LRES 501. Writing and Professional Development for Environmental Scientists. 1-2 Credits. (1 Lec, 1 Rec) F/S
PREREQUISITE: Graduate status or consent of instructor. Foundational skills for writing scientific manuscripts, grant proposals, and thesis chapters with a focus on career development in the environmental sciences.

LRES 505. Concepts of GIS in Environmental Science. 3 Credits. (2 Lab, 1 Rec) Su
8 Weeks GIS Concepts in Environmental Science utilizing QGIS open-source software to build a spatial science toolkit. Evaluate vector and raster analysis in LRES topics. Semester project will deliver professional study area map, data management of graduate work, and exposure to advanced spatial techniques.

LRES 507. Environmental Risk Assessment. 3 Credits. (3 Lec)
Annually Principles of risk analysis, including risk assessment, perception, communication, and management. Emphasis on human toxicology, ecotoxicology, dose-response relationships, exposure analysis, environmental fate, and deterministic and probabilistic risk assessment. Case studies will include examples from pesticides, biotechnology, natural resource extraction, and invasive species. Co-convened with ENSC 407.

LRES 510. Biodiversity Survey and Monitoring Methods. 3 Credits. (2 Lec, 1 Lab) F
Biodiversity survey and monitoring designs, sampling methods, and data evaluation techniques are introduced. Emphasis is on plants but other taxa are addressed for agricultural, rehabilitation and wildland systems. One week of fieldwork required prior to semester; course completion 3rd week of October.

LRES 511. Environmental Data Mgmt. 2 Credits. (2 Lec) S
Alternate years to be offered even years PREREQUISITE: Graduate standing. Foundational skills for wrangling and management of natural sciences data sets using the R statistical computing environment. Students develop a deep understanding of the inner workings of R, learn skills for data import, tidying, and restructuring to prepare data for statistical analysis, and techniques for integrating R with databases to facilitate management, analysis, and archival of large, complex and cumbersome data sets.

LRES 515. Microbial Ecology. 3 Credits. (3 Lec) F
Annually. PREREQUISITE: BIOM 415. Critical review of literature on the distribution and activity of microorganisms in natural microbial communities based on microbial adaption and physical, chemical and biological features of the microenvironment. A critical discussion of literature and approaches.

LRES 521. Holistic Thought & Management. 3 Credits. (3 Lec) S
PREREQUISITE: Graduate Standing Students will apply holism and systems thinking to natural and human resource management issues. Learn about the role of adaptability, resilience, and collaborative decision making for the long-term sustainability of socio-ecological systems. Use of real cases from the Greater Yellowstone Ecosystem and other locations. Critical study and discussion of literature.

LRES 525. Applied Remote Sensing. 3 Credits. (2 Lec, 1 Lab) S
3 cr. LEC 2 LAB 1 Applications of remote sensing for graduate students, including advanced studies of multispectral and hyperspectral sensors and image processing algorithms. Emphasis is on using remote sensing technologies for solving applied land resource issues.

LRES 528. Bridging Principles & Practices of Sustainable Cropping Systems. 1 Credit. (1 Rec) F
Alternate Odd Years PREREQUISITE: Any graduate student or undergraduate student with approval from the instructor. The course goal is to elevate agricultural students' awareness of peer-reviewed literature that demonstrates application of principles to address issues of sustainability in cropping systems. The course will use a student-lead discussion format to highlight issues and principles in a series of papers that the class will read. The course will emphasize the practical interaction among agronomy, ecology, economics, and sociology to create an awareness of the interdisciplinary issues associated with sustainability in agriculture.

LRES 529. Cropping Systems and Sustainable Ag. 3 Credits. (3 Lec) S
PREREQUISITE: AGSC 341 or AGSC 342; graduate standing or consent of instructor. The course goal is to elevate agricultural students' awareness of peer-reviewed literature that demonstrates application of principles to address issues of sustainability in agriculture. The course will use a student-lead discussion format to highlight issues and principles in a review of a series of papers that the class will read, will focus on the interaction among agronomy, ecology, economics, and sociology to create an awareness of the interdisciplinary issues associated with sustainability in agriculture. Topical issues associated with climate change impacts, system resilience and thresholds and ways to understand complex interactions will be considered for discussion. Co-convened with AGSC 428.

