University Senate Plenary

April 4, 2025

UNIVERSITY
SENATE

University Senate

Proposed: April 4, 2025

Adopted: April 4, 2025

PROPOSED AGENDA

University Senate

Friday, April 4, 2025 at 1:15 p.m.

Via Zoom

Registration required

After registering you will receive a confirmation email.

1. Adoption of the agenda
2. Adoption of the minutes of March 7, 2025 (postponed to May 2, 2025)
3. President's report and questions
4. Chair's report and questions
5. Old business:
   a. Resolution Addressing Current Events: The Sundial Report
6. New business:
   a. Resolutions:
      i. Resolution to Approve an Academic Program Leading to a Master of Science in Biodiversity Data Analytics (School of Professional Studies and Arts & Sciences) (Education)
   b. Committee Reports and Updates:
      i. Elections Commission Update on the University Senate Officer Elections Spring 2025
7. Adjourn

Attendees to this Plenary meeting are reminded not to post this meeting, or any portion of this meeting, online as such a posting could result in a violation of the University's Acceptable Usages of Information Resources Policy.

University Senate

Proposed: April 4, 2025 Adopted:

77-0-0: in favor-opposed-abstained

RESOLUTION TO APPROVE AN ACADEMIC PROGRAM LEADING TO THE MASTER OF SCIENCE IN BIODIVERSITY DATA ANALYTICS (School of Professional Studies and Arts & Sciences)

WHEREAS there is a growing need for specialized skills in biodiversity analytics—the use of data-driven approaches, tools, and technologies to monitor, assess, and manage biodiversity and nature-related strategies, solutions, and goals, given the economic implications, policy drivers, and increasing availability of biodiversity and ecosystem data; and

WHEREAS the Columbia Ecology, Evolution and Environmental Biology Department (Graduate School of Arts and Sciences) and the School of Professional Studies have joined forces to propose a new master's program to prepare students to work in this burgeoning field; and

WHEREAS the relative scarcity of master's programs focusing on biodiversity data analytics in American universities offers exceptional opportunities for a Columbia program, and for its graduates in such as positions as data analysts, ecologists, environmental scientists, GIS specialists, policy analysts, consultants, and researchers; and

WHEREAS the fully online proposed program will enroll 30 students a year at a steady state, and require 36 credits with a minimum of 30, to be completed over three full-time semesters (or up to six part-time semesters), and will teach 30 students a year at a steady state; and

WHEREAS the curriculum will draw on a wide range of existing courses in Arts and Sciences and SPS, 3 new core courses (Data in Nature Conservation and Environmental Management Decisions, Advanced Biodiversity Data Analysis I, and Advanced Biodiversity Data Analysis II), and a capstone course; and

WHEREAS the Senate Education Committee has favorably reviewed the program, with particular appreciation for the active involvement of the senior Ecology, Evolution and Environment Biology Department faculty, both in the planning and after the launch;

THEREFORE BE IT RESOLVED that the University Senate approve the establishment of the Master of Science in Biodiversity Data Analytics, and

BE IT FURTHER RESOLVED that the Senate Education Committee will review the program five years after its expected launch in the fall of 2027.

Proponent: Education Committee

Proposal for New Degree, New Degree from Existing Track, New Certificate, or New Certification of Professional Achievement (CPA) Program

Please insert the requested information in the table below:

Degree:	Master of Science
Program Name:	Biodiversity Data Analytics
If this program is currently a track in an existing program but has evolved as a stand-alone program, please indicate the program it's based on:	N/A
Sponsoring School(s):	Department of Ecology, Evolution and Environmental Biology in the Graduate School of the Arts & Sciences School of Professional Studies
Proposed Start Date:	Fall 2027
Name and Email Address of the Primary Contact Person for this Proposal:	Viorel Popescu: dvp2110@columbia.edu Maria Uriarte: mu2126@columbia.edu
Date of Proposal Submission:	November 1, 2024

Description of Proposed Program

Please complete the questions below and submit this document and the external reviewer list (if applicable) through the APAS system (https://apas.provost.columbia.edu/) to begin the review process. *Please note: Firefox is the recommended browser for APAS; functionality may be less optimal when using Internet Explorer or Chrome.*

1) Purpose

A) Describe in 1-2 paragraphs the purpose of the proposed program, its target audience, its content, and its format/pedagogical approaches.

