Michigan Tech

Office Memo

Office of the Provost and
Senior Vice President for Academic Affairs

Phone: (906) 487-2440
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TO: Richard Koubek, President

FROM: Andrew Storer, Provost & Senior Vice President for Academic Affairs

DATE: September 20, 2023

SUBJECT: Senate Proposal 29-23

Attached is Senate proposal 29-23, “Proposal for a Bachelor’s of Science Degree in Environmental Data Science,” and a memo stating the Senate passed this proposal at their September 6, 2023 meeting. I have reviewed this memo and recommend approving the proposal.

If you concur with my recommendation, the provost’s office will seek the following approvals.

X Board of Trustees
X Michigan Association of State Universities (MASU)
X Higher Learning Commission (HLC); screening required for all degree programs as well certificates

Programs cannot be fully advertised until all noted approvals are obtained. Once Board of Trustees approval has been granted, limited advertising to make prospective students aware of the planned program may conducted so long as any outstanding regulatory approvals are noted, e.g., "pending state and Higher Learning Commission approval".

I concur X do not concur _____ with the provost’s recommendation as stated in this memo.

Richard Koubek, President

9/20/23
Date

Michigan Tech

University Senate

DATE:	September 7, 2023
TO:	Richard Koubek, President
FROM:	Robert Hutchinson University Senate President
SUBJECT:	Proposal 29-23
COPIES:	Andrew Storer, Provost & Senior VP for Academic Affairs

At its meeting on September 6, 2023, the University Senate approved Proposal 29-23, "Proposal for a Bachelor's of Science Degree in Environmental Data Science." Feel free to contact me if you have any questions.

The University Senate of Michigan Technological University

Proposal 29-23

(Voting Units: Full Senate)

Proposal for a Bachelor's of Science Degree in Environmental Data Science

Proposed by: College of Forest Resources and Environmental Science

1. Date: March 15, 2023

2. Contacts: a. David J. Flaspoher, Interim Dean and Professor, CFRES
b. Stacy Cotey, Assistant Teaching Professor, CFRES

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3. Interdisciplinary Programs

Although this proposed degree program is housed in the College of Forest Resources and Environmental Science, it includes important components provided by other academic units across campus, particularly from the College of Computing and the Department of Mathematics. This proposal has been developed with close communication with these two units.

4. General Description of the Program

A. Mission - To provide students with a broad understanding of environmental data science and to prepare them for careers in this fast-growing field. Students will be trained to understand the fundamentals of ecological science and will learn computational and analytical tools to enable them to manage and visualize data to apply to inform decisions about environmental issues. This program will be distinctive in its science-based curriculum in that it integrates an understanding of environmental and ecological data with new analytical and visualization approaches and tools to summarize and draw inference from data. Inclusion and accessibility for all students is a core value for this program as a means of utilizing the creativity and intelligence of all members of society to address current and future challenges. This degree program is designed to produce the next generation of environmental data scientists to work in the private sector, for government agencies, and to promote entrepreneurship.

B. Programmatic goals - The goal of this degree program is to provide students with background in the components and interrelationships related to the natural environment, the drivers of ecosystem processes, and the tools to understand the data that describe land, water, air, and biodiversity. This technical background will be grounded in an understanding of the biophysical sciences as well as courses that focus on specific technical skills in computer science, statistics, and math. Students will then build upon this technical foundation through one of three tracks to further develop their knowledge base: 1) Global Change Science, 2) Environmental Statistics 3) Geographic Information Systems or 4) Genetic Applications in Data Science. These tracks have been planned such that all students will gain an interdisciplinary perspective on how computational tools can be applied to ecological systems and address environmental challenges. These students will be unique in the broader field of data science because of their familiarity with the physical and biological fundamentals of natural ecosystems and the

methods by which such data is collected, which furnish the foundational structure of all data.

C. Track Goals - Students will choose one track in Global Change Science, Environmental Statistics, Geospatial Information Science, or Genetic Applications in Data Science. Below are the individual objectives of each track.

1. Track in Global Change Science

   Students electing the Global Change track will complete classes relating to topics such as the science of climate change, wildland fire, biogeochemistry, biodiversity loss, and land use change. They will take two team-based classes in data management and data visualization. Team dynamics and group decision making will be emphasized in these courses because graduates from this track frequently need these types of skills to be effective in the workplace. Students will also receive explicit training in cross-disciplinary communication between life scientists and computer scientists to strengthen their skills in this important realm.

2. Track in Environmental Statistics

   Students electing the Environmental Statistics track will complete classes that cover experimental design, hypothesis testing, and data collection and analysis as it pertains to environmental research and policy. Students in this track will take some additional classes in the Department of Mathematics such as MA4750 Design and Analysis of Experiments and MA4790 Predictive Modeling

3. Track in Geospatial Information Science

   Students electing the track in Geographic Information Science will take courses that add to their skill sets in collecting geospatial data, visualizing this data and large-scale consideration of landscapes including mapping. Students in this track will also take an extra semester of physics which includes gaining important understanding of the physics of light which is relevant to remote sensing technologies.

4. Track in Genetic Applications in Data Science

Students in the Genetic Applications in Data Science track will take courses that explore the role of the environment on genetic structure, evolution, and adaptation. Courses unique to this track include FW4082 Gene Expression Data Analysis and FW4099 Programming Skills for Bioinformatics.

The free electives in the program also enable students to develop their own areas of focus beyond that provided in the track that they chose. Students may also choose to use the free

electives to pursue other academic credentials such as a Minor in Business, a language minor, or a Minor in Diversity Studies.

D. Learning Goals and Competencies

Learning goal	Description
Disciplinary knowledge	Explain core concepts in the field of environmental data science and approaches to understanding, manipulating and analyzing data sets
Evaluating information	Identify and evaluate sources of data and information relating to the environment
Solutions to problems	Summarize and analyze alternative ways to use data and computer programming to address problems in environmental science
Human dimensions	Assess the diverse human relationships, environmental justice, ethics, and policies related to data collection and access
Communication	Communicate effectively (orally and in writing) about issues related to environmental data science at local, regional, and global scales
Professionalism and Ethics	Recognize the professional standards that ensure their behaviors are consistent with working in the environmental and computer science fields. Demonstrate the ability to apply ethical reasoning to data use, privacy and security.
Teamwork	Perform effectively in teams

Track specific learning goals:
1) Climate Science – Students will model and forecast the effects of global change on ecological and human altered systems.
2) Environmental Statistics –. Students will design experiments that provide statistically significant support for environmental issues and policies.
3) Geospatial Information Science – Students will integrate the use of geospatial tools to address issues relating to land use and ecological processes.
4) Genetic Applications in Data Science - Students will use genetic data to analyze the effects of environmental factors on gene and protein expression, evolutionary processes, and adaptation.

E. Administration – The Environmental Data Science program will be administered through the College of Forest Resources and Environmental Science (CFRES) working closely with the College of Computing. The CFRES academic advisor will assist students with scheduling and degree completion. Advice on directed electives and career choices will be provided by CFRES faculty and the academic advisor.