LRES 530. Natural Resource Law. 3 Credits. (3 Lec) S
The course examines major natural resources laws, emphasizing the federal model. A modified case study approach is used to review legislation and related court cases governing natural resources, including water, minerals, timber, range, wildlife, recreation, and wilderness. Co-convened with NRSM 430.

LRES 531. Applied Watershed Hydrology. 3 Credits. (3 Lec)
PREREQUISITE: ENSC 245 or an equivalent course in soil science AND an introductory physical geography course (equivalent to GEO 103CS) or an introductory earth science course (equivalent to ERTH 101N) Applied watershed hydrology explores how water from rain and snow moves through landscapes and stream networks. This class will provide a broad introduction that focuses on patterns of steamflow, their measurement, and underlying physical processes including precipitation, evapotranspiration, soil water dynamics, snowmelt, overland and subsurface hillslope runoff, and channel flow. Real-world examples will be used to illustrate the influence of climate, topography, geology, soils, vegetation, land use, and other factors. Applications to aquatic and riparian resources, environmental problems, and human safety will be emphasized.

LRES 532. Soil Ecosystems and Processes. 3 Credits. (3 Lec) F
PREREQUISITES: BIOB 160. This course focuses on biological and non-biological processes in soil ecosystems. Topics covered are soil's function and role within our environment, nutrient and carbon cycling in soil, and effects of human activities and disturbance on soil and ecosystem function.

LRES 533. Wetland Ecology & Management. 3 Credits. (3 Lec) F
PREREQUISITES: General Biology, General Ecology. This class will examine wetland ecology and the management of resources. Students will study hydrological and geomorphic processes at watershed and site scales, how processes drive wetland hydrology and hydric soil development and maintenance, and the interaction with biological systems.

LRES 534. Environmental Data Analysis. 3 Credits. (3 Lec) F/S
PREREQUISITE: M 121Q or equivalent. Modern sciences are data-driven and this course focuses on making sense of data, both quantitatively and conceptually. Topics include a review of relevant algebra skills, methods to describe data, inferential statistical methods, sampling, experimental design, and regression focusing on interpretation.

LRES 535. Techniques of Spatial Analysis. 3 Credits. (2 Lec, 1 Lab) S
PREREQUISITE: Either GPHY 426, 429R, 284, or 504 or LRES 525, and either STAT 401 or 411, or graduate standing and permission of instructor. Exploration and understanding of analytical techniques needed to deal with spatially correlated data. Emphasis is placed on practical applications within geographic information systems and image processing.

LRES 536. Ecology of Invasive Plants II. 1 Credit. (1 Lec) Su
PREREQUISITE: LRES 569. Through this course, students will learn to organize plant population data and analyze it to determine population temporal and spatial dynamics. In addition they will learn how to apply the conclusions drawn from the analysis to invasive species management decisions.

LRES 539. Ecological Restoration and Management. 3 Credits. (2 Lec, 1 Lab) Su
PREREQUISITES: This course is restricted to LRES-online students only. General Biology, General Ecology. Insights into ecological processes require an understanding of the unique chemical environment that wetlands represent. You must be familiar with basic high school chemistry (e.g., Eh/pH/Redox) to be able to succeed in this course. Similarly, you must be familiar with basic, high-school-level quantitative approaches in environmental sciences. This class combines readings, #eld measurements and site visits to examine scientific# legal and management components that define the practice of restoration. Fundamentals are based on foundational science and practical elements that affect the implementation of restoration projects.
LRES 540. Ecology Plants & Community. 3 Credits. (3 Lec) F
PREREQUISITE: BIOB 160, BIOB 258 and STAT 216Q. This course will explore plant ecology at the individual, population and community levels. Topics include plant response to stress, population biology, and community assembly, and possibly non-native species and restoration. Quantitative measures for assessing populations and communities will be addressed.