We are proposing a fully online Master of Science program in Biodiversity Data Analytics with an online delivery method and two residencies (3-4 day visits on the Columbia University campus in New York City). The students will be required to take 12 courses for a total of 36 credits. This is a non-thesis degree, and students will complete a Capstone project (worth 3 credits) focused on applying analytical and decision-making skills to real-world environment conservation and management problems within or outside their organization. The Program will facilitate connections between students and relevant companies and organizations. The courses will be taught by core and affiliate faculty in the Department of Ecology, Evolution and Environmental Biology (https://e3b.columbia.edu/faculty/) and faculty from various graduate programs at the School of Professional Studies.

The target audience are current and future decision makers across sectors, including the non-profit (NGO) sector, government agencies, consultancies, industry professionals in ESG offices, the investment sector (biodiversity-friendly investments and portfolios), environmental planning, urban planning and engineering a wide range of businesses in a sectors may face legal, regulatory, reputational and market risks if their biodiversity-related dependencies are not appropriately identified and managed in connection with their operations. Our target audience may require new or updated analytical skills to evaluate the weight of evidence in nature-related decisions and to communicate with stakeholders, shareholders, permitting agencies, and peers within and across sectors. They may also seek opportunities to obtain a graduate degree for promotion purposes or to acquire skills to change fields, sectors, or companies.

B) How does the new program relate to ongoing programs? Will it replace any existing program(s)? Does the proposed program completely or partially duplicate (an) existing program(s) in any other unit of the University?

The proposed degree has many ties with current graduate programs offered by Columbia University, but the overlap with other programs is minimal. The Department of Ecology, Evolution and Environmental Biology offers an MA degree in Ecology, Evolution and Conservation Biology. This degree is in-person and research-focused, with students required to produce a thesis at the end of their tenure. The School of Professional Studies offers two MSc degrees in Sustainability Management and Sustainability Science. These degrees are also in-person. E3B is working with the Sustainability Science program to create an Ecology and Evolution-focused track for students that are available for in-person instruction, but do not want to pursue research.

2) Need

A) Why is the proposed program needed locally, statewide or nationally?

Program Need

Given the economic implications, policy drivers, and increasing availability of biodiversity and ecosystem data, there is a growing need for specialized skills in biodiversity analytics—the use of data-driven approaches, tools, and technologies to monitor, assess, and manage biodiversity and nature-related strategies, solutions, and goals. Biodiversity analytics involves advanced methods such as remote sensing, machine learning, geographic information systems (GIS), genomic data, and big data analytics to monitor and predict changes in biodiversity and ecosystems. These methods provide the detailed insights necessary to ensure that solutions are targeted, measurable, and effective in preserving biodiversity and ecosystem health. The emergence of biodiversity credits, nature conservation solutions, and the rising demand for biodiversity analytics expertise mark critical steps toward securing a sustainable future, ensuring benefit-sharing, and promoting equitable access to natural resources and funding mechanisms.

Market Opportunity

Increasing biodiversity data analytics literacy among industry decision-makers requires a multifaceted approach that includes foundational knowledge acquisition, developing a systems-thinking mindset, cultivating technical skills, and gaining practical experience integrating and applying these skills to real-world problems. Professionals who can leverage data and computational methods to extract valuable insights from biodiversity data have the potential to improve decision-making across various sectors where existing talent pools lack the full complement of knowledge and skills needed for optimal success. Furthermore, given the interdependencies between sectors involved in the market for biodiversity credits, it is essential that these skills are developed across myriad organizations interacting in this space. This includes corporations seeking to purchase biodiversity credits, financial institutions aiming to develop nature-friendly portfolios, local communities and other actors managing lands for biodiversity, and NGOs dedicated to improving both wildlife and human health and wellbeing.

Biodiversity data analytics literacy, along with management and decision-making, is a requirement in many job postings across various roles, including data analysts, ecologists, environmental scientists, GIS specialists, policy analysts, and researchers. As global and national commitments to biodiversity and equity grow, the focus on biodiversity is extending across numerous sectors of the economy and public service organizations. The demand for skilled professionals in this area is expected to continue rising as the world places more emphasis on environmental sustainability and conservation efforts. While job opportunities may vary by region, there is a clear global trend toward increased focus on biodiversity and environmental issues.

