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Research Associate

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Education

1997	Ph.D. in Population Biology, *University of California, Davis*
1991	M.S. in Biology, *University of California, San Diego*
1990	B.A. in Ecology, Behavior and Evolution, *University of California, San Diego*

Career Employment

2015-Present	*Research Scientist, Institute for Bird Populations:* Hierarchical modeling of point count data on bird species in western national parks
2008-Present	*Research Associate, Institute of Arctic and Alpine Research, University of Colorado, Boulder:* Ecology of sub-surface habitat specialists
2014	*Research Associate, Museum Collections, University of Colorado, Boulder:* User interface development and research applications for several data archives
2008-2013	*Research Associate, Ecology and Evolutionary Biology, University of Colorado, Boulder:* Modeling the metacommunity dynamics of vernal pool plants
2008	*Instructor, Ecology and Evolutionary Biology, University of Colorado, Boulder:* Graduate seminar in population biology—modeling and data analysis
2002-2007	*Research Associate, Ecology and Evolutionary Biology, University of Colorado, Boulder:* Modeling the dynamics of plague in prairie dogs and alternate hosts
2001-2005	*Independent contractor, US Fish & Wildlife Service:* Black-footed ferret endangered species recovery plan revision
1998-2003	*Research Associate, University of Nevada, Reno:* Developing predictive models of population dynamics and population genetics for species at risk

Publications

Ray, C., J. F. Saracco, A. L. Holmgren, R. L. Wilkerson, R. B. Siegel, K. J. Jenkins, J. I. Ransom, P. J. Happe, J. R. Boetsch, and M. H. Huff. 2017. Recent stability of resident and migratory landbird populations in National Parks of the Pacific Northwest. *Ecosphere* 8(7). http://dx.doi.org/10.1002/ecs2.1902

Foley, P., T. Roth, J. Foley and **C. Ray**. 2017. Rodent-pika parasite spillover in western North America. *Journal of Medical Entomology*. https://academic.oup.com/jme/article/3737823

Waterhouse, M., S., Bryson, **C. Ray**, L. Erb, J. Wilkening and M. Russello. 2017. Individual-based analysis of hair corticosterone reveals factors influencing chronic stress in the American pika. *Ecology and Evolution* 7(12):4099–4108. http://dx.doi.org/10.1002/ece3.3009

Koju, N.P., K. He, M.K. Chalise, **C. Ray**, Z. Chen, B. Zhang, T. Wan, S. Chen, X. Jiang. 2016. Multilocus approaches reveal underestimated species diversity and inter-specific gene flow in pikas (*Ochotona*) from southwestern China. *Molecular Phylogentics and Evolution* 107:239–245.

Wilkening, J. L., and **C. Ray**. 2016. Characterizing predictors of survival in the American pika (*Ochotona princeps*). *Journal of Mammalogy* 97(5):1366–1375.

Ray, C., E. A. Beever, and T. J. Rodhouse. 2016. Distribution of a climate-sensitive species at an interior range margin. *Ecosphere* 7(6):e01379. 10.1002/ecs2.1379

Castillo, J. A., C. W. Epps, M. R. Jeffress, **C. Ray**, T. J. Rodhouse, and D. Schwalm. 2016. Replicated landscape genetic and network analyses reveal wide variation in functional connectivity for American pikas. *Ecological Applications* 26:1660-1676. Online 17 March 2016. DOI: 10.1890/15-1452.1

Schwalm, D., C. W. Epps, T. J. Rodhouse, W. B. Monahan, J. A. Castillo, **C. Ray** and M. R. Jeffress. 2016. Habitat availability and gene flow influence diverging local population trajectories under scenarios of climate change: a place-based approach. *Global Change Biology*. http://dx.doi.org/10.1111/gcb.13189.

Wilkening, J. L., **C. Ray** and J. Varner. 2016. When can we measure stress non-invasively? Post-deposition effects on a fecal stress metric confound a multi-regional assessment. *Ecology and Evolution*. http://dx.doi.org/10.1002/ece3.1857.

Bhattacharyya, S., and **C. Ray**. 2015. Of plants and pikas: evidence for a climate-mediated decline in forage and cache quality. *Plant Ecology & Diversity* 8:781-794. http://dx.doi.org/10.1080/17550874.2015.1121520

Wilkening, J. L., **C. Ray**, N. Ramsay and K. Klingler. 2015. Alpine biodiversity and assisted migration: the case of the American pika (*Ochotona princeps*). *Biodiversity*. DOI: 10.1080/14888386.2015.1112304.

Ray, C., McKnight, D.M., Bidwell, M.D., Fourment, T., Flanagan Pritz, C. and A.H. Rinehart. 2015. Children's book series and associated curricula support elementary education and outreach in water resources. *Plant Ecology and Diversity*, DOI: 10.1080/17550874.2015.1050711.

Wilkening, J. L., and **C. Ray**. 2015. Parks, pikas, and physiological stress: implications for long-term monitoring of an NPS climate-sensitive sentinel species. *Park Science* 32(1):42–48.

Wilkening, J., **C. Ray** and J. Varner. 2015. Relating sub-surface ice features to physiological stress in a climate sensitive mammal, the American pika (*Ochotona princeps*). *PLoS ONE* 10(3):e0119327. http://dx.doi.org/10.1371/journal.pone.0119327.