LRES 543. Agroecology/Applic Plant Ecology. 3 Credits. (2 Lec, 1 Lab) S alternate years to be offered even years 3 cr. LEC 2 LAB 1 PREREQUISITE: BIOE 370, M 171, BIOE 444 and STAT 410. Focus on the principles and theories of watershed and community ecology as they relate to invasive plant species in natural and agroecosystems. Measuring plant interference and assessing population interactions and dynamics through empirical and theoretical models. Review theory and methodology concerning plant population demographics, dispersal, and natural trait selection. Examine the role of biodiversity and evolution in determining sustainable management of ecosystems.

LRES 544. Water Quality. 3 Credits. (3 Lec) F PREREQUISITE: ENSC 110 or equivalent This course covers water quality fundamentals (physical, biological, and chemical) and integrates science-policy and management research. This course uses examples from county Extension, watershed groups, conservation districts, and agencies across Montana interfaced with MSU hydrology and water quality research.

LRES 545. Watershed Analysis. 3 Credits. (3 Lec) S 3 cr. LEC 2 LAB 1 PREREQUISITE: ENSC 444 and STAT 216 or BIOE 318 Conceptual and quantitative analysis of watershed processes with an emphasis on modeling surface water hydrology and water resources management. Watershed modeling concepts including analysis of time series, spatially variable data, model calibration, and uncertainty analysis will be studied and demonstrated. The course will emphasize critical analysis of current hydrologic computational methods and hands-on use of watershed models.

LRES 546. Quant Methods Environmental. 3 Credits. (3 Lec) S Alternate Even Years PREREQUISITE: STAT 410 and ENSC 444 Introduction and application of numerical skills desirable for watershed and environmental modelers, including applied time series analysis, applied spatial statistics, introducing programming skills, and fundamental strategy of watershed modeling approaches to measurement and uncertainty analysis. Incoming students are expected to have a quantitative undergraduate degree related to environmental science.

LRES 547. Adv Soil/Envir Microbiology. 3 Credits. (3 Lec) S alternate years to be offered even years 3 cr. LAB 3 PREREQUISITE: Graduate standing or consent of instructor. Advanced laboratory course wherein students define a project de novo, design and execute the appropriate experiments, interpret data appropriately, and then assemble the results into a written format that thoroughly discusses the project and outcomes. Projects may include the isolation and characterization of specific microorganisms or the study and in-depth characterization of select biogeochemical cycles catalyzed by microorganisms. Classic, novel, and ecologically relevant incubation approaches are used with the pertinent environmental samples that typically include soil, lake, river or groundwater samples.

LRES 554. Soil Landscape Modeling. 3 Credits. (2 Lec, 1 Lab) S alternate years to be offered odd years LEC 2 LAB 1 PREREQUISITE: ENSC 454 and STAT 410. Quantitative soil-landscape modeling with an emphasis on multi-variate spatial statistics, digital terrain modeling, and underlying landscape processes. The course is built around "hands-on" projects and discussions of peer-reviewed literature.

LRES 555. Aqueous Geochemistry. 3 Credits. (2 Lec) S alternate years to be offered odd years 3 cr. LEC 2 REC 1 PREREQUISITE: CHMY 211, CHMY 228, ENSC 245 or equivalent. Advanced coverage of aqueous geochemistry in terrestrial and aquatic systems including chemical processes such as complexation, precipitation-dissolution, sorption-desorption, partitioning, oxidation-reduction and gas-water equilibria. Applications of these principles will be demonstrated in subject areas including biogeochemical cycling, biomethylation, contaminant fate and transport, salt-affected soils and wetland processes. Recitation will focus on current literature, applied problems, and case studies.

LRES 557. Thermal Biology in YNP. 2 Credits. (1 Lec, 1 Lab) Su 2 cr. LEC 1 RCT/DIS 1 PREREQUISITE: B.S. Science/Science Education; Enrollment limited to M.S. Science Education Graduate Program A survey of the ecology of important organisms common in thermal habitats of Yellowstone National Park, including a review of different life forms (prokaryotes and eukaryotes) and their modes of metabolism, and the physical, and chemical habitats that define their environment. Course includes lecture, laboratory, and field components. Students will be asked to design curricula for K-12 audiences.