5. **Title of Program: BS in Environmental Data Science**

6. **Rationale**

This program is a major part of a plan to continue to increase enrollments and undergraduate education in the College of Forest Resources and Environmental Science. The College is home to a top 10 nationally ranked forestry program and also offers other natural resource management degrees, including Forestry, Wildlife Ecology and Conservation, Applied Ecology and Environmental Science, Natural Resources Management, and Environmental Science and Sustainability, and Sustainable Bioproducts. Increasing visibility in emerging degree programs with growth potential at a national level will be helpful as MTU builds a nationally recognized program in environmental and computational science. The transition of the College from a School at Michigan Tech was designed as a mechanism for growth through the expansion of the breadth of degree program offerings. This has included the new BS in Environmental Science and Sustainability (first offered in Fall 2021) and BS in Sustainable Bioproducts (first offered in Fall 2020) along with this proposed BS in Environmental Data Science.

Understanding and describing natural resources is at the core of the programs offered in the College of Forest Resources and Environmental Science. Data that has always contributed to this understanding is now being created at an astounding pace, one that is often overwhelming to traditionally trained natural resource practitioners. This large stream of incoming data presents enormous opportunities for advancing our understanding of some of the greatest challenges facing humanity including climate change, extreme weather events, biodiversity loss, anthropogenic land use change, and even public health and disease. Recognizing this, organizations are sparing no effort to extract meaningful insights from the data to guide decision making. This degree program will train graduates to work with complex data sets to address issues in environmental science and natural resource management.

Consistent with the discipline of data science, the BS in Environmental Data Science is an interdisciplinary program drawing from strengths in all of the colleges in the University. Students will have CFRES as their home academic unit for administrative purposes but we expect that they will build especially strong ties with the College of Computing, Department of Mathematical Sciences, College of Business and other units. We have designed the curriculum to introduce students to the field through seminar classes in the first and last years of their degree. In keeping with the hands-on field based courses which are a strength of CFRES and are popular with students, we have chosen courses in other academic units that give students the opportunity to work with real-world data sets and address contemporary regional and global problems as they develop new skills in data science.

Students in this degree program will follow a curriculum that introduces theory and application of ecological concepts such as biogeography, plant and animal identification, census methods,

experimental design as well as computational skills related to time-series analysis, neural networks, recommendation engines, regression, and data visualization.

The field of data science has developed to meet the need to organize, classify, and understand the ever-growing quantity of data being generated for use in research, industry, engineering and economics, and other fields. The amount of data stored globally has risen exponentially in the last decade. According to the Bureau of Labor Statistics (BLS), employment for computer and information research scientists grew by nearly 20 percent in the decade before 2020. Moreover, BLS stated that jobs for statisticians fluent with big data are "projected to grow the fastest of any occupation in this mathematical group, at 36% from 2016-2026."[1] Such positions had a median annual wage of $100,901 in May 2021, with a bachelor's degree as an entry-level position.[2] Data scientist was ranked No. 6 in the 100 Best Jobs list in 2022 by U.S. News and World Report.[3]

Big producers of data include social media, remote sensing from satellites and drones, airplanes and autonomous sensing devices including those placed in forests, oceans, the atmosphere, and attached to wildlife including birds, mammals, reptiles, amphibians, fish and even insects. Today, many organizations find themselves overwhelmed by or unable to fully capitalize on the large amounts of data available to them. Some experts have estimated that less than 5% of the available data is being utilized in part because of the scarcity of properly trained data scientists. Thus, there is a growing demand for people with the training and skills to organize, analyze, and interpret large complex data sets. The National Science Foundation recognized the need to support growth in this field when they created a new $20 million Environmental Data Science Innovation and Inclusion Lab in Colorado in July 2022.[4]

Data science as a discipline is relatively new so it is important to clearly define what it is. The Integrated Postsecondary Education Data System (IPEDS) defines data science as: "*A program that focuses on the analysis of large-scale data sources from the interdisciplinary perspectives of applied statistics, computer science, data storage, data representation, data modeling, mathematics, and statistics. It includes instruction in computer algorithms, computer programming, data management, data mining, information policy, information retrieval, mathematical modeling, quantitative analysis, statistics, trend spotting, and visual analytics*." Another important aspect of data science involves ethics, privacy and social responsibility and this curriculum includes coursework that will give students a strong understanding of these issues.

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[1] U.S. Bureau of Labor Statistics. https://www.bls.gov/opub/btn/volume-7/big-data-adds-up.htm

[2] U.S. BLS, Occupational Outlook Handbook. https://www.bls.gov/ooh/math/data-scientists.htm

[3] U.S. News and World Report. https://money.usnews.com/careers/best-jobs/rankings/the-100-best-jobs

[4] National Science Foundation. https://beta.nsf.gov/news/new-nsf-center-will-advance-broaden-catalyze

This major supports and draws upon the themes of a number of the Tech Forward Initiatives, including those in Data Revolution and Sensing; Natural Resources, Water and Energy; Policy, Ethics and Culture; and Human Health and Quality of Life and Education for the 21st Century. Students in this program will develop knowledge critical to current and future decision making in natural resources, business, climate change and even weather forecasting.

7. Related Programs within the Institution and in the Region

At Michigan Tech

BS in Applied Ecology and Environmental Science. The Applied Ecology and Environmental Science program in CFRES has been in place for over 20 years. Students are attracted to it as a blend of environmental science and ecological management of natural systems. As such it has a more management focused curriculum than the proposed program and appeals to students who are looking for a knowledge set in ecology and environmental science to prepare them as managers of natural ecosystems and for work in ecological restoration.

BS in Environmental Science and Sustainability. Offered through CFRES, students in this program gain a technical foundation in measuring and monitoring environmental factors and the environmental challenges faced by society. They specialize in one of three tracks to gain an interdisciplinary perspective on Climate Science, Environmental Policy, or Geospatial Science. This degree program started officially in Fall 2022.

BS in Sustainability Science and Society. The BS in Sustainability Science and Society program is offered through the Department of Social Sciences This major explores the interactions between global, social, and natural systems in order to understand how sustainable those systems are. This program provides breadth with classes that include environmental policy, engineering sustainability, communities, environment and society, environmental health and justice, or environmental decision-making, and provides the opportunity to develop additional focus in one of these areas.

BS in Environmental Engineering. The BS in Environmental Engineering is an ABET accredited engineering program that attracts a different group of students than the proposed program. The focus for environmental engineering is applying engineering principles to the design of technologies to solve environmental issues in natural and manmade systems.

MS in Data Science. The MS in Data Science is a graduate degree that combines classes in computer science, business, engineering and mathematical sciences to address questions related to data analytics. This could be a logical next step for some students in the BS in Environmental Data Science.

Proposed BS in Data Science. This proposed degree is offered through the College of Computing (CC) and is on a similar proposal timeline as this EDS major. Since the earliest stages of development, CFRES has worked closely with CC to ensure that the two degree

programs will offer complimentary curricula that capitalizes on shared learning goals while clearly defining what is distinct about each major. As an example, we plan to offer the option for EDS majors to take the CC capstone course. This will provide a richer pool of students and ideas in a more diverse learning environment. The CC Data Science proposal contains the following statement: "*Note, that the College of Computing fully supports the proposed Environmental Data Science program and hope that other units will also develop data science programs more deeply couched within a given discipline. We believe that data science is broad enough for there to be room for both, which will elevate the visibility and overall quality of both our offerings.*"

Other universities

Although there are expanding offerings for Data Science majors in the region, few degree programs in data science focused on the environment currently exist in the US. The demand for graduates with expertise in this area is increasing rapidly.