Ray, C. and S. K. Collinge. 2014. Quantifying the dominance of local control and the sources of regional control in the assembly of a metacommunity. *Ecology* 95:2096–2108. http://dx.doi.org/10.1890/13-0628.1

Erb, L. P., **C. Ray** and R. Guralnick. 2014. Determinants of pika population density versus occupancy in the Southern Rocky Mountains. *Ecological Applications* 24:429–435. http://dx.doi.org/10.1890/13-1072.1.

Collinge, S. K., **C. Ray** and J. Martee. 2013. A long-term comparison of hydrology and plant community composition in constructed versus naturally occurring vernal pools. *Restoration Ecology* 21:704–712. http://dx.doi.org/10.1111/rec.12009

Wilkening, J. L., **C. Ray** and K. L. Sweazea. 2013. Stress hormone concentration in Rocky Mountain populations of the American pika (*Ochotona princeps*). *Conservation Physiology* 1:cot027 (13 pp.). http://dx.doi.org/10.1093/conphys/cot027.

Jeffress, M. R., T. J. Rodhouse, **C. Ray**, S. Wolff and C. W. Epps. 2013. The idiosyncrasies of place: geographic variation in the climate-distribution relationships of the American pika. *Ecological Applications* 23:864–878. http://dx.doi.org/10.1890/12-0979.1.

Cuddington, K., M.-J. Fortin, L. R. Gerber, A. Hastings, A. Liebhold, M. O'Connor, and **C. Ray**. 2013. Process-based models are required to manage ecological systems in a changing world. *Ecosphere* 4:art20. http://dx.doi.org/10.1890/ES12-00178.1

Ray, C., E. Beever and S. Loarie. 2012. Retreat of the American pika: up the mountain or into the void? Pages 245-270 in Brodie, J. F., E. Post and D. F. Doak (eds.) *Wildlife conservation in a changing climate*. University of Chicago Press. 416 pp.

Sackett, L. C., T. B. Cross, R. T. Jones, W. Johnson, K. Ballare, **C. Ray**, S. Collinge, and A. P. Martin. 2012. Connectivity of prairie dog colonies in an altered landscape: inferences from analysis of microsatellite DNA variation. *Conservation Genetics* 13: 407–418. http://dx.doi.org/10.1007/s10592-011-0293-yL [LINK BROKEN].

Garrett, L., M. Jeffress, M. Britten, C. Epps, **C. Ray** and S. Wolff. 2011. Pikas in peril: multiregional vulnerability assessment of a climate-sensitive sentinel species. *Park Science* 28:9–13.

Guralnick, R., L. P. Erb and **C. Ray**. 2011. Mammalian distributional response to climatic change: A review and research prospectus. Pages 85-106 i*n* E. A. Beever and J. Belant (eds.) *Ecological consequences of climate change: Mechanisms, conservation, and management*. CRC Press (Taylor and Francis Group). 302 pp.

Collinge, S. K., **C. Ray** and F. Gerhardt. 2011. Long-term dynamics of biotic and abiotic resistance to exotic species invasion in restored vernal pool plant communities. *Ecological Applications* 21(6):2105–2118.

Erb, L. P., **C. Ray** and R. Guralnick. 2011. On the generality of a climate-mediated shift in the range of the American pika (*Ochotona princeps*). *Ecology* 92: 1730–1735.

Beever, E. A., **C. Ray**, J. L. Wilkening, P. W. Mote, and P. F. Brussard. 2011. Contemporary climate change alters the pace and drivers of extinction. *Global Change Biology* 17(6):1–17. DOI: 10.1111/j.1365-2486.2010.02389.x

Wilkening, J. L., **C. Ray**, E. A. Beever, and P. F. Brussard. 2011. Modeling contemporary range retraction in Great Basin pikas (*Ochotona princeps*) using data on microclimate and microhabitat. *Quaternary International* 235:77–88.

Johnson, T.L., J.F. Cully, Jr., S.K. Collinge, **C. Ray**, C. Frey and B. Sandercock. 2011. Spread of plague among black-tailed prairie dogs is associated with colony spatial characteristics. *Journal of Wildlife Management* 75(2):357–368

Rodhouse, T. J., E. A. Beever, L. K. Garrett, K. M. Irvine, M. R. Jeffress, M. Munts, and **C. Ray**. 2010. Distribution of American pikas in a low-elevation lava landscape: conservation implications from the range periphery. *Journal of Mammalogy* 91:1287–1299.

Cully, J. F. Jr., S. K. Collinge, R. E. VanNimwegen, **C. Ray**, W. C. Johnson, B. Thiagarajan, D. B. Conlin and B. Holmes. 2010. Spatial variation in keystone effects: small mammal diversity associated with black-tailed prairie dog colonies. *Ecography* 33:667–677. DOI: 10.1111/j.1600-0587.2009.05746.x

Cully, J.F., Jr., T.L. Johnson, S.K. Collinge, and **C. Ray**. 2010. Disease limits populations: plague and black-tailed prairie dogs. *Vector-Borne and Zoonotic Diseases* 10(1):7-15.

Beever, E. A., **C. Ray**, P. W. Mote, and J. L. Wilkening. 2010. Testing alternative models of climate-mediated extirpations. *Ecological Applications* 20:164–178.

