Dr. David Ayala
My work uses methods in algebraic topology to study manifold topology. Specifically, my work concentrates on how to obtain sensitive manifold, and embedding, invariants from purely algebraic, or higher categorical, input. Such manifold invariants are inspired by rigorous approaches to quantum physics, and abide by a nuanced local-to-global principle. My work develops factorization homology as the essential maneuver connecting higher categories and manifold topology. Through factorization homology, unforeseen dualities among manifold invariants, notably invariants arising as partition functions of quantum field theories (QFTs) thereon, correspond to deformations of higher categorical structures (Koszul duality). This duality often exchanges affine with non-affine input, thereby explaining and resolving certain divergence issues in QFT.

Here is the essence of the idea. Fix a compact Riemannian manifold $M$. Fix a particle type on this manifold (which is to say a vector bundle over $M$, whose local sections are equipped with an action of its Lie algebra of infinitesimal isometries of $M$). Consider one such particle in $M$. Compactness of $M$ grants a lowest-energy state of the particle. Self-interference of this particle results in some ‘resonance’ for where one might find it in $M$. This resonance is governed by a complex number $Z(M)$. This feature of lowest energy, grants that $Z(M)$ is independent of the Riemannian metric. Therefore, $Z(M)$ is an invariant of the manifold. Furthermore, one might imagine finding $Z(M)$ by chopping $M$ into chambers, and understanding the resonance of the particle in each chamber, compatibly across interfaces between these chambers. The effect is that one can, in principle, calculate $Z(M)$ through a local-to-global principle. Formalizing, and organizing, this procedure is conveniently accommodated through higher category theory, and its relationship with stratifications. Poincare’ duality intertwines with a duality among higher categories (Koszul duality), resulting in peculiar dualities among such manifold invariants.

Dr. Jack Dockery
Dockery's research interest are in the area of mathematical modeling, analysis and numerical simulations of complex systems. He has written papers on traveling waves in the Belousov–Zhabotinsky reaction, biofilm modeling, population dynamics, chemical reaction systems, coupled systems of neurons, fluid dynamics, systems biology modeling of quorum sensing, traveling waves in coupled neuron systems, pattern formation in reaction diffusion systems and bifurcation analysis of Burgers equation. He has a current research project on quorum sensing using deterministic and stochastic modelling, funded through the National Science Foundation's collaborative research program with Martin Schuster, a microbiologist at Oregon State University.

Dr. Scott McCalla
Dr. Scott McCalla applies modeling, computation, and analysis to understand pattern forming systems stemming from biological, social, and renewable energy systems. His approach is centered in dynamical systems techniques to understand solutions to pattern forming partial differential equations and their instabilities. He has active collaborations with Ryan Anderson (MSU), Jeff Brantingham (UCLA), Bjorn Sandstede (Brown), Steven Shaw (MSU), Martin Short (Georgia Tech), James von Brecht (CSULB), and James Wilking (MSU).
Dr. Lisa Davis
Davis’s research interests are in the areas of numerical methods for solving partial differential equations, sensitivity analysis and mathematical modeling of biological and ecological processes. She studies efficient and robust computational algorithms for solving problems in various areas of applied mathematics. She has a background in finite element methods as well as finite volume methods for various numerical simulation of systems governed by partial differential equations. Her research has received national funding from the NSF, DEPSCoR and AFOSR. Her most recent work is in the area of model construction and numerical simulation for DNA transcription models accounting for the presence of transcriptional pausing. She has taught courses ranging from first year calculus to graduate level courses in numerical analysis and linear algebra. Lisa enjoys directing PhD students, and she is also active in advising and mentoring students involved in undergraduate research programs such as the Undergraduate Scholars Program and Montana INBRE.

Dr. Tianyu Zhang
Zhang’s research interest includes numerical analysis, modeling and simulation of biofilm-related phenomenon, and computational fluid dynamics. His current research projects include mathematical modeling of metabolic activity in chronic polymicrobial communities, role of dynamic microbiome in Cystic Fibrosis lung disease, and the activated sludge in the waste water treatment plants. His teaching interest includes courses related to numerical solution of differential equations (finite difference and finite element methods).