University	**Examples of BS programs**
Eastern Michigan University	Data Science and Analytics, BS (Concentrations in theory, web analytics, advanced data analysis)
Indiana University	Data Science, BS
Montana Technological University	Data Science, BS
Northeastern University	Data Science, BS
Oregon State University	Biological Data Science, BS (Concentrations in computational biology, genomics, ecological and environmental informatics)
Purdue University	Data Science, BS
University of Wisconsin-River Falls	Data Science & Predictive Analytics, BS (Concentrations in Computer Science, Math, Accounting, Finance, Management, Marketing, Economics or GIS)
University of Michigan	Data Science, (COE), BS
University of Michigan	Data Science, LSA, ,BS
University of Wisconsin-Madison	Data Science, BS

Winona State University	Data Science, BS
Colorado State University	Data Science, BS (Concentrations in Computer Science, Economics, Math, Neuroscience, Statistics

Other programs in region

As would be expected, many other universities in the region also offer degrees in the environmental science field; however, they do not have a data science emphasis. This includes degrees at University of Wisconsin, Madison (Environmental Sciences; Environmental Studies), University of Minnesota (Environmental Geosciences; Environmental Sciences, Policy and Management), and University of Minnesota, Duluth (Environmental Science).

8. **Projected Enrollment**

The College of Forest Resources and Environmental Science has 25 full-time tenured or tenure-track faculty and 5 full-time instructional faculty. Current enrollment is 261 undergraduate student majors in five degree programs and 73 graduate students. Over the last five years, undergraduate enrollment has been 165, 180, 194, 231, 261 and graduate enrollment has been 68, 67, 63, 65, 73.

Because the College of Computing and Mathematics provides important support for this new degree program, we are including some background regarding the capacity and current enrollment. Computing has 21 full-time tenured or tenure-track faculty, 2 full-time teaching faculty and enrolls 554 undergraduate student majors. Mathematical Science has 24 tenured or tenure-track faculty and 6 instructional track faculty members and enrolled 68 undergraduate majors in 2021-22.[5]

Because EDS is a more specialized branch of data science, we expect enrollment will be considerably smaller than the Data Science B.S. offered by the College of Computing with approximately 5 students expected in the first year and 10, 17, 25-30 students when the degree reaches a steady state. Our goal is to admit the first students in fall 2024 and we will use the period from fall 2023 to fall 2024 to market and advertise the degree.

We anticipate that the students attracted to this new major will include those with an interest in quantitative and computational applications to environmental issues. This major will attract some students from our existing population and some students from other majors at MTU who are looking for an environmental or natural resource focus for their education. Because data science is among the fastest growing professions and offers relatively high paying employment options, we expect that this major will attract students interested in these qualities.

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[5] Data from 2021-22 Michigan Tech Institutional Research Compendium

The modest increase in student numbers associated with EDS means that only modest additional resources will be needed. We have discussed with the Provost the potential to add a new faculty in the area of statistics and environmental data science in the next 2 years. However, the degree can be offered and supported with current faculty in CFRES, CC and the Dept. of Mathematical Sciences.

9. Curriculum Design

Students will be required to take 24 general education credits as well as 28 credits of mathematics and computer science. The latter list of courses is aimed at building the quantitative foundation, statistical analysis, computational, communication, and listening skills. The science core courses (38 credits) provide a background in biology, chemistry, ecology, and human dimensions.

Each of the four Tracks contains 18-19 credits. Students will have 9-10 credits of free electives to reach the minimum credit requirement of 120 credits. Importantly, all students will have a cornerstone experience in their first year and a capstone experience in their fourth year (see below). In addition, students will complete 3 units of co-curricular (PE) courses.

Cornerstone Experience
A cornerstone seminar is designed to introduce DSE students to their discipline and professional opportunities through guest lectures and professional development activities. This class will also build a sense of community among each cohort of students at the beginning of their academic careers.

Capstone Experience
A capstone data science course of at least 3 credits must be taken, typically during the fourth year. Another way to meet the capstone requirement is to take an independent study (FW4500) or senior research thesis (FW4840). The latter option will normally involve original research in an area making use of data science, possibly part of an honors degree. The independent study option may also document an internship experience that would involve a substantial data science related project. All options for fulfilling the Capstone requirement other than pre-approved regular courses must be approved by the DSE advisor. The course grade for any independent study must be based on a final project document that outlines the activities undertaken and the report turned into the DSE program office.

I. General Education (24 Credits + 3 co-curriculars)
UN 1015 Composition (3)
UN 1025 Global Issues (3)
Goal 4 Critical and Creative Thinking (3)
Goal 8 Social Responsibility (3)
HASS Electives (12)
Co-curriculars (3)

II. Math and Computer Science core courses (35 Credits)

CS 1121 Introduction to Programming I	3
CS 1122 Introduction to Programming II	3
CS 2321 Data Structures	3
CS 3000 Ethics + Social Aspects in Computing or SAT 1700 Cyberethics	3
CS 3425 Databases	3
CS 4821 Data Mining	3
DS 1101 Intro to Data Science 1 (being developed by CC)	3
DS 1102 Intro to Data Science 2 (being developed by CC)	3
MA 1135 Calculus for Life Sciences	4
MA 2330 Elementary Linear Algebra	3
MA 2720 Statistical Methods (prereq MA1030 or MA1032)	4

III. Science core courses (36 credits)

BL1400 and BL 1410 Principles of Biology with lab	4
CH 1150 and CH 1151 University Chemistry with lab	4
FW 1XXX Intro to Data Science for the Environment (to be proposed)	1
FW 2051 Field Techniques	2
FW 2060 Fundamentals of Environmental Sustainability	3
FW 3020 Forest Ecology (coreq FW2051)	3
FW 3200 Biometrics and Data Analysis (prereq MA2720)	4
FW 3540 Introduction to GIS for Natural Resources (coreq MA2720)	4
FW 4800 Communications for Natural Resources	2
FW 4XXX Env. Data Science Senior Project or CS3141 Team Data Science Project (to be proposed)	3

Choose at least 6 credits of environmental directed electives: Any course numbered 3000 or higher with BL, FW, or GE prefixes	6

IV. Choose one of the following four tracks:

Global Change Science (18-19 credits)

FW 3110 Natural Resource Policy or FW3313 Sustainability Science (Prereq UN1015 & UN1025)	3
FW 3330 Soil Science or FW4300 Wildland Fire	3-4
FW 4370 Forest and Landscape Hydrology	3
FW 4380 Landscape Ecology and Planning	3
FW 4421/5421 Climate Change and Management in Great Lakes Forest Ecosystems or UN4400 Climate Change Science and Policy	3
FW 4710 Environmental Biogeochemistry (prereq CH1150) OR GE 2640 Atmospheric Observation and Meteorology OR FW5519 Atmospheric Biogeochemistry	3

Environmental Statistics (18 credits)

MA 3720 Probability (Prereq MA1135 or MA1160 or M1161)	3
MA 3740 Statistical Programming and Analysis (prereq MA2720)	3
MA 4710 Regression Analysis	3
MA 4720 Design and Analysis of Experiments (prereq MA2720)	3
MA 4730 Nonparametric Statistics (prereqs MA2710 MA2720) or MA 4780 Time Series Analysis and Forecasting (prereqs MA2720 and MA3720)	3
MA 4790 Predictive Modeling(prereq MA4720) or EET 4501 Applied Machine Learning	3