Torres-Pérez, F. L. Wilson, S. K. Collinge, H. Harmon, **C. Ray**, R. A. Medina, and B. Hjelle. 2010. Sin Nombre virus infection in field workers, Colorado, USA. *Emerging Infectious Diseases* 16:308–310. DOI: 10.3201/eid1602.090735

Brinkerhoff, R. J., **C. Ray**, B. Thiagarajan, S. K. Collinge, J. F. Cully, Jr., B. Holmes and K. L. Gage. 2010. Prairie dog presence affects occurrence patterns of disease vectors on small mammals. *Ecography* 31:654–662. DOI: 10.1111/j.0906-7590.2008.05336.x

Brinkerhoff, R. J., S. K. Collinge, Y. Bai, and C. Ray. 2009. Are carnivores universally good predictors of plague? *Vector-Borne and Zoonotic Diseases* 9(5):491-497. DOI: 10.1089/vbz.2008.0075.

Collinge, S. K., and **C. Ray**. 2009. Transient patterns in the assembly of vernal pool plant communities. *Ecology* 90:3313–3323.

Collinge, S. K., and **C. Ray**. 2009. Ecology and restoration of vernal pools: A ten-year study of plant community dynamics. *Pages* 281–290 *in* P. Fraga i Arguimbau (ed.) *International conference on*

mediterranean temporary ponds: Proceedings and abstracts. Consell Insular de Menorca. Recerca 14. Mao, Menorca, Spain.

Collinge, S. K., **C. Ray** and J. F. Cully, Jr. 2008. Effects of disease on keystone species, dominant species, and their communities. *Pages* 129-144 *in* Ostfeld, Eviener, and Keesing (eds.) *Effects of Ecosystems on Disease and of Diseases on Ecosystems*. Princeton University Press.

Bai, Y., M. Y. Kosoy, **C. Ray**, R. J. Brinkerhoff and S. K. Collinge. 2008. Temporal and spatial patterns of *Bartonella* infection in black-tailed prairie dogs (*Cynomys ludovicianus*). *Microbiology Ecology* 56:373-382.

Bai, Y., M. Kosoy, A. Martin, **C. Ray**, K. Sheff, L. Chalcraft and S. K. Collinge, 2008. Characterization of *Bartonella* strains isolated from black-tailed prairie dogs (*Cynomys ludovicianus*). *Vector-Borne and Zoonotic Diseases* 8:1-5.

Snäll, T., R. O'Hara, **C. Ray** and S. Collinge, 2008. Climate-driven spatial dynamics of plague among prairie dog colonies. American Naturalist 171:238-248.

Ray, C. and S. K. Collinge, 2007. Introducing the trophic vortex. (Invited letter.) EcoHealth 4:122-124.

Bai, Y., M. Y. Kosoy, J. F. Cully Jr., B. Thiagarajan, **C. Ray** and S. K. Collinge. 2007. Acquisition of non-specific *Bartonella* strains by the northern grasshopper mouse (*Onychomys leucogaster*). Microbiology Ecology 61:438-448.

Ray, C. and S. K. Collinge, 2006. Potential effects of a keystone species on the dynamics of sylvatic plague. *Pp*. 202-216 *in* Collinge, S. K. and C. Ray (eds.), *Disease ecology: community structure and pathogen dynamics*. Oxford University Press. 227 pp.

Collinge, S. K. and **C. Ray**, 2006. Community epidemiology. *Pp*. 1-5 *in* Collinge, S. K. and C. Ray (eds.), *Disease ecology: community structure and pathogen dynamics*. Oxford University Press. 227 pp.

Collinge, S. K., W. C. Johnson, **C. Ray**, R. Matchett, J. Grensten, J. F. Cully, Jr., K. L. Gage, M. Y. Kosoy, J. E. Loye and A. P. Martin, 2005b. Landscape structure and plague occurrence in black-tailed prairie dogs on grasslands of the western USA. Landscape Ecology 20:941–955.

Collinge, S. K., W. C. Johnson, **C. Ray**, R. Matchett, J. Grensten, J. F. Cully, Jr., K. L. Gage, M. Y. Kosoy, J. E. Loye, and A. P. Martin, 2005a. Testing the generality of a trophic-cascade model for plague. EcoHealth 2:1–11.

Jones, R., A. Martin, A. Mitchell, S. Collinge and **C. Ray**, 2005. Characterization of 14 polymorphic microsatellite markers for the black-tailed prairie dog. Molecular Ecology Notes 5:71-73.

Fleishman, E., **C. Ray**, P. Sjögren-Gulve, C. L. Boggs, D. D. Murphy, 2002. Assessing the relative roles of patch quality, area and isolation in predicting metapopulation dynamics. Conservation Biology 16:706-716.

Harrison, S. and **C. Ray**, 2002. Plant population viability and metapopulation-level processes. *Pp.* 109-122 *in* Beissinger, S. and D. McCullough (eds.), *Population viability analysis*. University of Chicago Press. 577 pp.

Ray, C., 2001. Maintaining genetic diversity despite local extinctions: effects of population scale. Biological Conservation 100:3-14.

Debinski, D. M., **Ray, C.** and E. H. Saveraid, 2001. Species diversity and the scale of the landscape mosaic: do scales of movement and patch size affect diversity? Biological Conservation 98:179-190.

Peacock, M. and **C. Ray**, 2001. Dispersal in Pikas (*Ochotona princeps*): combining genetic and demographic approaches to reveal spatial and temporal patterns. *Pp.* 43-56 *in* Clobert et al. (eds.) *Dispersal: causes, consequences and mechanisms of dispersal at the individual, population and community level*. Oxford University Press. 480 pp.

Holyoak, M. and **C. Ray**, 1999. A roadmap for metapopulation research. Ecology Letters 2(5):273-275.

Ray, C. and M. Hoopes, 1997. A step toward synthesizing metapopulation biology. (Book review.) Ecology 78(7):2270-2271.

