LRES 507. Environmental Risk Assessment. 3 Credits. (3 Lec) F
Alternate Even Years 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) 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 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 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) F PREREQUISITES: ENSC 245 or GEO 325 Patterns of streamflow, their measurement, quantitative characterization, underlying physical processes including precipitation, evapotranspiration, soil water dynamics, snowmelt, overland and subsurface hillslope runoff, and channel flow are examined. Applications to aquatic and riparian resources, environmental problems, and human safety are emphasized.

LRES 532. Soil Ecosystems and Processes. 3 Credits. (3 Lec) F PREREQUISITE: BIOE 160. This course focuses on biological and non-biological processes in soil ecosystems. Topics covered are soil's functions 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) S 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, & regression focusing on interpretation.

LRES 535. Techniques of Spatial Analysis. 3 Credits. (2 Lec, 1 Lab) S (2 Lec, 1 Lab) 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) S 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., Ehhp/Ehredox) 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, field 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: BIOL 160, BIOL 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/Appl Plant Ecology. 3 Credits. (2 Lec, 1 Lab) S PREREQUISITES: 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 agriculture. The course will use a student-lead discussion format to highlight issues and principles in review of 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 544. Water Quality. 3 Credits. (3 Lec) F PREREQUISITES: ENSC 110 or equivalent This course covers water quality fundamentals (physical, biological, and chemical) and integrates science-policy management and 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 BIOB 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
hydrological process. The course will focus on the use of real life and relevant
environmental/watershed case studies and examples to illustrate theory.

LRES 552. Adv Soil/Envir Microbiology. 3 Credits. (3 Lab) 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
statistical, digital terrain modeling, and underlying landscape processes. The course
is built around "hands-on" projects and discussions of pre-reviewed literature.

LRES 555. Aquene 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 complexion,
precipitation-dissolution, sorption-desorption, partitioning, oxidation-reduction
and gas-water equilibria. Applications of these principles will be demonstrated in
subject areas including biogeochemical cycling, bioremediation, 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 isotope systems 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 433 or equivalent.
Application of basic ecological principles to belowground interactions of
plant communities. Topics include plant competition, belowground herbivory,
plant-microbe interactions including mycorrhiza, 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
programmatic 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 PHYS 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 focus on 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—emphasizing 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 even years 3 cr. LAB 1 PREREQUISITE: Graduate standing in LRES Graduate program or permission
of instructor. How organismal interactions are shaped through plant secondary
metabolites—emphasizing 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 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 phosphorous 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
Alternate even years 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: General 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 442 or LRES 525
or equivalent. This course focuses on the emerging trends, technologies, and
applications in remote sensing. Each time the course is taught, it will focus on
a novel aspect of remote sensing science. Potential topics include UAS, lidar,
radar, newly deployed satellites/sensors, and emerging scientific applications in
remote sensing. Students who have a background and/or interest in remote sensing
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 the field" 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.

LRES 586. Lake Ecology for Teachers. 2 Credits. (1 Lec. 1 Lab) Su This course will provide a comprehensive understanding of the biotic and abiotic factors that influence lake dynamics. It will address the unique ecosystem of Yellowstone Lake with an emphasis on the aquatic invertebrate life. This will be accomplished through lecture, field investigation, and laboratory analysis. Students will synthesize and be able to apply learned skills and knowledge in their classroom (grades 5-12). The course will take place in Yellowstone National Park and on the MSU campus. Montana State University educators, National Park Service resource managers, and other agency professionals will join the class to provide a multi-disciplinary perspective.

LRES 588. Professional Development. 1-3 Credits. (1-3 Lec) On Demand 1 - 3 cr. May be repeated; maximum 3 cr. PREREQUISITE: Graduate standing, teaching experience and/or current employment in a school organization, consent of instructor and Dean of Graduate Studies. Courses offered on a one-time basis to fulfill professional development needs of in service educators. A specific focus is given to each course which is appropriately subtitled.

LRES 589. Graduate Consultation. 3 Credits. (3 Ind) F,S,Su 3 cr. TUT PREREQUISITE: Master's standing, consent of instructor and approval of the Dean of Graduate Studies. This course may be used only by students who have completed all of their coursework (and thesis, if on a thesis plan), but who need additional faculty or staff time or help.

LRES 590. Master's Thesis. 1-10 Credits. (1 Ind; max unlimited) F,S,Su 1 - 10 cr. IND Maximum credits unlimited. PREREQUISITE: Master's standing.

LRES 591. Special Topics. 1-4 Credits. (1 Rct; 12 cr max) On Demand 1 - 4 cr. Maximum 12 cr. PREREQUISITE: Upper division courses and others as determined for each offering. Courses not required in any curriculum for which there is a particular one-time need or given on a trial basis to determine acceptability and demand before requesting a regular course number.
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.