Geographic Information Systems (18 credits)

FW 4540 Remote Sensing of the Environment	3
FW 4545 Map Design with GIS	2
FW 4552/5541 Remote Sensing of the Environment Lab	1
FW 4554 GPS Field Techniques	2
FW 4XXX/5553 Python Programming in GIS	3
FW 4XXX/5557 Applied Spatial Statistics	4
SU 4012 Geospatial Data Mining and Crowdsourcing or EET 4501 Applied Machine Learning	3

Genetics, Genomics, and Bioinformatics (18 credits)

BL 3300 Introduction to Genomics (prereq FW3320)	3
FW 2100 Introduction to Biochemistry (prereq:CH1150)	3
FW 3075 Introduction to Biotechnology	3
FW 3320 Forest Genetics and Genomics	3
FW 4082 Gene Expression Data Analysis (prereq CS1121)	3
FW 4099 Programming Skills for Bioinformatics (prereq CS1121) or FW 4128 Conservation Genetics (prereq BL1400 & BL1410)	3

V. Free electives (8-9 credits)

10. New Course Descriptions

There will be a 1-credit first year seminar course (DSE Cornerstone) that will provide an introduction to the many applications of environmental data science. This will include guest lecturers from MTU and the community. Readings, discussion, and professional development activities will serve to build student identity and understanding of their major and employment options.

There are some 4000-level courses that will need to be developed as dual listings with existing graduate level courses for the geographic information systems track. The numbers for these graduate level courses are shown in the above table. In each case the undergraduate courses

that they will be dual listed with have the same prefix, and are introductory graduate courses. The course learning goals will be modified in the syllabi for the undergraduate versions of the courses.

Below is desirable but we can see how well the CS Team Data Science Project course provides a capstone experience.

FW 4XXX Environmental Data Science (EDS) Capstone (3 credits). This course is a capstone experience in which students will identify a source of data and develop a set of related questions that can be evaluated and analyzed as the primary focus of the class. A final report in the form of a term paper and/or manuscript that includes introduction/background, methods, results, discussion, and literature cited will be a significant part of the class. Students will draw on the knowledge and experiences in previous courses in the major to synthesize broad perspectives on contemporary issues, and communicate this work in writing and as an oral presentation.

The classes that will have an upper division undergraduate course added are:

- FW 5421 Climate Change and Management in Great Lakes Forest Ecosystems (3 credits). Will submit to be listed as FW4421 in Fall 2023.
- FW5557 Applied Spatial Statistics will add a 4000-level in Fall 2023 binder process.
- FW5553 Python Programming will add a 4000-level in Fall 2023 binder process.

11. Model Schedule

BS in Environmental Data Science, sample course schedule (total 120 credits)

	Course 1	Cr	Course 2	Cr	Course 3	Cr	Course 4	Cr	Course 5	Cr	Total
Fall 1	UN1015 Composi-tion	3	DS1101 Intro Data Science 1	3	CS1121 Intro Program-ming 1	3	BL1400 & BL1410 Principles of Biology	4	FW 2051 Field Technique	2	15
Spring 1	UN1025 Global Issues	3	DS1102 Intro Data Science 2	3	CS1122 Intro Program-ming 2	3	MA1135 Calc for Life Sci	4	FWxxxx EDS Corner-stone	1	14
Fall 2	Crit Creat Think	3	CS2321 Data Structures	3	MA2720 Statistics	4	FW 3020 Forest Ecology	3	Free elective	2	15

Spring 2	Soc Res Ethic	3	CS3425 Database	3	MA2330 Linear Algebra	3	CH1150 + CH1151 U Chem	4	Environmental Directed Elective	3	16
Fall 3	HASS	3	CS3000 or SAT1700 Ethics in Computing	3	FW 2060 Fund Env Sustainability	3	Track Requirement	3	Track Requirement	3	15
Spring 3	HASS	3	FW3540 GIS for NR	4	Environmental Directed Elective	3	FW3200 Biometrics	3	Track Requirement	3	16
Fall 4	HASS	3	FW4800 Comm for NR	2	Track Requirement	3	Track Requirement	3	Free Elective	3	14
Spring 4	HASS	3	CS4821 Data Mining	3	FW 4XXX EDS Capstone	3	Track Requirement	3	Free elective	3	15

Key:	Math and Computer Science
	Core
	Track
	Gen Ed
	Free elective

Degree schedules require a minimum of 3 units of Co-curricular/PE units. In this model schedule, 0.5 units would be completed in each of the first six semesters.

12. Library and Learning Resources

No additional materials required or requested.

13. Available/Needed Equipment (including Learning Resources and Space)

Program students will have access to the existing classroom, lab, and study spaces in CFRES. There is sufficient space available. No new space will be required by the program with anticipated enrollments.

14. Program Costs and Justification for Years 1, 2, and 3

We expect that the only initial costs for the program will be advertising (including adjustments to MTU and CFRES websites, and recruiting). The expected costs are estimated to be $1,000-$2,000 per year. We are not requesting additional resources currently.

Additional Courses: Two new classes will be added, the cornerstone course and the DSE capstone course. The remaining courses that are new at the undergraduate level are already offered at the graduate level. There is capacity in these classes for junior and senior undergraduates to take the new undergraduate version of these classes. The new capstone course will be taught by existing instructional personnel.

As the program grows, additional sections of some of the core and track classes may be needed, and this may include the need for additional TA support for some classes. There will also be a need for additional advising support.

15. Accreditation requirements

There are no accreditation requirements for the Program beyond those required by the Higher Learning Commission.

16. Planned Implementation Date

We anticipate a program starting date of Fall 2024. In addition, we will spend the next academic year working with University Marketing and Communication on efforts relating to advertising and outreach.

Sections for New Degree Programs

1. Program Administration, Policies, Regulations, and Rules

Administration of the Program will reside with the Dean of the College of Forest Resources and Environmental Science, who reports to the Executive Vice-President and Provost for Academic Affairs. Policies, regulations, and rules are those of the University.

2. Scheduling Plans (Extension, Evening, Regular)

At the outset, the scheduling of this degree will be regular on campus classes.

3. Space

Program students will have access to the existing classroom, lab, and study spaces in CFRES. There is sufficient space available. No new space will be required by the program with the anticipated enrollments.

4. Faculty resumes

Faculty resumes are downloadable from the faculty webpages that are linked from https://www.mtu.edu/forest/about/faculty-staff/.

5. Financial Documentation
See appendix A.

Approvals:

CFRES: Approved by CFRES faculty: 28 Feb. 2023

Deans Council:

University Senate:

Michigan Tech Administrative Approval

Appendix A - Financial Documentation

I. Relation to University Strategic Plan
A. Relation of program to the University's educational and research goals.
The proposed Program conforms to the University Strategic Plan and includes a rigorous, interdisciplinary curriculum of classroom, laboratory, and experiential learning that will enhance student preparedness for the future job market or further education. Hence the major fits the University's educational goal to "Provide a distinctive and rigorous action-based learning experience grounded in science, engineering, technology, sustainability, business, and an understanding of the social and cultural contexts of our contemporary world."

B. Consistency with the University's resource allocation criteria.
We are not requesting any allocation in salary or space for this degree.

