Luke J. Zachmann

Data scientist · Statistician

1532 42nd St, Los Alamos, NM 87544

(612) 859-4983 | lzachmann@gmail.com | lzachmann | lzachmann | luke-zachmann-b76534229

Experience

Conservation Science Partners, Inc. [501(c)(3)] — *Remote / Truckee, CA*
Senior Scientist / Data Scientist / Co-founder — *2012–present*

Northern Arizona University, Lab of Landscape Ecology and Conservation Biology, School of Earth & Sustainability — *Flagstaff, AZ*
Senior Research Specialist — *2010–2012*

Utah State University, Department of Wildland Resources and the Ecology Center — *Logan, UT*
Research Assistant and Lab Manager — *2007–2010*

U.S. Department of Energy, Oak Ridge National Laboratory — *Oak Ridge, TN*
Research Fellow — *2006–2007*

Education

Utah State University, Dept. of Wildland Resources and the Ecology Center — *Logan, Utah*
M.S. in Ecology / Graduate Advisor: Dr. Peter Adler — *2008–2010*

- Statistical and simulation modeling techniques in theoretical ecology, with applications to plant population and community dynamics, coexistence and patterns of diversity, and ecological forecasting.
- Experimental and observational field work in dryland and forest ecosystems.

University of Minnesota Morris — *Morris, Minnesota*
B.A. in Environmental Science, Div. of Science & Math; B.A. in English, Dept. of English — *2002–2006*

Skills

Programming languages	R, Python, SQL
Development / DevOps	Shell scripting, Git, Docker, CI/CD
Modeling	Machine / deep learning (PyTorch, TensorFlow), Bayesian hierarchical modeling (greta, JAGS, Stan), maximum likelihood estimation, and multivariate methods
Remote sensing / GIS	Google Earth Engine, Microsoft Planetary Computer, GDAL/OGR, QGIS, ArcGIS
Cloud platforms	Google Cloud Platform, Microsoft Azure
Data viz	Shiny, Plotly, Leaflet, ggplot2, Matplotlib
Web	HTML, CSS, and JavaScript
Writing / publishing	G Suite apps (e.g., Google Docs), Markdown, LaTeX, reveal.js, Microsoft Office

Selected grants and contracts

Statistical support for long-term monitoring in five intermountain Inventory & Monitoring Networks — *PI*
National Park Service | $360,210 — *2016–present*

- Develop Bayesian hierarchical models supporting inference on indicators observed annually by the National Park Service Inventory and Monitoring (I&M) Program.
- A Bayesian approach is used for several reasons. Bayesian models are highly flexible, allowing analysis appropriate for many different types of observations: counts, counts in categories, proportions, real numbers, strictly non-negative real numbers, ordinal scores, and others. Models can be composed to deal with data that are "missing by design" in addition to data missing unintentionally – a feature that is typical of I&M data. The models we developed allow inference on status and trend as well as covariates that vary over space and time. This model based approach improves on design based estimators in several regards, as described in this recent paper.
- Develop data and model APIs and software to support specifying a large variety of models – specifically, different combinations of likelihoods / priors, link functions, group level effects, variance structures, covariates, and derived quantities.

Modeling dynamics of the Nēnē population in Hawai'i Volcanoes National Park
Co-I

National Park Service | $81,372 — *2018–present*

- Develop stage structured, Jolly-Seber state-space models that incorporate sex and weather covariates to provide accurate estimates of survival and abundance.
- Evaluate alternatives for future sampling designs relative to their ability to meet goals for cost and precision as specified by the National Park Service.
- Evaluate applying Pollock's Robust Design to analysis of mark-resight data to improve inference on total population size and individual survival probabilities.

Ecosystem monitoring using the the "Planetary Computer"
Co-I

Microsoft AI for Earth | $633,180 — *2020–present*

- Research projects include mapping wildlife connectivity across U.S. agricultural lands, assessing anthropogenic impacts on terrestrial lands over time, and monitoring U.S. forest disturbance at scale with AI (see https://analytics-lab.org/ecosystemmonitoring/ for more).
- General advising and support services, including recent work to predict suspended sediment load in Brazilian rivers using artificial intelligence and Sentinel imagery. Sediment flux is used to monitor and measure the impacts of conversions of Amazonian forests to pasturelands and human settlement areas, and of natural resource extraction.