Ray, C. and A. Hastings, 1996. Density dependence: are we searching at the wrong spatial scale? Journal of Animal Ecology 65(5):556-566.

Sjögren-Gulve, P. and **C. Ray**, 1996. Using logistic regression to model metapopulation dynamics: large-scale forestry extirpates the pool frog. *Pp.* 111-137 *in* D. R. McCullough (ed.), *Metapopulations and Wildlife Conservation & Management.* Island Press, Washington D.C.

Ray, C., M. Gilpin, T. Philippi and C. Biehl, 1993. Modeling raven predation on the desert tortoise: a structured approach. *Pp.* 118-124 *in* Proceedings of the 1992 Desert Tortoise Council Symposium.

Ray, C., M. Gilpin and A. T. Smith, 1991. The effect of conspecific attraction on metapopulation dynamics. *Pp.* 123-134 *in* Gilpin, M. and Hanski, I. (eds.) *Metapopulation Dynamics, Empirical and Theoretical Investigations*. Academic Press, London.

Edited Volume

Collinge, S. K. and **C. Ray**, 2006. *Disease ecology: community structure and pathogen dynamics*. Oxford University Press. 227 pp.

Species Recovery Plan

Ray, C., 2006. Species recovery plan for the black-footed ferret (*Mustela nigripes*): Revised and fully annotated outline. Submitted to US Fish and Wildlife Service, June 2006. 140 pp.

Professional Reports

Ray, C., J. Saracco, K. Jenkins, M. Huff, P. Happe, and J. Ransom. 2017. Development of a robust analytical framework for assessing landbird population trends, dynamics and relationships with environmental covariates in the North Coast and Cascades Network. Natural Resource Report NPS/NCCN/NRR—2017/1483. National Park Service, Fort Collins, Colorado.

Epps, C. W., D. Schwalm, J. Castillo, T. J. Rodhouse, M. Jeffress, and **C. Ray**. 2013. Analysis of proposed rock quarrying and trail improvement impacts on American pikas in Grand Teton National Park. Natural Resource Technical Report NPS/UCBN/NRTR—2013/756. National Park Service, Fort Collins, Colorado.

Ray, C. and E. Beever, 2007. Distribution and abundance of the American pika (*Ochotona princeps*) within Lava Beds National Monument. Submitted to US National Park Service, May 2007. 62 pp.

Software

Chamberlain, S., **C. Ray** and Vijay Barve. c 2015. `rvertnet`: an R interface for the VertNet database. https://github.com/ropensci/rvertnet.

Ray, C., c 2000. POPNET: model of structured population dynamics, based on movement and survival patterns implied from demographic census data.

Ray, C. and G. Hoelzer, c 1999. VISCOUS: cellular automata model of genetic viscosity in spatially structured populations.

Ray, C., c 1996. BRYOGROW: spatially realistic (non-cellular) modeling of clonal growth, competition and integration (developed for study of bryozoans or lichens).

Ray, C., P. Sjogren-Gulve and M. Gilpin, c 1994. METAPOP2: general software for modeling patch dynamics in heterogeneous and spatially explicit metapopulations.

Gilpin, M., **C. Ray** and C. Biehl, c 1989*. LESSON: self-instruction software for learning the True BASIC programming language. (*New version released by M. Gilpin, c 1990.)

Conferences, Symposia, Oral Sessions and Workshops Organized

Ray, C. et al. 2015. 3rd Annual North American Pika Research Conference. April 17-18, Golden, CO.

Ray, C. and S. Collinge, 2007. Climate change and disease ecology. Organized oral session for the Ecological Society of America.

Ray, C., 2006. Detection and monitoring of the American pika. National Park Service Workshop, Lava Beds National Monument, CA.

Ray, C., 2006. Bayesian analysis and hierarchical modeling in ecology. Weekly Fall Workshop, University of Colorado.

Ray, C., 2006. Modern methods for modeling presence-absence data. Weekly Fall Workshop, University of Colorado.

Collinge, S. and **C. Ray**, 2003. Emerging diseases: stressing the union of community ecology and epidemiology. Symposium for the Ecological Society of America.

Invited Presentations (* indicates presenter)

Ray, C.*, 2014. A pika in my pocket: snuggling up to study climate change. Teen Café, Denver Botanical Gardens, March 10.

Ray, C.*, J. Wilkening, S. Bhattacharyya and L. Erb, 2013. Cheating climate change: can microhabitat selection save a species? University of Nevada, Reno, NV, October 17.

Ray, C.*, 2013. Climate and the American pika. 20th Annual Boulder County Ecosystem Symposium on *Climate Change and the Resilience of High Elevation Ecosystems*, University of Colorado, Boulder, CO, March 16.

Ray, C.*, 2013. Pika CPR in the Indian Peaks: status and stories of an alpine icon. Annual meeting of the Indian Peaks Wilderness Association, USDA Forest Service, Boulder, CO, March 4.

Ray, C.*, M. Jeffress et al., 2013. National Park Service pika study: habitat occupancy results from eight parks and preliminary genetic results. Interpretation and Resource Stewardship Workshop, Continental Divide Research Learning Center's Annual Interpretation and Resource Stewardship Day, Rocky Mountain National Park, CO, February 27.

Ray, C.*, 2012. Climate and the American pika: in our wilderness and beyond. USDA Forest Service Wilderness Volunteer Workshop, Denver, CO, December 3-4.

Ray, C.*, 2012. Climate and the American pika. Fort Collins Audubon, Fort Collins, CO, November 8.