Dr. Tomas Gedeon
Tomas Gedeon is interested in all aspects of mathematical biology, including cell biology, gene regulation, immunology and neuroscience. Four of his projects are currently funded by federal agencies. In collaboration with Prof. Davis, he works on models of the transcription process in prokaryotes, where the main emphasis is on the understanding the constraints that this process imposes on speed of mRNA production, and, ultimately, the growth rate of the bacteria. This project had been funded by DMS NSF over the last three years and funded work of two PhD students. In collaboration with Prof. Schmidt in Department of Microbiology and Immunology prof. Gedeon is working on understanding the development of hepatocytes in liver. This work has been supported by NIH R01 grant for the last 5 years and supported one PhD student. How do microorganisms keep time? Do genetic networks that support different time-periodic cellular processes (cell cycle, circadian rhythm, metabolic oscillations) exhibit common structures? These and similar questions have been focus of Gedeon's research in DARPA sponsored project named Biochronicity. His collaborators include J. Harer, S. Haase from Duke University, K. Mischaikow from Rutgers, N. Wingreen from Princeton and J. Plotkin and J. Hogenesh from Penn. Inspired by the work on genetic networks supporting the time-periodic processes, we have developed over the last 4 years a new approach to study dynamics of regulatory networks over large parameter spaces. They use switching network models that allow combinatorization of phase space and parameter space, and allow finite characterization of dynamics in terms of Morse graphs. Gedeon is also PI on a collaborative grant with Dr. Heys and Dr. Carlson from Chemical and Biological Engineering Department at MSU, sponsored by joint NSF-NIH program in Mathematical Biology. The main goal is to understand metabolic exchanges that allow microbial consortia to outcompete monocultures in nature. This project supports one PhD student in Mathematics and one PhD student in CBE department.
Dr. Mark Pernarowski
Mark Pernarowski is an applied mathematician who has worked on a variety of models in mathematical biology. He has published numerous papers on topics such as the dynamics of excitable media, evolution, and pattern formation in population models, the visual system and genetic circuits. He has applied numerous dynamical system and perturbation techniques to such models with extensive studies of bursting oscillations in the insulin secreting pancreatic beta cell and cortical neurons.

Dr. Lukas Geyer
My research interests are in the area of complex analysis, complex dynamics, fractal geometry, and analysis on graphs. Complex dynamics is the study of iteration of analytic functions in the complex plane. It turns out that even very simple families of functions exhibit very complicated behavior such as fractal invariant Julia sets and very complicated bifurcation loci, most famously the boundary of the Mandelbrot set for a family of quadratic polynomials. My own work in this area has mostly centered around small divisor problems and stability of fixed points, periodic points, and invariant circles. My work in fractal geometry has been mostly concerned with questions of conformal dimension of self-similar fractals, studied through analysis on finite graph approximations.

Dr. Jing Qin
Signal/image processing based on mathematical modeling and computational techniques have been well developed and still attract much attention due to their broad applications. In practice, the lack of some certainties in the given data leads to a highly ill-posed inverse problem, which could be remedied by constructing an appropriate mathematical model with regularization techniques. Given insufficient data generated by the sophisticated mechanism, many image processing tasks and its related signal/image reconstruction problems boil down to solving a highly ill-posed inverse problem.

Dr. Qin’s research interests include variational image processing/analysis and its applications, compressive sensing based image reconstruction, and numerical optimization and applied partial differential equations. In particular, her work focus on developing rigorous mathematical models for various inverse problems and solving them using a variety of methods, including calculus of variations, optimization, partial differential equations and harmonic analysis.

Dr. Jarek Kwapisz
Jarek Kwapisz works in the area of Theoretical Dynamical Systems (DS), which studies qualitative behavior of systems that evolve in time according to some fixed transformation rule (e.g., resulting from a differential equations governing a real-life system). DS methods, developed originally for problems of celestial mechanics, now permeate mathematics and inform many other scientific applications. In particular, Jarek's most recent results are on aperiodic tilings of space that model quasicrystals. (Such tilings can be viewed as dynamical systems with multidimensional time.) He is also pursuing projects in theory of formal languages and geometry of fractals.
Dr. John Lund

Dr. Ryan Grady
Ryan Grady holds a PhD from the University of Notre Dame (2012). His research entails applying rigorous quantum field theory to understanding of geometry and topology of manifolds. Here, a 'manifold' is an abstraction of a set of arrangement-states of physical system. Passing to a 'quantum' physical system involves examining solutions to a wave equation on the given manifold. It is a well-developed research program within algebraic topology to ask how much about the given manifold can be recovered just from knowledge of how quantum particles 'resonate' within it. Motivated through this program, Ryan's work uses abstract algebra, topology, and multi-variable calculus to study abstract geometry. Ryan is very interested in advising at both the undergraduate and graduate level.