Formal degree programs in data analytics with a focus on biodiversity and ecosystems are essential to equip professionals with the frameworks, methods, and practical skills needed to analyze complex ecological data, design effective conservation strategies, monitor results, and assess the impact of solutions across a wide variety of sectors. A landscape analysis of marketplace academic offerings revealed that few programs specifically target these areas. Existing programs lack the depth of analytics training needed and are often research-focused, requiring a thesis. Furthermore, they are not designed to accommodate the needs of working professionals.

Columbia Academic Expertise
Columbia University is ideally positioned to address the emerging global need for professional training in data analytics related to biodiversity and ecosystems. The university's academic resources, including the faculty expertise from the Ecology, Evolution, and Environmental Biology department (E3B) in the Arts & Sciences, combined with scholar-practitioner faculty from the Sustainability Management and Applied Analytics programs at the School of Professional Studies (SPS), provide a robust basis for developing a high-quality academic offering. This collaboration offers a unique opportunity to cultivate a deep analytics literacy among students, covering essential areas such as:

1. Collecting, organizing, and analyzing biodiversity and conservation data.
2. Interpreting insights from large, complex datasets.
3. Applying systems thinking and decision science to make informed decisions.
4. Communicating data-derived insights effectively.

These skills will distinguish graduates in the marketplace, enabling them to excel in existing and newly emerging roles within the global economy. Leveraging the existing course inventory from both the Graduate School of Arts & Science and the School of Professional Studies, Columbia can establish a comprehensive curriculum that includes both core and elective courses for a Master of Science degree and a Certificate of Professional Achievement.

B) Have students at the University or elsewhere requested this program? How many?

There are a growing number of programs around the country and in New York that focus on the links between sustainability, finance, and climate; however, few of these programs provide analytical tools for dealing with a complex topic such as biodiversity. With concepts such as “biodiversity metrics” and “biodiversity credits” increasingly being discussed within and across government, corporate, investment, consulting, non-profit and other sectors, preparing students analytically and substantively to understand, develop, and apply these concepts as part of their future jobs. A recent panel in “*Biodiversity Metrics in Financial Reporting: Capturing Issuer Level Impact and Dependency*” organized by Dr. Satyajit Bose, Columbia School of Professional Studies (17 Oct 2024) which included the lead of the current program proposal, Dr. Viorel Popescu, as a panelist, elicited interest from more than 200 Columbia students, with over 100 students attending in person.

C) If the program is professionally oriented, have persons in the profession requested establishment of the program? How have the employment needs of professionals in the field been taken into account when designing the program?

We conducted a survey across sectors and requested feedback on the need and relevance of the program for developing marketable skills from professionals in the NGO, government, Zoo/Aquaria, corporate and philanthropy sectors. We reached out to 30 individuals, received 8 responses, and received feedback on three topics:

1. *Please comment on the relevancy of such a program for building the skills and competencies that are needed in your organization.*
2. *Which aspects of the program do you find most desirable when thinking about the type of talent your organization needs to be successful?*

3. *What skills/competencies are missing from the program that would be beneficial to your organization?*

Overall, the feedback was positive, and all respondents saw a benefit in developing a program focused on biodiversity analytics for students already in the workforce. The respondents felt strongly that emphasis must be placed on a variety of analytical courses and skills (including coding in R and Python) and requested that clarifying the term 'biodiversity' for non-ecologists (for reporting, accounting purposes, and others) is critical. The respondents also felt that it is critical to include a minimum number of courses to instill a business mindset and prepare students for positions in the corporate, government and NGO sectors. These courses should focus on (1) decision-making, (2) policy and (3) finance. Last, but not least, the program should weave in ethical and diversity considerations throughout the curriculum.

D) What other institutions in the New York metropolitan area and in the Northeast offer similar programs?

Our competitor program analysis revealed little overlap with other similar online programs nationwide. Most programs in this space are research focused and require a thesis and are not geared towards working professionals. There is an online certificate that requires 3 courses that focus specifically on biodiversity data analytics (including spatial data analysis) with courses similar to those proposed for the SPS program. No existing market programs offer any courses in finance specifically in biodiversity or conservation.

Below is a list of programs with the closest match to our proposed program. The full description of these programs can be found here.

School	Program Name	Degree Awarded	Location	Tuition per Point	Tuition for Degree	Credits	Modality
University of Wisconsin - Green Bay	Biodiversity Conservation & Management	Master of Science	Online	$750	$23,250	31	Online
Oregon State University	Environmental Sciences	Professional Science Master's	Online	$560	$25,200	45	Online
Colorado State University	Master of Fish, Wildlife, and Conservation Biology	Master of Fish, Wildlife, and Conservation Biology	Online	$705	$21,150	30	Online Asynchronous
Cornell University	Natural Resources and the Environment Concentration in Conservation Biology	Master of Professional Studies	Ithaca, NY	-	$42,688	30	In-person

3) Curriculum

A) Provide a brief summary of the program, in the form of a one-paragraph catalogue or website description.