Erb, L. P.*, **C. Ray** and R. Guralnick, 2012. Climatic influences on multi-year occupancy of the American pika (*Ochotona princeps*) in the southern Rocky Mountains. Naturalist Nights lecture series at the Aspen Center for Environmental Studies.

Ray, C.*, 2012. Effects of microclimate on patterns of survival in the American pika inferred from long-term data on a population in the central Rocky Mountains. Symposium for the North American Congress for Conservation Biology, Oakland, CA.

Jeffress, M.*, **C. Ray** et al., 2012. Status and trend in American pika site occupancy patterns across the western US: insights from some of the nation's "crown jewel" national park units. Symposium of the North American Congress for Conservation Biology, Oakland, CA, July 15-18.

Erb, L. P.*, **C. Ray** and R. Guralnick, 2012. Climatic influences on multi-year occupancy of the American pika (*Ochotona princeps*) in the southern Rocky Mountains. Symposium of the North American Congress for Conservation Biology, Oakland, CA, July 15-18.

Ray, C.*, M. Jeffress et al., 2012. National Park Service pika habitat occupancy study: Preliminary results from eight parks. 6th Biennial Rocky Mountain National Park Research Conference, Estes Park, CO, March 28-29.

Ray, C.*, M. Jeffress et al., 2012. National Park Service pika habitat occupancy study: Preliminary results from eight parks. Biodiversity and Climate Change Workshop, Continental Divide Research Learning Center's Annual Interpretation and Resource Stewardship Day, Rocky Mountain National Park, CO, February 8.

Ray, C.*, 2012. The American pika, a model species for studying climate sensitivity. Science Hubs teacher development workshop, Colorado Springs, CO,

Ray, C.*, 2011. When tailings are habitat: hard rock mining and the American pika. Colorado Art Ranch Artposium, *Hardrock revision: re-envisioning the Ute-Ulay mine*, Lake City, CO, July 29. Sponsored by the Office of University Outreach, University of Colorado-Boulder.

Ray, C.*, 2011. Climate and the American pika. Pueblo Zoo, Pueblo, CO, April 7. Sponsored by the Office of University Outreach, University of Colorado-Boulder.

Ray, C.*, 2010. Climate-mediated relations between biodiversity and disease: answers on the horizon. Symposium, 95th Annual Meeting of the Ecological Society of America, *All You Need to Know is...: advice from theorists on managing ecosystems in a changing climate*. Pittsburgh, PA, August 1-6.

Ray, C.*, 2010. The American pika. Denver Zoo. Sponsored by Denver Zoo, Center for Native Ecosystems and the Front Range Pika Project.

Ray, C.*, 2010. A passel of pikas in lava beds at low elevation: Exploring the distribution of the American pika within Lava Beds National Monument, CA. Symposium of The Wildlife Society, Western Section, Irvine, CA.

Ray, C.*, 2010. Climate and the American pika. California Polytechnic, San Luis Obispo, CA.

Ray, C.*, 2010. Inferring effects of climate on the American pika. Boulder County Nature Association.

Ray, C.*, 2010. Climate and the American pika. Audubon Society of Boulder, CO.

Ray, C.*, E. Beever, P. Mote, J. Wilkening, L. Peterson, K. Sweazea and S. Loarie, 2010. Climate and the American pika. COSEE Institute, Boulder High School, Boulder, CO.

Ray, C.*, E. Beever, P. Mote, J. Wilkening and L. Peterson, 2010. Inferring effects of climate on the American pika. Speaker series for Gore Range Natural Science School, sponsored by the Gore Range Natural Science School and Avon Public Library, Avon, CO.

Ray, C.*, 2010. Inferring effects of climate on the American pika. Roaring Fork Audubon, Glenwood, CO.

(Invited presentations prior to 2010 omitted.)

Contributed Presentations (* indicates presenter)

Ray, C., J. Saracco, M. Holmgren, R. Wilkerson, R. Siegel and J. Ransom*. 2018. Landbird population trends in protected areas of the North Coast and Cascades Network. American Ornithological Society, Tucson, Arizona, April 9-17.

Ray, C.*, J. Saracco, M. Holmgren, R. Wilkerson, R. Siegel, K. Jenkins, J. Ransom, P. Happe, J. Boetsch and M. Huff. 2017. Landbird population trends in protected areas of the North Coast and Cascades Network. 64th Annual Meeting of The Wildlife Society, Reno, Nevada, February 6-10.

Benedict, L.* and **C. Ray**. 2017. From dawn to dusk: a behavioral study of the American pika. 64th Annual Meeting of The Wildlife Society, Reno, Nevada, February 6-10, Symposium of the North American Pika Consortium.

Craighead, A.*, **C. Ray** and J. L. Wilkening. 2017. Why is melanism uncommon in the American pika? 64th Annual Meeting of The Wildlife Society, Reno, Nevada, February 6-10, Symposium of the North American Pika Consortium.

Wasser, M.* and **C. Ray**. 2017. Inferring range contraction from apparent cache age in a food-hoarding species. 64th Annual Meeting of The Wildlife Society, Reno, Nevada, February 6-10, Symposium of the North American Pika Consortium.

Wiebe, M.*, M. Plichta, H. Batts, L. Benedict and **C. Ray**. 2017. Subsurface temperature and other environmental effects on the summer surface activity of a microhabitat specialist. 64th Annual Meeting of The Wildlife Society, Reno, Nevada, February 6-10, Symposium of the North American Pika Consortium.