Dr. Dominique Zosso
Dr. Zosso’s research interests are variational and PDE methods, and efficient algorithms to solve inverse problems in imaging, computer vision, and related machine learning applications. There is a strong convergence between problems and methods in imaging on the one side, and data science and machine learning on the other side, and in his research he wants to further explore these commonalities.

Statistics Faculty

Dr. Mark Greenwood
Greenwood is an Associate Professor of Statistics who does research on statistical methods for high dimensional and correlated data. This includes supervised and unsupervised classification and high-dimensional testing problems such as those encountered when working with functional data (data that are recorded or can be treated as curves). Additional interests include hierarchical and generalized additive models and methods for incorporating measurement error into statistical models. Application areas include health outcomes related to Multiple Sclerosis and long-term body mass index changes, longitudinal environmental data related to hydrology and climate change, multi-level educational data, with some growing interests in sports statistics.
Dr. Jennifer Green
Dr. Green’s interests include developing strategies and methods to enhance and assess educational programs in Science, Technology, Engineering and Mathematics (STEM)-related disciplines. Her research focuses on the development of statistical methodology to characterize the impact of professional development and educational programs on teacher effectiveness and student learning, and she collaborates with others in the mathematical and educational sciences to create innovative approaches for developing teachers of statistics in grades K-16 and beyond.

Dr. John Borkowski
John Borkowski has been a faculty member in the Department of Mathematical Science at Montana State University since 1991 and a Professor of Statistics since 2003. His primary research and teaching interests include experimental design, response surface methodology, and sampling. His recent research is focused on optimal design of experiments, mixture experiments, and adaptive cluster sampling. He has also been a Visiting Professor at Thammasat University in Thailand since 2005.

Dr. Stacey Hancock
Dr. Hancock’s primary research interests lie in statistics education. Currently, she is exploring how students use metaphors and metonymies when learning statistical concepts related to sampling distributions and informal statistical inference. Additional research topics include time series analysis, specifically, change-point detection, and statistical applications in ecology.

Dr. Andrew Hoegh
Dr. Hoegh’s research is largely focused on Bayesian computation with an emphasis on spatial and spatiotemporal modeling. Within that realm, Dr. Hoegh works on projects related to environmental and ecological research and occasionally sports analytics.

Dr. Nicole Carnegie
Dr. Carnegie’s research focuses on the intersections between causal inference, infectious disease modeling, and networks. This includes network-based infectious disease models to inform strategies for HIV prevention and methodologic work on making causal inferences in infectious disease settings, where observations are inherently not independent. She has a line of research developing methods for analyzing potential sensitivity of causal inferences to unobserved confounding in a variety of settings, including multilevel models and Bayesian Additive Regression Trees. For fun, she occasionally enters predictive modeling or causal inference competitions using BART.
Dr. Katharine Banner
Dr. Katharine Banner is an Assistant Professor of Statistics at MSU. She believes, as statisticians, we have a responsibility to not only develop methodology for addressing specific research questions, but to also provide tools for assessing when those methods are appropriate to use. She is interested in developing tools and guidelines (e.g., R packages for visualizing data/results) for practitioners to aid in understanding complex (and often popular) methods so that they can make informed decisions about when to use them. Currently, she collaborates with a team of statisticians, ecologists, and bat biologists to develop appropriate methodology for informing conservation and management decisions for the geographically-extensive North American bat monitoring program. This work has sparked a general interest in the use and development of Bayesian methods for ecological applications.

Mathematical Education Faculty

Dr. Elizabeth Burroughs
Dr. Burroughs’s research interests involve the teaching of mathematical modeling; the connections between the mathematics pre-service teachers study as undergraduates and the mathematics they will teach to school students; mathematics coaching in elementary mathematics classrooms; and gender issues in mathematics education. She is currently leading a grant-funded project to develop materials that incorporate applications of teaching in undergraduate mathematics courses. She also works with Dr. Carlson on a research study concerning the teaching of mathematical modeling in community settings.

Dr. Mary Alice Carlson
Dr. Carlson’s research revolves around teacher learning and teacher change in mathematics; innovative formats for teacher professional development; and mathematical modeling. Her current work involves understanding the knowledge bases all youth bring to problem solving situations and using those knowledge bases to develop modeling tasks centered on issues that directly affect rural communities. She teaches mathematics content and methods courses for elementary and middle grades students, as well as a variety of mathematics education graduate courses.