Increasing biodiversity data analytics literacy among practitioners in decision-making positions requires a multifaceted approach that includes foundational knowledge acquisition, building a systems thinking mindset, cultivating technical skills, and gaining practical experience integrating and applying learning to real-world problems. The new degree program aims to cultivate systems thinking in decision-making for nature conservation, emphasize usage of data and analytics in environmental decisions, enable the development and implementation of biodiversity-related metrics, build capacity with analytical tools for biodiversity data modeling and interpretation, and provide management skills through exposure to financial, policy, and communication training. The program is designed to increase biodiversity and environmental data analytics proficiency of:

1. **Experienced, Working Professionals** who hold decision-making positions in organizations that span a variety of applicable sectors (private industry, NGO, government, indigenous groups)
2. **Early Career Professionals/Recent Graduates** with constraints for pursuing in-person graduate studies.

B) Indicate the **minimum total number of credits** (or clock hours, as appropriate) required for completion of the program, as well as any other program requirements (e.g., final paper, field placement, capstone project). For Bachelor's programs, please indicate both the total number of credits required for graduation (e.g., 124 or 128), as well as the minimum number of credits within the major or concentration. Also note that the **minimum number of credits is 30 for Master's programs, 20-24 for Certificate programs, and 12 for Certification of Professional Achievement (CPA) programs.**

The proposed degree will require 36 credits with 7 core courses covering the foundations of conservation science and biodiversity data analytics as well as a Capstone experience. Students will also complete 2 additional courses focused on *Spatial Data Analysis and Visualization* and 3 courses in *Finance, Policy and Decision-making*. Analytical skills courses include 3 biodiversity data analysis courses (elements of statistics, biodiversity and ecosystem services metrics and indicators, data applications in population and community ecology, social science), 2 spatial ecology courses (GIS, remote sensing) and 2 foundational conservation biology and data use in environmental decisions courses. Courses will be offered asynchronously, but hands-on labs will be offered and led by teaching associates.

The program requires a Capstone culminating experience, which will provide students the opportunity to work on a real-world project or consulting assignment. As a cohort-based program, students with different professional and academic backgrounds will be encouraged to collaborate on Capstone projects that take an interdisciplinary approach to environmental and nature conservation problem-solving. This model will be amplified by two residencies (3-4 days) on the Columbia University campus, which is aimed at forging networks and work/study relations for an enhanced learning experience.

In addition to above courses, a zero-credit pre-program 'bootcamp' in the R language (3-4 days) will be offered at the onset of the degree. This bootcamp will provide the foundations for subsequent analytical courses.

C) Please use the table below to list the required, elective, and selective coursework. "Selective" coursework consists of a list of courses from which a student must select a minimum number of credits (but need not take all courses on the list).

REQUIRED COURSES **Minimum number of required credits = 21**	**School**	**Course Number (indicate if course is NEW)**	**Course Title & Instructor**	**Indicate whether course is fully, partially, or not at all online**	**# of Credits**
Optional Pre-program Course	A&S	Existing online resources	Pre-program Bootcamp in R for statistical computing & data visualization - Viorel Popescu	Fully online	0
Core requirement	A&S	EEEB 6905	Seminar in Conservation Science - Partridge (Adjunct), Bekka Brodie, Viorel Popescu	Fully online	3
Core requirement	A&S	NEW	Data in Nature Conservation and Environmental Management Decisions - Viorel Popescu, Maria Uriarte, Duncan Menge	Fully online	3
Core requirement	A&S	EEEB 5005	Introduction to Ecological Data Analysis - Foerster (Adjunct)	Fully online	3
Core requirement	A&S	NEW	Advanced Biodiversity Data Analysis I - Modern methods in biodiversity data analysis - Viorel Popescu, Maria Uriarte, Shahid Naeem	Fully online	3
Core requirement	A&S	NEW	Advanced Biodiversity Data Analysis II - Ecosystem services and integration with social data - Viorel Popescu, Ruth DeFries, Shahid Naeem	Fully online	3
Core requirement	A&S	EEEB 4192	Introduction to Landscape Analysis - Shivani Agarwal (Adjunct)	Fully online	3
Core requirement	SPS	NEW	Capstone	Fully online	3
SELECTIVE COURSES **Minimum number of selective credits = 15**	**School**	**Course Number (indicate if course is NEW)**	**Course Title & Instructor**	**Indicate whether course is fully, partially, or not at all online**	**# of Credits**
CURRICULAR AREA 1 = 6 credits					
Spatial Data Analysis and Visualization	A&S	EEEB 4670	Introduction to GIS - Eric Glass (Adjunct)	Fully online	3
Spatial Data Analysis and Visualization	SPS	APAN 5210	Python for Data Analysis - Various	Fully online	3
Spatial Data Analysis and Visualization	SPS	SUSC 5050	GIS for Sustainable Science - Frank Nitsche	Fully online	3
Spatial Data Analysis and Visualization	A&S	EEEB 4160	Landscape Ecology - Maria Uriarte	Fully online	3
Spatial Data Analysis and Visualization	SPS	APAN 5800	Storytelling with Data - Various (many sections)	Fully online	3
Spatial Data Analysis and Visualization	SPS	SUMA 5255	Data analysis and visualization for sustainability - Gregory Yetman	Fully online	3