Siegel, R. B.*, R. L. Wilkerson, J. F. Saracco, A. L. Holmgren, **C. Ray** and S. Haultain. 2016. Monitoring SIEN bird populations in an era of rapid environmental change. Sequoia and Kings Canyon National Parks Science Symposium, Three Rivers, California, November 9-10.

Erb, L.P.*, L.C. Sackett, P.L. Erb, **C. Ray** and R.P. Guralnick. 2016. Impacts of climatic and landscape characteristics on gene flow among American pika (*Ochotona princeps*) populations in the southern Rocky Mountain region. 5th World Lagomorph Conference, CSU-Stanislaus,Turlock, California, July 11-13.

Koju, N.P.*, et al. (**Ray**). 2016. A multilocus phylogeny of pikas (Ochotona) and its implications for systematics and gene flow. 5th World Lagomorph Conference, CSU-Stanislaus,Turlock, California, July 11-13.

Bhattacharyya, S.* et al. (**Ray**). 2016. Royle's pika in a changing climate: insight from past and present distributions. 5th World Lagomorph Conference, CSU-Stanislaus,Turlock, California, July 11-13.

Howe, J. Jr., C. Prince and **C. Ray***. 2015. Seasonal effects of microhabitat structure on sub-surface microclimates in blocky debris. LTER ASM, Estes Park, CO, Aug 30-Sep 2.

Ray, C.*, J. Vukomanovic, P. Bourgeron, J. G. Smith and R. Andrus, 2015. V-ART curriculum for teaching social-ecological systems to children in mountain communities. LTER All Scientists Meeting, Estes Park, Colorado, Aug 30-Sep 2.

Wiebe, M., M Plichta*, H. Batts, S. McLaughlin, J. Johnson and **C. Ray**, 2015. Effects of surface and sub-surface temperature on the activity budget of a microhabitat specialist. LTER All Scientists Meeting, Estes Park, Colorado, Aug 30-Sep 2.

Wilkening, J., and **C. Ray***, 2015. Determining effects of microclimate on individual survival in the American pika. LTER All Scientists Meeting, Estes Park, Colorado, Aug 30-Sep 2.

Bhattacharyya, S., and **C. Ray***, 2015. Climate change and foraging efficiency in a territorial herbivore: changes in food cache quality parallel a change in microclimate. LTER All Scientists Meeting, Estes Park, Colorado, Aug 30-Sep 2.

Beers, A.*, **C. Ray** and R. Guralnick, 2015. Seasonality in the use of heterogeneous terrain by a territorial habitat specialist. LTER All Scientists Meeting, Estes Park, Colorado, Aug 30-Sep 2.

Schwalm, D., et al. (**Ray***), 2015. Projecting futures for the American pika, a climate indicator species, in Rocky Mountain National Park. RMNP Research Conference, March 4-5.

Schwalm, D.,* et al., 2014. Accounting for lost habitat when forecasting effects of climate change on metapopulation dynamics. The Wildlife Society, 21st Annual Conference, Pittsburgh, Pennsylvania, October 29.

Castillo, J.,* et al., 2014. Landscape effects on gene flow of American pika: a comparative landscape genetics study. North America Congress for Conservation Biology, Missoula, Montana, July 13-16.

Wilkening, J.* and **C. Ray**, 2013. "Comparison of stress hormone levels measured in pikas across the western US". North American Congress for Conservation Biology. Baltimore, Maryland, July 21-25.

Wilkening, J.* and **C. Ray**, 2013. Indicators of physiological stress in American pikas. 11th International Mammalogical Congress. Belfast, Ireland, August 11-16.

Wilkening, J.* and **C. Ray**, 2013. Effects of environment on stress hormone metabolites measured in American pika feces. International Society of Wildlife Endocrinology 5th annual conference. Chicago, Illinois, October 14-16.

Wilkening, J.* and **C. Ray**, 2012. A non-invasive technique for assessing stress in a sensitive alpine species. 97th Ann. Meeting of the Ecological Society of America. Portland, Oregon, August 5-10.

Wilkening, J.* and **C. Ray**, 2012. Poster: Using fecal samples to measure stress in American pikas in a Rocky Mountain LTER. Long Term Ecological Research (LTER) All Scientists Meeting: The unique

role of the LTER network in the Anthropocene: Collaborative Science Across Scales. Estes Park, Colorado, September 10-13.

Erb, P.*, L. P. Erb and **C. Ray**, 2012. Poster: ScienceLIVE: Providing innovative connections between LTER research and the public. Long Term Ecological Research (LTER) All Scientists Meeting: The unique role of the LTER network in the Anthropocene: Collaborative Science Across Scales. Estes Park, Colorado, September 10-13.

Nichols, L., **C. Ray*** and L. P. Erb, 2012. Factors influencing persistence in a declining population of American pikas in the Bodie Hills of eastern California. The Wildlife Society 19th annual conference. Portland, Oregon, October 13-18.

Wilkening, J.* and **C. Ray**, 2012. Using physiological samples to measure stress in American pikas. The Wildlife Society 19th annual conference. Portland, Oregon, October 13-18.

Collinge, S.* and **C. Ray**, 2011. Reflections on vernal pool plant community restoration: Three lessons from a long-term field experiment. 96th Ann. Meeting of the Ecological Society of America.

Erb, L.*, **C. Ray** and R. Guralnick, 2011. Multi-year pika occupancy in the Southern Rockies: A regional stronghold or the next Great Basin? 95th Ann. Meeting of the Ecological Society of America.