Dr. Jennifer Luebeck
Dr. Jennie Luebeck’s research interests are effective models of school-based professional learning for pre-service and in-service teachers (e.g., lesson study, coaching, learning communities, classroom action research) as well as overcoming barriers to providing content-focused professional development for rural and otherwise isolated mathematics teachers. She also is interested in effective uses of online and blended learning to develop mathematical and pedagogical knowledge for teaching and construction of knowledge through mathematical discourse in the online learning environment. Her teaching interests revolve around mathematics content and pedagogy courses for in-service and pre-service mathematics teachers at elementary (K-5), middle (6-8), and high school (9-12) levels, topics in mathematics education for graduate students and qualitative and action research methods for graduate students.
Dr. Megan Wickstrom
Dr. Wickstrom is interested in the development of rich, mathematical tasks based on students’ thinking. Through this work, she seeks to understand K-16 students’ mathematical understanding and perceptions in relation to mathematical tasks and how best to link research and practice to support pre-service and in-service teachers in task development connected to students’ thinking. Her work is situated in the domains of geometric measurement and mathematical modeling and is primarily qualitative. She has been published in a variety of journals including The Journal of Mathematical Behavior, Journal for Mathematics Teacher Education, Teaching Children Mathematics, Mathematics Teaching in the Middle School, and Equity and Excellence in Education. Her teaching interests include mathematics education content courses for the elementary and middle school teachers and methods courses for middle school and secondary teachers. She especially enjoys teaching mathematics education courses with a focus on geometry and measurement.

Dr. Derek Williams
Dr. Williams is interested in students' experiences while learning mathematics: relationships between affect and cognition, students' understanding of concepts central to calculus and precalculus, and students' mathematical reasoning with technology. He enjoys teaching Advanced Mathematics for Teachers, precalculus, and calculus.

Research Faculty Members
Dr. Megan Higgs
Dr. Megan Higgs is a Research Faculty member and is currently working as a statistician for Neptune and Company, Inc and the Director of the Statistics Consulting Research Center at MSU. She has with a broad background and over 15 years of experience. Megan earned her M.S. in Statistics from Oregon State University and her Ph.D. in Statistics from Colorado State University, all while keeping her connections to biology and the environmental sciences. Megan spent 8 years as a professor of Statistics at Montana State University where she taught a variety of courses, but mainly a graduate level course in Bayesian statistics and general statistical methods and inference courses to mainly graduate students Land Resources and Environmental Science, Ecology, Animal and Range Science, and Earth Sciences. Therefore, she has years of experience teaching the fundamental concepts of statistical inference to researchers in a wide variety of disciplines. She has also collaborated with many ecological and environmental researchers. Megan has a strong background in Bayesian inference, spatial statistics, and computational statistics and is passionate about using her expertise to work on environmental problems. She is currently interested in Bayesian decision analysis, problems involving multiple spatial and/or temporal scales, and adaptive sampling methods. She also believes statisticians, and scientists in general, should spend more time considering the philosophical and general practice issues involved in using statistical inference to inform science and management. As the 2016 chair of the Section on Statistics and the Environment (ENVR) of the American Statistical Association (ASA), she will encourage statisticians to play a more active role in decision making, dissemination of statistical information to the media and public, and to promote appropriate use and justification of statistical inference.
Dr. Breschine Cummins
Dr. Bree Cummins is an applied mathematician working on the dynamical behavior of networks, specifically genetic regulatory networks and social networks. She is working on the design and diagnosis of synthetic biological regulatory networks, the discovery from time series data of cellular networks, and exponential random graph models of social networks. Her research has both strong theoretical and computational aspects, using tools in differential equations and graph theory. She works with undergraduate and Masters' students, and has published papers with them in the SIAM Journal on Applied Dynamical Systems, Physica D, and the Bulletin of Mathematical Biology.

Dr. Kathryn Irvine
I am a Research Statistician with the U.S. Geological Survey at the Northern Rocky Mountain Science Center in Bozeman, Montana. My statistical research evolves from collaborations with ecologists that study bats, plants, and trees and are involved with long-term monitoring to inform management of natural resources. I have mentored Statistics students for writing projects and supported graduate research assistants at Montana State University (MSU). Several of my students have participated in writing peer-reviewed papers during their time at MSU. I encourage students interested in applied statistical work with ecological applications to contact me for possible graduate research assistantships, paid summer work, and other opportunities. my USGS profile page