California State Parks fire and fuels monitoring dataset 25-year analysis
PI

California Department of Parks and Recreation | $61,000 — *2015–present*

- Lead statistical analysis of the California State Parks Prescribed Fire Management Dataset.
- The data consist of measures of live tree density, dead tree (snag) density, tree size (based on Quadratic Mean Diameter), regeneration (based on seedling density), organic layer depth (duff and litter), fine woody debris in 1-, 10-, and 100-hour fuel volume classes, and coarse woody debris (1000-hour fuels).
- The models are being be used to test hypotheses related to change in forest structure and surface fuel attributes in response to fuel treatment manipulation over a 25-year period in state parks in the Lake Tahoe Basin of California.

The Advanced Phenology Information System
Institutional PI

NASA, Advanced Information Systems Technology Program | $345,804 — *2017–2020*

- Phenology – the study of the *timing* of plant and animal life cycle events, including spring greenup, insect emergence, and wildlife migrations – is extremely sensitive to changes in climate. It provides critically important information for the management of natural resources, food production and security, and human health. Developing a solid understanding of how phenological activity interacts with the structure and function of ecosystems requires integrated information at multiple scales and through time.
- We built APIs and software to improve discovery, accessibility, and interoperability of phenological and ancillary (e.g., climate / weather and geophysical) datasets. The tools we developed provide access to integrated field, tower-based, airborne, and multi-scale satellite time series data, such that phenological change can be tracked over the various scales at which it is occurring, from individual species to ecosystems to entire continents.

Actionable phenological science for the water-limited Southwest
PI

Southwest Climate Adaptation Science Center (USGS and the University of Arizona) | $154,973 — *2017–2020*

- We developed datasets, models, and indices to more rigorously quantify shifts in phenology using ground-based observations. Results are used in climate-informed monitoring, adaptive management, and vulnerability assessments.
- The Bayesian models we developed to analyze in situ phenological observations accommodate censoring and allow for event transition probabilities to vary over time as a function of temporally-explicit drivers (see the R package tempo for more information).

An early-warning mapping tool for forecasting fire risk on DoD lands in the arid West
Co-I

U.S. Department of Defense (DoD) Legacy Resource Management Program | $82,791 — *2016–2018*

- Wildland fire can reduce mission capabilities and pose a threat to personnel, property, and public safety. Active fires can shut down ranges and training areas, and even the potential for fire risks can limit range use or munition types. Sensitive desert ecosystems in the western U.S. are negatively impacted by non- native invasive plants, which increase fire frequency and dominate post-fire landscapes. As a result, nearly one half of all DoD lands in the U.S. are faced with the consequences of a rapidly changing fire regime, such as biodiversity loss and fragmentation of native habitats.
- We built models and a web application to serve near real-time maps of fire probability across DoD and surrounding lands in the Great Basin, Mojave, and Sonoran Desert ecosystems. See https://desertfire.net/map/ for more information.

Linking ground, airborne, and satellite data to develop models of wood supply for the central Sierra Nevada
PI

U.S. Forest Service Wood Innovations Grant | $35,000 — *2016–2018*

- Consistent and up-to-date estimates of forest land cover type and forest structural metrics are needed to guide national policies on forest management, carbon sequestration, and ecosystem health.
- We applied a multi-task recurrent convolutional neural network to freely available aerial and satellite imagery, as well as relevant environmental factors (e.g., meteorological and terrain data) to simultaneously classify five forest cover types and estimate four continuous forest structure metrics. Development of the training data required fusing multiple datasets of varying spatial, spectral, and temporal resolutions with USDA Forest Service Forest Inventory and Analysis field plots from within California and Nevada.

Mapping changes to agricultural lands in the U.S. *Co-I*

American Farmland Trust | $420,449 *2015–2018*

- The American Farmland Trust's "State of America's Farmland Initiative" generated a comprehensive national snapshot of the most valuable and most threatened farm and ranch land.
- We used spatial statistics to generate the datasets required to understand past land use changes and assess major threats – including urban / residential development and climate change – to America's most valuable farmland over the next 25–30 years.