II. Impact on University Enrollment
A. Projected number of students in the program.
We project a class size of 5-10 students with an eventual program size of 30 students.

B. Source of new students; in particular, will the students be drawn from existing programs, or will they be students who would otherwise not have come to Michigan Tech?
We expect that most of the students in this major will not otherwise have come to Michigan Tech. Students looking for a data sciences degree with an environmental science focus will be attracted to this program and are not the typical student who enrolls in the field-based CFRES majors. We will advertise the program with a focus on high schools with AP Environmental Science classes and Computer Programming classes, programs, or extracurriculars. There may be some students who move in the program from existing CFRES and computer science programs at the University. This should help to improve overall retention at the University as

these students may have left the MTU in search of alternatives without the option to major in DSE.

C. What is the likely correlation between demand for the new program and existing enrollment patterns at Michigan Tech?
Between 2017 and 2022, enrollment growth in CFRES and CC has been among the fastest at MTU. We anticipate the proposed program will increase the enrollment in CFRES, and this is consistent with the goal of the program and of the College. We do not anticipate that enrollments in other academic units will be impacted, though some students who may not be retained in other programs may transfer internally to this program rather than leave the University. This will improve the effective retention rates.

What is the current enrollment in the unit?
2022-2023: 261 undergraduate students, 73 graduate students
2021-2022: 231 undergraduate students, 65 graduate students
2020-2021: 197 undergraduate students, 64 graduate students
2019-2020: 183 undergraduate students, 68 graduate students
2018-2019: 168 undergraduate students, 71 graduate students
Source: Compendium (except 2022-23-Banner)

III. Impact on Resources Required by Department in which the Program is Housed. (including but not limited to):
A. Faculty lines.
None.

B. Faculty and student laboratories, including ongoing maintenance.
The existing labs are sufficient to deliver the lab-based core and track classes; however, additional sections of labs may be needed.

C. Advising.
The CFRES academic advisor will assist students with scheduling and degree completion. Additional advice on free electives and career choices will be provided by CFRES faculty and the advisor.

D. Assessment.
The proposed Program will be assessed as part of the University's assessment activities. All of the University learning goals and disciplinary knowledge learning goals will be addressed by the Program curriculum.

IV. Impact on Resources Required by other Units Within the University. Including but not necessarily limited to impacts on:

A. Other academic (e.g., General Education) units with regard to faculty, laboratories, and assessment. (Note: The current student to faculty ratio for the university as a whole is approximately 12:1 per Institutional Analysis.)
The respective units have reviewed their courses and none have indicated insufficient capacity for students of this proposed Program. We recognize that as the program grows there may be the need to add sections to come classes, and this may include the need for additional TA support. This is the same as for any new program that aims to increase enrollments.

B. Informational Technology, the Library, central administration and career planning with respect to the impact on the need for computing services, library resources, advising, record keeping, development of employer relations, etc.
Existing resources are sufficient to support the anticipated enrollment.

V. Assessment of the Ability to Obtain the Necessary Resources Assuming Requested Funds are Obtained.
For high demand fields (e.g., business fields, etc.), will it be possible to fill allocated lines.
No faculty lines are needed to establish this degree.

VI. Past Proposals. Has the unit initiated any other degree programs in the last five years?
An undergraduate degree program in Natural Resources Management (NRM) was created in 2016.
An undergraduate degree program in Sustainable Bioproducts started in Fall 2020.
An undergraduate degree program in Environmental Science and Sustainability began in Fall 2021.

A. Describe the extent to which the new programs have met the original goals with respect to:
1. Enrollment.
Enrollment in the NRM program has been low and the program is under review to explore ways to enhance enrollments. The Program is fairly new and requires more marketing to increase enrollment. The program is also considering some restructuring to increase its attractiveness.

While it is too early to evaluate enrollments in the Sustainable Bioproducts program, it is being promoted to students interested in the intersection between the environment, engineering and business. The associated Enterprise team (HOTFOREST) has attracted students from multiple academic programs, including students transferring into the Sustainable Bioproducts program. This program is part of the College plan to increase enrollments in undergraduate degree programs though the continued broadening of degree program areas.

The Environmental Science and Sustainability degree was made official in Fall 2021, however, it was after the regular recruitment process for the academic year. Initial students transferred from other Michigan Tech programs and in the 2022-23 school year (the first full cycle recruitment year), incoming student enrollment was 10 or about ½ that of our established majors. It is expected to increase as more students become aware of the program and as it is promoted within the regular recruitment cycle.

2. Costs.
The recent programs have met the goals related to costs.

3. New faculty
No new faculty lines were required to initiate the new programs.

4. Other resources required for the program
None.

B. How have degree programs added in the past five years affected total enrollment in the unit?
Enrollment in the unit has increased by 32% over the past two years. The effect of new programs on this is difficult to evaluate in the early stages as some enrollment increases may be a result of students discovering other programs in the unit while investigating new programs.

VII. Departmental Budget Contribution
A. What is the department's total general fund budget?
CFRES General Fund Base Budget 2019-20 $4,394,402 (source: Compendium).
CFRES General Fund instructional expenditures 2019-2020 $2,673,466 (source: Compendium)

B. How much tuition does the unit generate? This information should be provided for both the credit hours taught by the unit and the number of credit hours taken by the unit's majors.
In FY 2019-2020, CFRES generated $3,836,464 in tuition for credit hours taught by CFRES, and $3,256,480 in tuition by the number of credit hours taken by CFRES enrolled undergraduate students calculated from flat tuition rate published for 83 lower division and 100 upper division students.

VIII. How do the benefits from this program compare to other alternatives that are currently under consideration or development. Will approval and allocation of resources to this program preclude the development of other programs?
This program is a logical addition to the programs offered through CFRES and potentially reaches students who are not typically interested in the field-based CFRES programs but who have an interest in helping the environment. Other programs that are being considered or in development include graduate certificates and programs. The approval of the BS in Data Science for the Environment does not preclude the development of these programs.

Appendix B – Sample Degree Audit

Michigan Technological University Bachelor of Science Degree Audit
Major Program: ENVIRONMENTAL DATA SCIENCE
Program Code: FTBD, Academic Year 2024-2025
Total credits required for the degree: 120

Math and Computer Science Core: 35 credits

- CS 1121(3)
- CS 1122(3)
- CS 2321 (3)
- CS 3000 (3)
- CS 3425 (3)
- CS 4821 (3)
- DS1101 (3)
- DS 1102 (3)
- MA 1135 (4)
- MA 2330 (3)
- MA 2720 (4)

Science Core: 36 credits

- BL 1400 (3)
- BL 1410 (1)
- CH 1150 (3)
- CH 1151(1)
- FW 1XXX (1)
- FW 2051 (2)
- FW 2060 (3)
- FW 3020 (3)
- FW 3200 (3)
- FW 3540 (4)
- FW 4800 (2)
- FW 4XXX or CS3141 (3)
- Environmental Directed Electives: Choose 6 credits numbered 3000 or higher with prefixes of BL,FW, or GE that are not already used in your program

Select one of four tracks: 18-19 credits
Choose one of four tracks in consultation with your academic advisor.