CURRICULAR AREA 2 = 9 credits					
Finance, Policy and Decision-Making	A&S	EEEB 4005	Conservation Policy - Viorel Popescu	Fully online	3
Finance, Policy and Decision-Making	SPS	SUMA 6116	Environmental Law and Policy in New York City - Laura Popa	Fully online	3
Finance, Policy and Decision-Making	SPS	SUMA 5445	Impact finance for sustainability practitioners - Bhakti Mirchandani	Fully online	3
Finance, Policy and Decision-Making	SPS	SUMA 5169	Sustainability metrics - Guo Dong	Fully online	3
Finance, Policy and Decision-Making	SPS	SUMA 5156	Climate finance and sustainable development - Satyajit Bose	Fully online	3
Finance, Policy and Decision-Making	SPS	SUMA 5025	Corporate sustainability reporting and strategy - Jessica Thurston / Celine Ruben-Salama	Fully online	3
Finance, Policy and Decision-Making	SPS	SUMA 5195	Accounting, Finance and Modeling of Sustainable Investments	Fully online	3
Finance, Policy and Decision-Making	SPS	SUMA 5020	Cost Benefit Analysis	Fully online	3
Finance, Policy and Decision-Making	SPS	SUMA 5142	Sustainable Finance	Fully online	3
ELECTIVE COURSES **Minimum number of elective credits** **= ______**	**School**	**Course Number (indicate if course is NEW)**	**Course Title & Instructor**	**Indicate whether course is fully, partially, or not at all online**	**# of Credits**
None					

(Please add new rows above as needed.)

D) Provide a sample schedule showing the courses the students will take during each semester of the program. For elective or selective courses, simply enter “elective” or “selective.”

Part-time Student Schedule - Completion in 6 consecutive semesters

Semester 1 (Fall)			
Course Number & Title	**Credits**	**New?**	**Prerequisites**
Pre-program Bootcamp in R & data visualization (CORE)	0		
EEEB 6905 Seminar in Conservation Science (CORE)	3		
EEEB 5005 Intro to Ecological Data Analysis (CORE)	3		
TOTAL CREDITS FOR SEMESTER:	**6**		
Semester 2 (Spring)			
Course Number & Title	**Credits**	**New?**	**Prerequisites**
EEEB 5005 Introduction to Landscape Analysis (CORE)	3		
Advanced Biodiversity Data Analysis I (CORE)	3	New	Introduction to Ecological Data Analysis
TOTAL CREDITS FOR SEMESTER:	**6**		
Semester 3 (Summer)			
Course Number & Title	**Credits**	**New?**	**Prerequisites**
Finance, Policy and Decision-making (SELECTIVE 1)	3		
Advanced Biodiversity Data Analysis II (CORE)	3	New	Advanced Biodiversity Data Analysis I
TOTAL CREDITS FOR SEMESTER:	**6**		
Semester 4 (Fall)			
Course Number & Title	**Credits**	**New?**	**Prerequisites**
Spatial Data Analysis and Visualization (SELECTIVE 1)	3		
Data in Nature Conservation and Environmental Management Decisions (CORE)	3	New	
TOTAL CREDITS FOR SEMESTER:	**6**		
Semester 5 (Spring)			
Course Number & Title	**Credits**	**New?**	**Prerequisites**
Spatial Data Analysis and Visualization (SELECTIVE 2)	3		
Finance, Policy and Decision-making (SELECTIVE 2)	3		
TOTAL CREDITS FOR SEMESTER:	**6**		
Semester 6 (Summer)			
Course Number & Title	**Credits**	**New?**	**Prerequisites**
Finance, Policy and Decision-making (SELECTIVE 3)	3		
Capstone	3	New	
TOTAL CREDITS FOR SEMESTER:	**6**		