LRES 558. Isotope Biogeochemistry. 2 Credits. (1 Lec) S alternate years to be offered even years PREREQUISITE: Consent of instructor. Fundamentals and applications of isotopes methods useful in the environmental sciences, including light elements such as carbon, mid-mass elements such as iron, and heavy elements such as uranium. Measurement techniques will be discussed, and application to student inspired questions explored.

LRES 561. Belowground Plant Ecology. 3 Credits. (3 Lec) S alternate years, to be offered odd years, PREREQUISITE: STAT 401 or equivalent; BIOE 370 or equivalent; BIOE 444 or equivalent. Application of basic ecological principles to belowground interactions of plant communities. Topics include plant competition, belowground herbivory, plant-microbe interactions including mycorrhizae, and diversity/productivity links in soil systems. Case studies will include invasive species, restoration scenarios, sustainable agriculture, and wildland communities.

LRES 562. Land Rehab Field Problem. 2 Credits. (2 Lab) Su alternate even years. PREREQUISITE: ENSC 460, ENSC 461. Extended field trip to numerous drastically disturbed sites across the Northern Plains. On-site review of land rehabilitation problems, solutions, and methodologies. Participation by industry, regulatory agency staff, and rehabilitation professionals will occur at most sites.

LRES 563. Restoration Ecology. 3 Credits. (3 Lec) F PREREQUISITE: BIOE 370 or equivalent ecology course. Review of ecosystem structure and function, and community and population processes in intact systems, along with the effects of major disturbances on natural systems. Restoration amendments will be discussed in terms of their effects on ecosystem structure and function. The course includes case studies, and focuses on plant and soil systems. Co-convened with ENSC 461.

LRES 564. Fundamentals of Environmental Monitoring. 2 Credits. (1 Lec, 1 Lab) F Provides a graduate level perspective on field measurement methodology in environmental science. Foci are electronic transducers, data loggers, and mathematical approaches to measurement and uncertainty analysis. Incoming students are expected to have a quantitative undergraduate degree related to environmental science.

LRES 565. Environmental Biophysics. 3 Credits. (2 Lec, 1 Lab) S 3 cr. LEC 2 LAB 1 PREREQUISITE: BIOE 170 or equivalent and PHSX 205. The study of physical relationships between organisms, ecosystems, and their environment. Basic principles of Micrometeorology, Biometeorology, Ecological Climatology, and Biophysical Ecology as applied to contemporary ecological challenges. Laboratory sessions will include computer exercises using ecosystem models and field observations. Co-convened with ENSC 465.

LRES 566. Chemical Ecology. 3 Credits. (3 Lec) F PREREQUISITE: Graduate standing in LRES Graduate program or permission of instructor. How organismal interactions are shaped through plant secondary metabolites—impacting the impacts on ecosystems across multiple scales and in response to a rapidly changing climate. This course combines lectures with student led discussions on contemporary issues and developments in the field and is also designed to improve critical readings of the primary literature and effective communication in science. Co-convened with ENSC 466.

LRES 567. Biogeochem Analy Synthesis. 1 Credit. (1 Sem) S, alternate years to be offered even years The course is meant to serve as an introduction to the study of biogeochemical dynamics from an Earth-systems perspective. The course will consist mostly of readings from primary literature and student-led discussion. We will choose a problem/question, work together to survey relevant literature through a meta-analysis, and strive to produce a manuscript for publication.

LRES 568. Ecosystem Biogeochemistry. 3 Credits. (3 Lec) S Introduction to the study of biogeochemistry and ecosystem dynamics from an Earth-systems perspective. Discussion will emphasize factors governing the "grand elemental cycles" of carbon, nitrogen, and phosphorus of Earth’s major ecosystems and how modern human activities are affecting these cycles. Co-convened with ENSC 468.

