.L. Richardson. Status report on the gypsy cuckoo bumble bee, *Bombus bohemicus* in Canada. 2014. Report to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Canadian Wildlife Service, Environment Canada. Ottawa, Ontario.

Hatfield, R., S. Jepsen, R.W. Thorp, L.L. Richardson, and S.R. Colla. 2014. IUCN Red List assessments for North American *Bombus* species. The IUCN Red List of Threatened Species. Version 2015.2. Available online: [www.iucnredlist.org](http://www.iucnredlist.org).

McFarland, K.P. and L.L. Richardson. 2014. Species status report for *Bombus affinis*. Endangered Species Committee, Vermont Agency of Natural Resources. Montpelier, Vermont.

McFarland, K.P. and L.L. Richardson. 2014. Species status report for *Bombus bohemicus*. Endangered Species Committee, Vermont Agency of Natural Resources. Montpelier, Vermont.

McFarland, K.P. and L.L. Richardson. 2014. Species status report for *Bombus terricola*. Endangered Species Committee, Vermont Agency of Natural Resources. Montpelier, Vermont.

Colla, S.R., L.L. Richardson, and P.H. Williams. 2011. Bumblebees of the eastern United States. U.S. Forest Service and The Pollinator Partnership.

### **Selected Public Speaking Engagements**

Richardson, L.L. "Mycorrhizal Fungi Affect Pollination Mutualisms Between Bees and Crop Plants." Cornell University, March 27, 2017.

Richardson, L.L. "Pollination is a Multispecies Interaction: Bees, Parasites, and Fungi Structure Reproduction of Wild and Cultivated Plants." Johnson State College, Johnson, VT. November 2, 2016.

Richardson, L.L., A.K. Brody, and T.H. Ricketts. "Mycorrhizal Fungi Affect Floral Traits Important to Pollination and Crop Yield." International Congress of Entomology, Orlando, FL. September 25, 2016.

Richardson, L.L., S. Alger, A.K. Brody, and T.H. Ricketts. "Mycorrhizal Fungi Affect Pollination Mutualisms Between Bees and Crop Plants." USDA National Institute of Food and Agriculture Project Directors' Meeting, Washington, DC. August 30, 2016.

Richardson, L.L. "Pollination: Effects of Plant Chemistry, Mycorrhizae, and Bee Declines." USDA Northeastern Integrated Pest Management Pollinator Habitat Working Group meeting, University of Massachusetts Cranberry Station, Wareham, MA. August 19, 2016.

Richardson, L.L., S. Alger, A.K. Brody, and T.H. Ricketts. "Mycorrhizal Fungi Affect Pollination Mutualisms Between Bees and Crop Plants." International Conference on Pollination Biology, Health, and Policy, Penn State University, State College, PA. July 19, 2016.

Richardson, L.L., M. Ferguson, and K.P. McFarland. "Status and Trends of Wild Insect Pollinators in Vermont and Beyond." Vermont Agency of Natural Resources Pollinator Symposium, Burlington, VT. March 17, 2016.

Richardson, L.L., K.P. McFarland, and S. Zahendra. "Declines in Bumble Bee Species Diversity in Vermont, 1915-2014." Vermont Monitoring Coop Annual Conference, Burlington, VT. December 11, 2015.

Richardson, L.L. "Multiple Mutualisms in Agriculture: Implications for Plants, Pollinators and Yield." Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT. November 19, 2015.

Richardson, L.L. "Chemical Ecology of Multispecies Interactions: Implications for Plants, Bees and Agriculture." Ecology, Evolution and Environmental Biology Group Seminar, University of Vermont, Burlington, VT. September 23, 2015.

Richardson, L.L., M.D. Bowers, L.S. Adler, and R.E. Irwin. "Foraging Behavior of Bee Pollinators Structured by Parasites and Plant Chemistry." Ecological Society of America Annual Meeting, Baltimore, MD. August 11, 2015.

Richardson, L.L. "Bittersweet: Tritrophic Effects of Nectar Secondary Metabolites on Plants, Pollinators and Parasites." Doctoral Dissertation Defense presentation, Dartmouth College, Hanover, NH. December 18, 2014.

Richardson, L.L., R.E. Irwin, and M.D. Bowers. "Iridoid Glycosides in Floral Nectar Alter Pollinator Behavior and Pollen Transfer Dynamics." Ecological Society of America Annual Meeting, Sacramento, CA. August 13, 2014.

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Richardson, L.L., K.P. McFarland, and S. Zahendra. "An Overview of the Vermont Center for Ecostudies Bumble Bee Atlas." Northeast Natural History Conference, Springfield, MA. April 9, 2014.

Richardson, L.L., L.S. Adler, A.S. Leonard, K. Henry, W. Anthony, and R.E. Irwin. "Plant Secondary Compounds in Floral Nectar Reduce Bumble Bee Parasite Load." Ecological Society of America Annual Meeting, Minneapolis, MN. August 8, 2013.

Richardson, L.L. "Bumble Bee Trends in Northeastern North America." Public Symposium: Plight of the Bumblebees. Smithsonian Institution's Natural History Museum, Washington, D.C. June 22, 2009.

### **Additional Honors and Awards**

[www.experiment.com](http://www.experiment.com) crowdfunded grant, 2016: "Home sick: Effects of migratory beekeeping on honey bee disease." (\$6,000)

United States Department of Agriculture National Institute of Food and Agriculture Specialty Crop Block Grant, 2016: "Managing locally sourced native bees as alternative pollinators for Vermont specialty crops." (\$36,000)

United States Department of Agriculture National Institute of Food and Agriculture Postdoctoral Research Fellowship, 2014: "Multispecies interactions affect crop yield and pollinator health." (\$150,000)

Dartmouth Graduate Assistance in Areas of National Need (GAANN) Fellowship, 2014 (\$40,000)

Dartmouth College Graduate Travel Award, 2013 (\$1,000)

New England Botanical Club Graduate Research Award, 2012: "Toxic nectar in turtlehead (*Chelone glabra*): Pollination by self-medicating bees." (\$1,000)

### **Professional and Community Activities**

#### **Member, Vermont Pollinator Protection Committee (2016-2017).**

Appointed by Vermont's governor, Dr. Richardson works with committee members, government agencies, and stakeholders to craft a Pollinator Protection Plan responsive to 2016 legislation. He has contributed to this effort with research and writing on the diversity and status of the state's pollinator fauna, the ecosystem service of pollination, and effects of agricultural pesticides on bees.