Ray, C.*, K. Sweazea and J. Wilkening, 2011. Signs of demographic change and physiological stress in Rocky Mountain pikas. 95th Ann. Meeting of the Ecological Society of America.

Ray, C.*, 2010. Demographic change and physiological stress in Rocky Mountain pikas. 1st North American Pika Conference, Jackson Hole, WY.

Ray, C.* and M. Shardlow, 2010. National Park Service pika habitat occupancy study: Preliminary results from eight parks. Meeting of the California Pika Consortium, at the annual conference of The Wildlife Society-Western Section.

(Contributed presentations prior to 2010 omitted.)

Academic Course Lectures

Ray, C., 2015. Pikas and climate. Lecture contributed to *Conservation biology* course, University of Colorado, Boulder, CO, June 15.

Ray, C.*, 2014. Pikas and climate. Lecture presented in *Conservation biology* course, University of Colorado, Boulder, CO, November 5.

Ray, C.*, 2012. A model of climate sensitivity? Lectures presented in upper-division/graduate courses *Mountain geography* and *Conservation biology*, University of Colorado, Boulder, CO.

Ray, C.*, 2012. Climate and the American pika. Biology Club, University of Colorado, Boulder, CO, November 8.

Ray, C.*, 2011. A model of climate sensitivity? Lectures presented in upper-division/graduate courses *Novel ecosystems: understanding local manifestations of global change* and *Conservation biology*, University of Colorado, Boulder, CO.

Ray, C.*, 2010. Climate and the American pika. Lecture presented in upper-division/graduate course *Mountain geography*, University of Colorado, Boulder, CO.

Ray, C.*, 2010. Climate change and disease ecology. Lecture presented in upper-division/graduate course *Disease ecology and evolution*, University of Colorado, Boulder, CO.

Ray, C.*, 2010. Signs of demographic change and physiological stress in Rocky Mountain pikas. Lecture presented in upper-division/graduate course *Novel ecosystems: understanding local manifestations of global change*, University of Colorado, Boulder, CO.

(Course lectures prior to 2010 omitted.)

Grants and Contracts

PI: Niwot Ridge LTER VII Grant (2017): $30K
PI: National Park Service Task Agreement P16AC00704/ UCOB-112 (2016) $11K
Co-author: National Park Service Task Agreement P15AC00468 (2017) (PI: R. Siegel)
Co-author: NSF LTREB Grant (2013) $450K (PI: S. Collinge)
PI: University of Colorado-Boulder Office of University Outreach Grant (2011) $5.5K
PI: National Park Service Climate Change Response Grant (2010) $713K
Co-author: NSF LTREB Grant (2008) $450K (PI: S. Collinge)
PI: Charlotte Martin Foundation Grant (2007) $10K
Co-author, Supervisor: Alcoa Foundation Practitioner Fellowship (2007) $10K (PI: A. Craighead)
Co-PI: WWF International Research Grant (2007) $8.6K (PI: E. Beever)
PI: WWF International Research Grant (2006) $4K
Contractor: US National Park Service Contract (2005) $12K (PI: E. Beever)
Contractor: Colorado Dept. of Transportation Contract (2003) $2.4K
Co-author: NSF/NIH Ecology of Infectious Diseases Grant (2002) $1.7M (PI: S. Collinge)
PI: US Fish and Wildlife Service Contract (2001) $30K
Co-author: EPA Species At Risk Grant (2001) $0.5M (PI: S. Collinge)
Co-author: US Fish and Wildlife Service Contracts (1998-2002) $0.4M (PI: M. Peacock)
Co-PI: NSF Dissertation Improvement Grant (1995) $4.5K (PI: A. Hastings)
PI: UC Davis Graduate Research Awards (1995, 1994) $3K
PI: UC Davis Center for Population Biology Research Grants (1992-5) $4.5K
PI: UC San Diego David J. Gambee Memorial Fellowship (1990) $1K

Professional Service and Society Memberships

NSF Population and Community Ecology Panel
IUCN Lagomorph Specialist Group
Ecological Society of America

Synergistic Activities

Innovations in teaching and training and research: Developed graduate student seminars on Bayesian hierarchical analysis, occupancy modeling, population viability analysis and demographic modeling for graduate students at the University of Colorado. Developed software: rvertnet for accessing the VertNet biological database using R, POPNET and METAPOP2 for modeling population and metapopulation dynamics, VISCOUS for simulating spatial patterns in genetic diversity, BRYOGRO for simulating clonal growth patterns, and LESSON for teaching basic programming skills to undergraduates. Co-developed citizen-science training programs (e.g., pikapartners) designed to develop skills in data collection and database use for conservation.

Outreach: Coordinated and performed educational programs and associated outreach for the Niwot Ridge Long Term Ecological Research (NWT LTER) program, through an annual appointment with the Institute for Arctic and Alpine Research (INSTAAR). During a five-year climate change vulnerability study for the American pika in eight National Parks and Monuments, provided a variety of targeted outreach products for park staff, including resource briefs highlighting key results and conservation implications for each park, as well as ways to communicate critical findings to the public, and contributed to three webinars for park staff and scientists nationwide.