LRES 569. Ecol of Invasive Plants in GYE. 2 Credits. (1 Lec, 1 Lab) Su 2 cr. LEC 1 LAB 1 Current theories on what makes species invasive and what ecosystem conditions invite or resist non-indigenous plant species will be considered. Direct involvement in field research associated with testing methodology for monitoring the invasive potential of several exotic species in the otherwise pristine mountain environments.
LRES 571. Landscape & Ecosys Ecology. 3 Credits. (3 Lec) F
PREREQUISITE: Graduate Biology, General Ecology, General Statistics. Focuses on principles and applications of landscape and ecosystem ecology. Students will explore factors that shape landscape patterns in space and time and consequences for ecosystem processes. The course explores the methods and tools of landscape and ecosystem analysis.

LRES 572. Frontiers in Remote Sensing. 1 Credit. (1 Sem) S
Alternate Even Years PREREQUISITES: GPHY 429 or GPHY 426 or LRES 525 or equivalent. This course focuses on the emerging trends, technologies, and applications in remote sensing. Students will have a background and/or interest in remote sensing and applications will be exposed to cutting-edge science, technologies and applications which will broaden their exposure to this rapidly developing field.

LRES 573. Remote Sensing Env Sci. 3 Credits. (3 Lec) S
PREREQUISITE: BIOE 370 and STAT 216Q. This course focuses on understanding the basics of remote sensing science geared towards critical interpretation of the applications of remote sensing in environmental science. In addition, students will be exposed to hands-on exercises in basic digital image processing and analysis.

LRES 575. Prof Paper & Project. 1-4 Credits. (1-4 Lec) On Demand 1-4 IND Maximum 6 cr. PREREQUISITE: Graduate standing A research or professional paper or project dealing with a topic in the field. The topic must have been mutually agreed upon by the student, the major advisor, and graduate committee.

LRES 582. Streamside Science for Teachers. 3 Credits. (3 Lec) Su
PREREQUISITES: Graduate standing; ability to work with Microsoft Excel spreadsheets; practicing educator. The primary goal of this course is to increase the water resource knowledge of students through hands-on, field-based curriculum. To accomplish this, students will be asked to adopt a local stream and perform lab assignments in order to better understand hands-on water quality monitoring techniques. The course will improve the teaching skills of secondary science teachers utilizing distant delivery technologies. By completing this course, secondary science teachers will have a better understanding and hands-on working knowledge of the characterization and quantification of water quality as it relates to secondary school science curriculum and environmental issues on a global scale.

LRES 583. The Dirt on Soil Science for Elementary Teachers. 1 Credit. (1 Lec) S
PREREQUISITES: Educator; graduate standing This course is for those who want to understand and teach the science of “dirt” in an interactive, hands-on manner so that it engages students. The focus of instruction will be on basic soil physical properties and processes with the idea that soil science is merely the “platform” for introducing elementary graders to science. Teachers completing this course will engage in “hands on” active learning with techniques immediately transferable to the classroom.

LRES 584. Twelve Principles of Soil Science for Teachers. 3 Credits. (3 Lec.) F
PREREQUISITES: Educator; graduate standing The goal of this course is to introduce teachers to the basic principles of soil science as an integral part of the curriculum for environmental sciences, ecology, earth science, geology, water quality, and geography. The course is structured around twelve basic soil concepts, beginning with the significance of soil in our everyday lives and progressing through soil formation, the physical and chemical properties of soils, and the role soil and the earth play in environmental management today and in the future. This course is filled with “how to” and hands-on classroom teaching opportunities and resources.

LRES 585. Water Quality in the Classroom for Teachers. 3 Credits. (3 Lec) S
PREREQUISITES: Educator; graduate standing Water Quality in the Classroom for Teachers - is a 'must' course for teachers involved in any aspect of biological sciences. The course has three central foci: 1) to increase student knowledge and assessment skills about the physical, chemical, and biological aspects of water quality investigations, 2) to develop and implement new pedagogy for teaching water quality concepts in the secondary school science classroom, and 3) increase student awareness and understanding of some of the more significant global water quality issues that will face science teachers and their students in the 21st century.
Font Notice

This document should contain certain fonts with restrictive licenses. For this draft, substitutions were made using less legally restrictive fonts. Specifically:

Times was used instead of Adobe Garamond Pro.

The editor may contact Leepfrog for a draft with the correct fonts in place.