Statistical analysis for the Terrestrial Observation System sampling design *Co-I*

National Science Foundation National Ecological Observatory Network | $126,642 *2013–2017*

- The National Ecological Observatory Network (NEON) seeks to quantify ecological changes in response to climate change, land use change, and invasive species over the next 30 years. NEON required external statistical support in the development of the NEON terrestrial sampling designs.
- Data analysis in support of development of site-specific sampling designs, including analysis of soil sample data, selection of species for plant phenology sampling, recommendation of plant biomass and productivity sampling protocols for each site, and optimization of tower plot size and number to be implemented for plant productivity and biomass sampling.
- Updated the Reversed Randomized Quadrant-Recursive Raster (RRQRR) algorithm for newer versions of ESRI's ArcGIS software.
- Devised a geodatabase and relational database structure to incorporate sample frames (site boundaries), RRQRR rasters, vegetation rasters, and plot lists. Populated data into the ArcGIS and PostgreSQL database.

Models and maps of fire connectivity to inform conservation planning efforts in western forests *Co-I*

Wilburforce Foundation | $45,000 *2015–2017*

- Provided dynamic models and maps of fire connectivity across all forested land in the western U.S. Leveraged a model of large-fire probability and new circuit-theoretic methods to derive wall-to-wall scenarios of low, moderate, and high fire connectivity within and among the forested regions of the West.

Measuring and mapping open lands lost to development from 1990–present in the western U.S. *Co-I*

Center for American Progress | $77,000 *2015–2016*

- Quantified how fast open lands in the West were disappearing to development.
- Compiled, developed, integrated, and analyzed key spatial datasets describing changes in human modification of the region over a 25-year period, and produced several statistics related to our estimates of the magnitude of these changes.
- Visualized these changes through a variety of data layers served via a web application.

Four Forest Restoration Initiative — Landscape Pattern Analysis *PI*

U.S. Forest Service, Coconino National Forest | $42,500 *2015–2016*

- Derived high-resolution (<1m), landscape-scale tree canopy cover classification model using a random forest algorithm. The models are used to map and monitor forest disturbance, hazardous fuels reduction, and restoration treatments.
- The spatially-explicit classification model was used to generate spatial, tabular, and graphical summaries of patterns of forest structural metrics (i.e., edge contrast, patch shape complexity, aggregation, nearest neighbor distance, patch dispersion, large patch dominance, and shape and correlation length of large patches) across the broad landscape.

Spatially explicit state-and-transition models to support management planning and improve the statistical efficiency and utility of the AIM strategy at Grand Staircase-Escalante National Monument *PI*

Bureau of Land Management, Assessment, Inventory, and Monitoring (AIM) program | $35,000 *2015–2018*

- Landscape-scale monitoring and management requires spatially-explicit information on the condition of natural resources. We used ecological site descriptions from state-and-transition models to enhance the statistical efficiency and utility of the Assessment, Inventory, and Monitoring strategy on Grand Staircase-Escalante National Monument.
- Specifically, we developed a sampling stratification that is capable of discriminating between different components of spatial structure at ecological sites, and of supporting inference on the relative influence of both natural and anthropogenic drivers of ecological change and land health.

Greater Grand Canyon Landscape Assessment *Co-I*

IMR - GRCA - Grand Canyon National Park | $35,000 *2014–2015*

- Used a spatially-explicit modeling framework to develop Natural Resource Condition Assessments (NRCAs) for Grand Canyon National Park. The NRCAs evaluated current conditions for key natural and cultural resources in the park and on adjacent lands.
- We reported on trends in resource condition and relevant threats, identified critical data gaps, and provided estimates of the level of confidence for study findings.
- The interdisciplinary, landscape-scale overview of resource conditions provided opportunities for stakeholder engagement, and a sound scientific foundation for park decision making, planning, and stewardship.