Track in Global Change Science: 18-19 credits

- FW 3110 (3) or FW 3313 (3)
- FW 3330 (4) or FW 4300 (3)
- FW4370 (30
- FW4380 (3)
- FW 4421 (3) or UN 4440 (3)
- FW 4710 or GE 2640 or FW 5419 (3)

Track in Environmental Statistics: 18 credits

- MA 3720 (3)
- MA 3740 (3)
- MA 4710 (3)
- MA 4720 (3)
- MA4730 or MA4780 (3)
- MA4790 or EET 4501 (3)

Track in Geographic Information Systems: 18 credits

- FW 4540 (3)
- FW 4545 (2)
- FW 4542 (1)
- FW 4554 (2)
- FW 4XXX/5553 (3)
- FW 4XXX/5557 (3)
- SU 4012 or EET 4501 (3)

Track in Genetics, Genomics and Bioinformatics: 18 credits

- BL 3300 (3)
- FW 2100 (3)
- FW 3320 (3)
- FW 3075 (3)
- FW 4082 (3)
- FW 4099 or FW 4128 (3)

Free Electives: 8 to 9 credits
Any coursework is allowable, excluding co-curricular and coursework below the 1000- level.

General Education Core, Humanities, Fine Arts, and Social Science (HASS) Requirements: 24 credits

Courses used to complete Core and HASS requirements may not be used to complete other degree requirements. Students must complete 12 credits of Core coursework and 12 credits of Humanities, Fine Arts, and Social Science (HASS) coursework. Repeatable courses may not be repeated for general education credit. Core and HASS courses can be found on the General Education page.

Core: 12 credits

- UN 1015 (3)
- UN 1025 or an upper level modern language (3)
- Critical and Creative Thinking (3)
- Social Responsibility and Ethical Reasoning (3)

HASS: 12 credits, six of the 12 credits must be at the 3000- or 4000- level

- Communication/Composition (minimum 3 credits)
- Humanities and Fine Arts (minimum 3 credits)
- Social and Behavioral Sciences (minimum 3 credits)
- Any course from the General Education Core, HASS, or Restricted HASS course list (0 to 3 credits)

Co-curricular Activities: 3 credits

Required for graduation, but not included in the GPA calculation or in the overall credits required for the degree. Only courses on the co-curricular course list are eligible. Half (0.5) credit courses may be repeated to a maximum of one time for co-curricular credit. Find eligible courses on the General Education page.

Appendix C: Complete List of Required Courses and Directed Electives

I: List of Required Math and Computer Science Courses

CS 1121 - Introduction to Programming I
Starting point of the computer science programs. A high-level, object-oriented programming language is introduced as a problem-solving tool. Topics include design, coding, documentation, debugging, and testing of programs. Programming assignments are given in both a closed lab setting and as homework.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: Fall, Spring, Summer
Pre-Requisite(s): MA 1031(C) or MA 1032(C) or MA 1120(C)

CS 1122 - Introduction to Programming II
Continuation of CS 1121. Topics include data abstraction, class hierarchies and polymorphism, list, stack, queue and tree data structures, complexity-based algorithm and data structure choices, and recursion. Homework programming assignments are given.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: Fall, Spring, Summer
Pre-Requisite(s): CS 1121

CS 2321 - Data Structures
Presents fundamental concepts in data structures. Topics include abstract data types (priority queues, dictionaries and graphs) and their implementations, algorithm analysis, sorting, text processing, and object oriented design. A significant programming project is assigned.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
Pre-Requisite(s): CS 1122 or CS 1131

CS 3000 - Ethical and Social Aspects of Computing
An examination of social and ethical issues associated with computing. Topics include: ethical theories and decision making, intellectual property, freedom of expression, privacy, security, and professional responsibility.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
Restrictions: Must be enrolled in one of the following Class(es): Junior, Senior
Pre-Requisite(s): CS 3141

CS 3425 - Introduction to Database Systems

This course provides an introduction to database systems including database design, query, and programming. Topics include goals of database management; data definition; data models; data normalization; data retrieval and manipulation with relational algebra and SQL; data security and integrity; database and Web programming; and languages for representing semi-structured data.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
Pre-Requisite(s): (CS 2311 or MA 3210) and CS 2321

CS 4821 - Data Mining
Data mining focuses on extracting knowledge from large data sources. The course covers data mining concepts, methodology (measurement, evaluation, visualization), algorithms (classification/regression, clustering, association rules) and applications (web mining, recommender systems, bioinformatics).
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): (CS 3425 or MIS 3100) and (MA 2330 or MA 2320 or MA 2321) and (MA 2710 or MA 2720 or MA 3710)

MA 1135 Calculus for Life Sciences
Topics include analytic geometry, limits, continuity of functions, transcendental functions, derivatives, integrals, and applications of the derivative in the fields of economics, biological sciences, and social sciences. Extensive use of graphing calculator.
Credit applicable only to those curricula specifying this course.
Credits: 4.0
Lec-Rec-Lab: (0-4-0)
Semesters Offered: Fall, Spring, Summer
Restrictions: May not be enrolled in one of the following: College(s): College of Engineering
Pre-Requisite(s): MA 1032 or MA 1031 or MA 1120 or ALEKS Math Placement >= 76 or CEEB Calculus AB >= 2 or CEEB Calculus BC >= 2 or CEEB Calculus AB Subscore >= 2 or ACT Mathematics >= 26 or SAT MATH SECTION SCORE-M16 >=610

MA 2330 - Introduction to Linear Algebra
An introduction to linear algebra and how it can be used, including basic mathematical proofs. Topics include systems of equations, vectors, matrices, orthogonality, subspaces, and the eigenvalue problem.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
Pre-Requisite(s): MA 1160 or MA 1161 or MA 1135 or MA 1121

MA 2720 Statistical Methods
Introduction to the design and analysis of statistical studies. Topics include methods of data collection, descriptive and graphical methods, probability, statistical inference on means, regression and correlation, and ANOVA. Not open to students with credit in MA2710, MA3710, or MA3715.
Credits: 4.0
Lec-Rec-Lab: (0-4-0)
Semesters Offered: Fall, Spring, Summer
Restrictions: May not be enrolled in one of the following Major(s): Mathematics
Pre-Requisite(s): MA 1020 or MA 1030 or ALEKS Math Placement >= 61 or CEEB Calculus BC >= 2 or CEEB Calculus AB Subscore >= 2 or ACT Mathematics >= 22 or SAT MATH SECTION SCORE-M16 >= 540

SAT 1700 - Cyber Ethics
Ethics, morality, and privacy issues when working with technology. Topics include: foundational and professional issues in cyber ethics; privacy, security, and crime in cyberspace; intellectual property and internet regulation; the digital divide and online communities; and emerging and converging technologies.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall

II. Science Core Courses

BL 1400 - Principles of Biology
Basic principles through which biological systems operate. Topics include cell biology, structure and function, energy production, genetics, physiology, diversity, evolution, and ecology.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, Summer
Restrictions: May not be enrolled in one of the following Major(s): Medical Laboratory Science, Biological Sciences

BL 1410 - Principles of Biology Laboratory
Topics include cell biology, structure and function, energy production, genetics, physiology, diversity, evolution, and ecology.
Credits: 1.0
Lec-Rec-Lab: (0-0-2)
Semesters Offered: Fall, Summer
Restrictions: May not be enrolled in one of the following Major(s): Medical Laboratory Science, Biological Sciences
Co-Requisite(s): BL 1400