Service to the broader scientific community: Serving as a member of the IUCN Lagomorph Specialists Group. Provided external review of Ph.D. theses for Tord Snäll (Uppsala University),

Geoffrey Heard (La Trobe University), and Haijing Shi (University of New South Wales). Co-organized the 3rd annual Conference of the North American Pika Consortium, April 2015, attended by researchers from India, Nepal, Canada and the US. Co-organized symposia/sessions for multiple international meetings of the Ecological Society of America. Coordinated a revision of the US Fish and Wildlife Service recovery plan for black-footed ferret. Provided external review for the Colorado Department of Transportation regarding strategies for reducing impacts of highway construction on Prebles' meadow jumping mouse and lynx. Provided external review for the NOAA Northwest Fisheries Science Center Cumulative Risk Initiative regarding development of salmonid population viability analyses. Provided merit review for the National Science Foundation, including service on NSF's Population and Community Ecology panel. Co-PI on an inventory and vulnerability assessment of the American pika within many land units administered by the National Park Service (Rocky Mountain, Yellowstone-Teton and Upper Columbia Basin Networks).

Community service: Co-organized the Front Range Pika Project, a citizen-science program to document change in the distribution and habitats occupied by the American pika. Sponsored by three non-profit organizations (Boulder County Nature Association, Rocky Mountain Conservancy Field Institute and Rocky Mountain Wild) to teach annual field courses on pika ecology for non-scientists (2007-present). Provided interviews for features in print, broadcast and web media including ABC Nightly News, National Public Radio, Science and National Wildlife.

Development of databases to support research and education: Published a long-term dataset on American pika demographics through the Niwot Ridge Long Term Ecological Research (LTER) project. Co-developed six citizen-science groups collecting American pika data throughout the western US (e.g., www.pikapartners.org). Improved QA/QC on landbird data from point counts conducted during 2005-2014 in five National Parks in the Pacific Northwest. Upgraded tools for accessing data via VertNet.

Innovations in teaching and training: Developed a long-term study of the American pika in support of graduate and undergraduate training. Since 2008, I have used the "Pika Project" to mentor seven doctoral students (one from India and one from Nepal), three masters students, and 26 undergraduates including 10 REU students and 12 students supported by individual grants. Three undergraduates have completed honors theses under my guidance, and two are expected to complete honors theses in May 2016.

Contributions to the science of learning: Authored an account of the development of the first books from the NSF-sponsored LTER Schoolyard Book Series: **Ray, C.**, McKnight, D.M., Bidwell, M.D., Fourment, T., Flanagan Pritz, C. and A.H. Rinehart. 2015. *Children's book series and associated curricula support elementary education and outreach in water resources* (http://dx.doi.org/10.1080/17550874.2015.1050711).

Broadening the participation of groups underrepresented in STEM: Mentored three students from backgrounds underrepresented in science through the Niwot Ridge LTER REU program. Co-developed on-line resources designed to reach broad K-12 audiences (www.science-live/pikas), and developed a twitter feed @pikaresearch to showcase diversity in field research. Contributed to the creation of five video documentaries on American pika research, each designed for a broad audience. Mentored three graduate and three undergraduate students in education and outreach culminating in STEM presentations for K-12 students in a variety of venues. Appeared as a guest researcher (twice) in the Teen Science Café program.

Student Mentoring

Post-doctoral Associates (co-advisor)
Tord Snäll, Swedish University of Agricultural Sciences, 2005

Graduate Students (co-advisor)
Isabel Corona, Masters x2018
Ashley Whipple, Masters x2019
Jennifer Wilkening, Ph.D. 2014
Liesl Peterson Erb, Ph.D. 2013
Sabuj Bhattacharyya, Fulbright 2010

Undergraduate Honors (advisor)
Haley Weaver, Humboldt State University Honors x2018
Emily Monk, EBIO Honors x2018
Max Wasser, EBIO Honors x2018
Lauren Benedict, Whitman College Honors 2017
Spencer Holtz, EBIO Honors x2016
Maxwell Plichta, EBIO Honors x2016
Meghan Wiebe, EBIO Honors 2015
James Howe Jr., ENVS Honors 2014

Undergraduate Research (supervisor or co-supervisor)
Haley Weaver, NSF REU Summer 2017
Emily Monk, UROP Summer 2017
Max Wasser, NSF REU Summer 2017
Hilary Rinsland, U Richmond Virginia Fellow Summer 2017
Lauren Benedict, NSF REU Summer 2016
Max Wasser, BURST Summer 2016
Jeremy Bonnell, ENVS Summer 2016
Spencer Holtz, UROP Summer 2015
Maxwell Plichta, NSF REU Summer 2015
Jasmine Vidrio, NSF REU Summer 2015
Hilary Brumberg, Wesleyan Fellowship Summer 2015
Christian Prince, ENVS Internship Fall 2014, UROP Spring 2015
Maxwell Plichta, UROP Fall 2014
Meghan Wiebe, NSF REU Summer 2013, UROP Spring 2013
Taylor Stratton, NSF REU Summer 2013
James Howe Jr., BURST Summer 2013
Kacey Fitzgerald, UROP Summer 2013
Kayla Barton, EBIO Independent Study Spring 2013
Riley Stuckey, BURST Fall 2012
Sarah McLaughlin, NSF REU Summer 2012
Jessica Johnson, UROP Summer 2012
Brooke Regan, UROP Fall 2011
Gerardo Dillehay, NSF REU Summer 2011
Lindsey Nietmann, NSF REU Summer 2008
Phillip Wasz, NSF REU Summer 2008

Recent Supervisors

Rodney Siegel (rsiegel@birdpop.org)
Director, Institute for Bird Populations, Point Reyes, CA

Katharine Suding (Katharine.Suding@colorado.edu)
Associate Professor of EE Biology, INSTAAR Associate and Lead Investigator for the Niwot Ridge LTER, University of Colorado, Boulder, CO