Developing a spatially explicit model of conservation priority areas on public lands in the western U.S. *Co-I*

PEW CHARITABLE TRUSTS | $109,436 *2012–2014*

- Identified unprotected roadless areas on lands managed by the Bureau of Land Management that possess important watersheds, critical fish and wildlife habitat and corridors (including habitat refugia), outstanding scenic and recreational opportunities, irreplaceable archaeological and other historic resources, and other non-extractive values. The project also identified potential threats to those values, as well as any special management prescriptions currently in place for these areas.

Colorado River Management Plan — Research, Monitoring, and Mitigation Program Data Analysis *Co-I*

GRAND CANYON NATIONAL PARK | $20,000 *2012–2013*

- Analyzed the effects of river recreation on natural resources within the river corridor in Grand Canyon National Park as implemented under the Colorado River Management Plan.

Peer-reviewed publications

Zachmann, L. J., E. M. Borgman, D. L. Witwicki, M. C. Swan, C. McIntyre, and N. T. Hobbs (2021). "Bayesian Models for Analysis of Inventory and Monitoring Data with Non-ignorable Missingness". In: *Journal of Agricultural, Biological and Environmental Statistics*, pp. 1–24.

Zachmann, L. J., J. F. Wiens, K. Franklin, S. D. Crausbay, V. A. Landau, and S. M. Munson (2021). "Dominant Sonoran Desert plant species diverge in phenological responses to changes in moisture availability". In: *Madroño*.

Morisette, J. T., K. A. Duffy, J. F. Weltzin, D. M. Browning, R. L. Marsh, A. M. Friesz, L. J. Zachmann, K. D. Enns, V. A. Landau, K. L. Gerst, et al. (2021). "PS3: The Pheno-Synthesis software suite for integration and analysis of multi-scale, multi-platform phenological data". In: *Ecological Informatics* 65, p. 101400.

Aslan, C. E., L. J. Zachmann, M. McClure, B. A. Sikes, S. Veloz, M. W. Brunson, R. S. Epanchin-Niell, and B. G. Dickson (2021). "Quantifying ecological variation across jurisdictional boundaries in a management mosaic landscape". In: *Landscape Ecology* 36.4, pp. 1215–1233.

Chang, T., B. P. Rasmussen, B. G. Dickson, and L. J. Zachmann (2019). "Chimera: A multi-task recurrent convolutional neural network for forest classification and structural estimation". In: *Remote Sensing* 11.7, p. 768.

Zachmann, L. J., D. W. Shaw, and B. G. Dickson (2018). "Prescribed fire and natural recovery produce similar long-term patterns of change in forest structure in the Lake Tahoe basin, California". In: *Forest Ecology and Management* 409, pp. 276–287.

Gray, M. E., L. J. Zachmann, and B. G. Dickson (2018). "A weekly, continually updated dataset of the probability of large wildfires across western US forests and woodlands". In: *Earth System Science Data* 10.3, pp. 1715–1727.

Dickson, B. G., C. M. Albano, B. H. McRae, J. J. Anderson, D. M. Theobald, L. J. Zachmann, T. D. Sisk, and M. P. Dombeck (2017). "Informing strategic efforts to expand and connect protected areas using a model of ecological flow, with application to the western United States". In: *Conservation Letters* 10.5, pp. 564–571.

Farnsworth, M. L., B. G. Dickson, L. J. Zachmann, E. E. Hegeman, A. R. Cangelosi, T. G. Jackson Jr, and A. F. Scheib (2015). "Short-term space-use patterns of translocated Mojave desert tortoise in southern California". In: *PloS one* 10.9, e0134250.

Hegeman, E. E., B. G. Dickson, and L. J. Zachmann (2014). "Probabilistic models of fire occurrence across National Park Service units within the Mojave Desert Network, USA". In: *Landscape ecology* 29.9, pp. 1587–1600.

Dickson, B. G., L. J. Zachmann, and C. M. Albano (2014). "Systematic identification of potential conservation priority areas on roadless Bureau of Land Management lands in the western United States". In: *Biological conservation* 178, pp. 117–127.

Sankey, T., B. Dickson, S. Sesnie, O. Wang, A. Olsson, and L. J. Zachmann (2014). "WorldView-2 high spatial resolution improves desert invasive plant detection". In: *Photogrammetric Engineering & Remote Sensing* 80.9, pp. 885–893.