CH 1150 University Chemistry I
Introduces the foundations of chemistry, including electronic structure of atoms and molecules, intermolecular forces, states of matter, chemical reactions, organic chemistry, chemical

equilibria, kinetics, and acid-base chemistry. Includes laboratory component that emphasizes lecture components.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, Spring, Summer
Co-Requisite(s): CH 1151
Pre-Requisite(s): MA 1031(C) or MA 1032(C) or MA 1120(C) or MA 1160(C) or MA 1161(C) or MA 1135(C) or MA 1121(C) or ALEKS Math Placement >= 56 or CEEB Calculus AB >= 2 or CEEB Calculus BC >= 2 or CEEB Calculus AB Subscore >= 2 or ACT Mathematics >= 22 or SAT MATH SECTION SCORE-M16 >= 540

CH 1151 University Chemistry Lab I
Laboratory to accompany CH1150.
Credits: 1.0
Lec-Rec-Lab: (0-0-3)
Semesters Offered: Fall, Spring, Summer
Co-Requisite(s): CH 1150
Pre-Requisite(s): MA 1031(C) or MA 1032(C) or MA 1120(C) or MA 1160(C) or MA 1161(C) or MA 1135(C) or MA 1121(C) or ALEKS Math Placement >= 56 or CEEB Calculus AB >= 2 or CEEB Calculus BC >= 2 or CEEB Calculus AB Subscore >= 2 or ACT Mathematics >= 22 or SAT MATH SECTION SCORE-M16 >= 540

CS 3141 - Team Software Project
This course introduces software design techniques (e.g., Design-By-Contracts), uses the UML for requirements and design specification, and requires implementation, unit testing and documentation in the context of a significant team project. Focus includes security, teamwork, user interfaces, social and professional responsibility.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
Pre-Requisite(s): (CS 2311 or MA 3210) and CS 2321

FW 2051 Field Techniques
Equipment and techniques used in forestry, wildlife, ecology, and recreation management. Topics include field safety, land measurement and navigation, establishment of sample locations, measurement of attributes of individuals and groups of trees, vegetation and other organisms.
Credits: 2.0
Lec-Rec-Lab: (1-0-3)
Semesters Offered: Fall

FW 2060 - Fundamentals of Environmental Sustainability
The four scientific principles of sustainability (reliance on solar energy, biodiversity, nutrient cycling, population control) are the foundation of the course. The course applies basic principles

of physics, chemistry, and biology and a systems approach to provide students with a fundamental understanding of how the environment functions and strategies for sustaining natural resources.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: May not be enrolled in one of the following Class(es): Freshman

FW 3020 Forest Ecology
Environmental factors and plant and animal characteristics which control composition, structure, and function of forest ecosystems. Emphasis on how ecosystems change across space and time and knowledge needed to sustainably manage forest ecosystems for social, economic, and ecological benefits.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Fall
Pre-Requisite(s): FW 2010(C) and FW 2051(C)

FW 3200 - Biometrics and Data Analysis
Sampling design, implementation and analysis for inventory and monitoring of attributes of stands, forests and landscapes. Includes computing skills for data entry, storage and analysis and application of statistical techniques to answer questions about ecological data.
Credits: 4.0
Lec-Rec-Lab: (3-0-3)
Semesters Offered: Spring, Summer
Pre-Requisite(s): FW 2051 and (MA 2710 or MA 2720 or MA 3710)

FW3540 Introduction to GIS for Natural Resources
The fundamentals of GIS and its application to natural resource management. Spatial data, its uses and limitations are evaluated. Students work extensively with the ARCGIS software package.
Credits: 4.0
Lec-Rec-Lab: (3-0-3)
Semesters Offered: Spring
Pre-Requisite(s): MA 2710(C) or MA 2720(C) or MA 3710(C) or ENVE 3502 or CEE 3502(C)

FW 4800 - Communication for Natural Resource Professionals
This class completes the development of oral and written communication skills for students as they prepare to graduate and gain employment in the field of natural resources.
Credits: 2.0
Lec-Rec-Lab: (1-1-0)
Semesters Offered: Fall
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

Pre-Requisite(s): FW 3190

III. Courses required in at least one of the tracks

BL 3300 - Introduction to Genomics
Introduction to Genomics. Genome organization, mapping and characterization from humans and related organisms. Topics include hierarchical arrangement of genes, genome mapping, molecular markers of physical genome maps, genome sequencing, comparative genomics, analysis of important human genes and their products, and ethical and legal aspects of genomics.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: May not be enrolled in one of the following Class(es): Freshman
Pre-Requisite(s): BL 2200 or FW 3320

EET 4501 - Applied Machine Learning
Introduces the general concepts and algorithms of machine learning (ML) with their implementation and applications to practical problems of modeling, detection, estimation, prediction, and control. Applications include cybersecurity, healthcare, robot vision, remote sensing, automation, and natural language processing.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): SAT 4310 or SAT 4650 or CS 1121

FW 2100 - Introduction to Biochemistry
This course provides a basic knowledge of biochemical processes underlying cellular mechanisms in living organisms. It examines the chemical nature of cellular components in plants and animals by relating the structure and function of macromolecules to their effects on the whole system level.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Pre-Requisite(s): CH 1150

FW 3075 - Introduction to Biotechnology
The course covers basic concepts and practical applications in biotechnology. Topics include the use of biotechnology in agriculture, healthcare, and environmental remediation. Advances in gene containment, regulatory, societal and environmental issues associated with commercialization of biotechnological products will be discussed.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)

Semesters Offered: Spring

FW 3110 - Natural Resource Policy
Covers concepts related to social systems and natural resources. Offers a survey of natural resource policies and organizations. State and federal levels of policymaking, policy processes, and policy implementation and evaluation as related to natural resource management.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, Summer

FW 3313 - Sustainability Science
Foundational scientific concepts (dynamic systems and catastrophe theory) as applied to socioecological systems. Use of indicators and indices to track progress towards sustainability goals. Review of local, national, and global sustainability policies to avoid catastrophes and guide sustainable development.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Pre-Requisite(s): UN 1015 and (UN 1025 or Modern Language - 3000 level or higher)

FW 3320 - Fundamentals of Forest Genetics and Genomics
This course will teach fundamental and applied genetic principles that are essential for management of forest and other ecosystems to maintain their long-term health and sustainability. The class will cover the following topics: structure and function of DNA, inheritance, molecular evolution, population and quantitative genetics, gene conservation, genomics and biotechnology.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): BL 1400 or BL 2160

FW 3330 - Soil Science
Introduction to the chemical, physical, and biological properties of soil.
Credits: 4.0
Lec-Rec-Lab: (3-0-3)
Semesters Offered: Fall
Pre-Requisite(s): CH 1112(C) or (CH 1150(C) and CH 1151(C))

FW 4082 - Gene Expression Data Analysis
This course is designed for students majoring in molecular biology, computer science, data science and related majors to develop fundamental but essential skills for manipulating, preprocessing, and analyzing high throughput gene expression data for pattern extraction and knowledge discovery.

Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Fall, in even years
Restrictions: May not be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): FW 4099 or CS 1121 or CS 1122 or CS 1131 or CS 1141 or CS 2321

FW 4099 - Programming Skills for Bioinformatics
Students will learn computer programming skills in Perl for processing genomic sequences and gene expression data and become familiar with various bioinformatics resources.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years
Pre-Requisite(s): CS 1121

FW 4128 - Conservation Genetics
This course will explore molecular methods as they apply to conservation, management, ecology, and evolution of wildlife. We will emphasize laboratory techniques and the application of genetic theory.
Credits: 3.0
Lec-Rec-Lab: (0-2-3)
Semesters Offered: Spring, in even years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): BL 1040 or BL 1020 or (BL 1200 and BL 1210) or (BL 1400 and BL 1410)

FW 4300 - Wildland Fire
Overview of wildland fire based on an understanding of fire history, fuel properties, fire weather, fire behavior, ecological effects and management.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): FW 3020 and (FW 3010 or FW 3012)

FW 4370 - Forest and Landscape Hydrology
The course will use a process-based approach to present the physical hydrology, geomorphology and water quality of forested watersheds. Course focuses on the interaction between watershed processes and forest management.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

FW 4380 - Landscape Ecology and Planning
Basic principles of landscape ecology, including pattern, process, and scale. Students will learn how to use quantitative tools to study landscape-scale patterns and processes, and how to apply these principles and tools to conservation, resource management, and planning issues.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): MA 2720 or CEE 3502

FW 4540 Remote Sensing of the Environment
Remote sensing principles and concepts. Topics include camera and digital sensor arrays, types of imagery, digital data structures, spectral reflectance curves, applications, and introductory digital image processing.
Credits: 3.0
Lec-Rec-Lab: (2-1-0)
Semesters Offered: Fall
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

FW 4545 - Map Design with GIS
Principles of making maps, from traditional to advanced visualization techniques, that convey information which is useful in decision making at many levels. Focus will be on creating maps using GIS software and digital data. A working knowledge of ArcGIS is required.
Credits: 2.0
Lec-Rec-Lab: (1-0-3)
Semesters Offered: Spring, in even years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): FW 3540 or FW 5550

FW 4452/5541 Remote Sensing of the Environment Lab
Applied introductory remote sensing analysis using industry standard software for digital image processing.
Credits: 1.0
Lec-Rec-Lab: (0-0-3)
Semesters Offered: Fall
Co-Requisite(s): FW 5540
Note: undergraduate listing to be added in Fall 2023

FW 4554 GPS Field Techniques
This course will provide hands-on experience with various types of GPS units and different applications of the technology. These applications include planning, data collection, data processing, and data management. Emphasis will be on practical applications of Global Positioning System technology.
Credits: 2.0

Lec-Rec-Lab: (1-0-3)
Semesters Offered: Fall
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

FW 4421/5421 Climate Change and Management in Great Lakes Forest Ecosystems
Provides an overview of climate change science, effects and adaptation for natural resource management in the Great Lakes region. Students develop climate change adaptation plans for real world forested ecosystem examples and learn how to communicate these climate change projects and plans with stakeholders.
Credits: 3.0
Lec-Rec-Lab: (2-1-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Note: undergraduate listing to be added in Fall 2023

FW 4710 - Environmental Biogeochemistry
Impacts of decisions regarding landuse, land management, and energy and mineral exploration on natural resources (i.e., air, water, land, and biodiversity) are discussed using the framework of the biogeochemical cycles of the elements.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): CH 1150

FW4XXX/FW 5553 - Python Programming for ArcGIS
An introduction to Python scripting and basic Python coding within ArcMap. Labs cover tasks found in typical GIS workflows. Students learn how to write and debug Python scripts, models and mapping programs.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Fall
Pre-Requisite(s): FW 5550 or FW 3540
Note: FW4XXX to be developed for Fall 2023

FW4XXX/FW 5557 - Applied Spatial Statistics
Focus on spatial statistical methods such as spatial regression, geographically weighted regression and cluster analysis. ArcMap is utilized for analysis.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): FW 5550

Note: FW4XXX to be developed for Fall 2023

FW 5519 - Atmospheric Biogeochemistry
Study of the relationship between atmospheric composition, global change, and the circulation of major elements through the Earth system. Responses of ecosystem emissions to changes in landuse, biodiversity, nutrient supply, plant stressors, and climate change are discussed.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in even years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): CH 1150

GE 2640 Atmospheric Observation and Meteorology
Introduction to fundamentals of atmospheric science and meteorology through direct observations of the atmosphere.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2002-2003 academic year

MA 3720 - Probability
Introduction to probabilistic methods. Topics include probability laws, counting rules, discrete and continuous random variables, expectation, joint distributions, and limit theorems.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Summer
Pre-Requisite(s): MA 1160 or MA 1161 or MA 1121

MA 3740 - Statistical Programming and Analysis
Project-based course enabling students to identify statistical methods and analysis using R and SAS. Topics include exploratory data analysis, classical statistical tests, sample size and power considerations, correlation, regression,and design experiments using advanced programming techniques.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: Fall, Spring
Pre-Requisite(s): MA 2710 or MA 2720 or MA 3710 or MA 3715

MA 4710 - Regression Analysis
Covers simple, multiple, and polynomial regression; estimation, testing, and prediction; weighted least squares, matrix approach, dummy variables, multicollinearity, model diagnostics and variable selection. A statistical computing package is an integral part of the course.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall

Pre-Requisite(s): MA 2710 or MA 2720 or MA 3710 or MA 3715 or MA 5701

MA 4720 - Design and Analysis of Experiments
Covers construction and analysis of completely randomized, randomized block, incomplete block, Latin squares, factorial, fractional factorial, nested and split-plot designs. Also examines fixed, random and mixed effects models and multiple comparisons and contrasts. The SAS statistical package is an integral part of the course.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, Summer
Pre-Requisite(s): MA 2710 or MA 2720 or MA 3710 or MA 3715 or MA 5701

MA 4730 - Nonparametric Statistics
Introduces nonparametric techniques that require less restrictive assumptions on the data. Topics include statistical inference concerning location and dispersion parameters as well as the general distributions. Goodness-of-fit tests for count and ordinal data are also discussed.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, in odd years
Pre-Requisite(s): MA 2710 or MA 2720 or MA 3710 or MA 3715
MA 4780 - Time Series Analysis and Forecasting
Statistical modeling and inference for analyzing experimental data that have been observed at different points in time. Topics include models for stationary and nonstationary time series, model specification, parametric estimation, and time regression models.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): (MA 2710 or MA 2720 or MA 3710 or MA 3715) and (MA 3720 or EE 3180)

MA 4790 - Predictive Modeling
Application, construction, and evaluation of statistical models used for prediction and classification. Topics include data visualization and exploratory methods, the normal theory regression model, logistic and Poisson regression, linear and quadratic discriminant analysis, and classification with logit models.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
Pre-Requisite(s): MA 3740 or MA 4710 or MA 4720 or MA 4780

SU 4012 - Geospatial Data Mining and Crowdsourcing
This course comprises theory and applications of geospatial data mining. Typical application scenarios are covered. Attention is given to open-source data and systems crowdsourcing, as well as social media. Special focus on imaging and visual analytics.
Credits: 3.0

Lec-Rec-Lab: (0-2-1)
Semesters Offered: Spring

UN 4400 - Climate Science and Policy
An interdisciplinary discussion-format course covering the basic science of climate change and the development of international climate policy. Includes an analysis of policy targets in their scientific context and links to global sustainable development goals. Additional topics will be guided by the interests of the class and current events.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

Appendix D – Course Add Proposals