Wang, O., L. J. Zachmann, S. E. Sesnie, A. D. Olsson, and B. G. Dickson (2014). "An iterative and targeted sampling design informed by habitat suitability models for detecting focal plant species over extensive areas". In: *PloS one* 9.7, e101196.

Gray, M. E., B. G. Dickson, and L. J. Zachmann (2014). "Modelling and mapping dynamic variability in large fire probability in the lower Sonoran Desert of south-western Arizona". In: *International Journal of Wildland Fire* 23.8, pp. 1108–1118.

Bradley, B. A., A. D. Olsson, O. Wang, B. G. Dickson, L. Pelech, S. E. Sesnie, and L. J. Zachmann (2012). "Species detection vs. habitat suitability: are we biasing habitat suitability models with remotely sensed data?" In: *Ecological Modelling* 244, pp. 57–64.

Zachmann, L. J., C. Moffet, and P. Adler (2010). "Mapped quadrats in sagebrush steppe: long-term data for analyzing demographic rates and plant–plant interactions". In: *Ecology* 91.11, pp. 3427–3427.

Presentations

Zachmann, L. J., V. A. Landau, T. Chang, and J. Morisette (2020). "The greenwave: Moving beyond descriptive to predictive models of seasonality". In: Ecological Society of America Annual Meeting.

Zachmann, L. J., M. E. Gray, and B. G. Dickson (2015). "An early-warning tool for forecasting dynamic fire hazard across sensitive North American desert landscapes". In: International Association for Landscape Ecology World Congress.

Zachmann, L. J., A. D. Olsson, S. E. Sesnie, and B. G. Dickson (2012). "Using machine learning and high-resolution, color-infrared aerial imagery to map tree canopy cover and monitor forest disturbance, hazardous fuels reduction, and restoration treatments". In: Tahoe Science Conference.

Zachmann, L. J. and S. Sesnie (2011). "High resolution, landscape-scale tree canopy cover models for mapping and monitoring forest disturbance, hazardous fuels reduction, and restoration treatments on the Coconino National Forest, Arizona". In: Colorado Plateau Biennial Conference.

Dickson, B., S. Sesnie, V. Horncastle, A. Olsson, J. Rundall, T. Sisk, O. Wang, M. Williamson, and L. J. Zachmann (2011). "Spatial models for quantifying and monitoring wildlife response to habitat attributes on the Colorado Plateau". In: Colorado Plateau Biennial Conference.

Olsson, A., B. Dickson, L. J. Zachmann, L. Wang, and S. Sesnie (2011). "Using multi-spectral trajectories for invasive species detection". In: Ecological Society of America Annual Meeting.

Olsson, A., B. Dickson, O. Wang, L. J. Zachmann, S. Sesnie, B. Bradley, J. Rundall, and T. Sisk (2011). "Landscape models of non-native plant phenology and invasion to support conservation of military and adjacent lands in the Sonoran Desert". In: Annual Research Insights in Semiarid Ecosystems Symposium).

Wang, O., A. Olsson, L. J. Zachmann, S. Sesnie, and B. Dickson (2011a). "African buffelgrass infestation in the Sonoran Desert of Arizona: a preliminary plant community assessment". In: Ecological Society of America Annual Meeting.

– (2011b). "Maximizing invasive plant detectability in the field using integrated habitat suitability models, GIS, and remote sensing data". In: American Association of Geographers Annual Meeting.

Zachmann, L. J. and P. Adler (2008). "Competition and climate effects on species abundance in shrub-steppe and grassland plant communities". In: Ecological Society of America Annual Meeting.

Zachmann, L. J. (2006). "From genes to ecosystems: linking shifts in the genetic structure of plant populations to ecosystem processes." In: U.S. Department of Energy Global Change Education Program.

Memberships

- Ecological Forecasting Initiative, 2020–present
- Landscape Conservation Initiative, Northern Arizona University, 2010–present
- Google Earth Engine Developers, 2014–present
- Society for Conservation Biology, 2014–2015
- Ecological Society of America, 2009–2010
- Ecology Center, Utah State University, 2007–2010