Full-time Student Schedule - Completion in 3 consecutive semesters

Semester 1 (Fall)			
Course Number & Title	**Credits**	**New?**	**Prerequisites**
Pre-program Bootcamp in R for statistical computing & data visualization (CORE)	0		
EEEB 6905 Seminar in Conservation Science (CORE)	3		
EEEB 5005 Intro to Ecological Data Analysis (CORE)	3		
Finance, Policy and Decision-making (SELECTIVE 1)	3		
Spatial Data Analysis and Visualization (SELECTIVE 1)	3		
TOTAL CREDITS FOR SEMESTER	**12**		
Semester 2 (Spring)			
Course Number & Title	**Credits**	**New?**	**Prerequisites**
EEEB 5005 Introduction to Landscape Analysis (CORE)	3		
Advanced Biodiversity Data Analysis I (CORE)	3	New	Introduction to Ecological Data Analysis
Finance, Policy and Decision-making (SELECTIVE 2)	3		
Spatial Data Analysis and Visualization (SELECTIVE 2)	3		
TOTAL CREDITS FOR SEMESTER	**12**		
Semester 3 (Summer)			
Course Number & Title	**Credits**	**New?**	**Prerequisites**
Finance, Policy and Decision-making (SELECTIVE 3)	3		
Advanced Biodiversity Data Analysis II (CORE)	3	New	Advanced Biodiversity Data Analysis I
Data in Nature Conservation and Environmental Management Decisions (CORE)	3	New	
Capstone (CORE)	3	New	
TOTAL CREDITS FOR SEMESTER	**12**		

E) Please provide the typical number of weeks in the Academic Year for this program, counting Fall and Spring semesters. Note that regulations define a “week” as any 7-day period in which ANY instructional activity occurs; this includes classes, discussion sections, labs, exam periods, and study periods. A single activity in a given week counts as a week of school. Virtually the only weeks not to be counted are orientation week and vacation weeks.

The typical weeks in the Academic Year for this program will be 40 weeks. Students will take courses over the 14-week fall and spring semesters as well as the 12-week summer session.

F) Please also indicate the number of weeks IN TOTAL that it would take a typical full-time student to complete the program. For example, for a one-year MS program, which can typically be completed in Fall and Spring semesters, you would likely provide the same answer you gave immediately above (for weeks in the academic year). If a program requires 2 years of study, then you would multiply the number of weeks in the academic year by 2. If Summer terms are included, please include 6-10 weeks, as appropriate, for each Summer term.

Full-time students in the MS in Biodiversity Data Analytics can complete the program in three consecutive semesters (fall, spring, summer), by enrolling in 12 credits during each of the three semesters, totaling 40 weeks of study.

Part-time students can complete the program in 80 weeks by taking two 3-credit courses during each fall, spring, and summer term for two consecutive years.

G) Does the proposed program rely to a significant extent on courses that are offered by other parts of the University? If so, identify those courses and confirm that you have discussed course availability and capacity with the unit in which those courses are housed.

Students will have the option to cross-register for courses offered at the Graduate School of Arts & Science and at the School of Professional Studies to satisfy their selective course requirements. Course availability has been confirmed by the following departments: Ecology, Evolution and Environmental Biology, Sustainability Management, Sustainability Science, and Applied Analytics.

H) For any new courses to be developed for this program, provide a draft syllabus and include information on when the courses have been or will be approved by the appropriate Committee(s) on Instruction.

Four new courses will be developed for this program:

1. Advanced Biodiversity Data Analytics I
2. Advanced Biodiversity Data Analytics II
3. Data in Nature Conservation and Environmental Management Decisions
4. Capstone course

Courses will require approval by the Curriculum Committee at the Department of Ecology, Evolution and Environmental Biology and the GSAS Committee on Instruction, which meet regularly during the academic year.

Draft syllabi for the 4 new courses are provided in *Appendix A*.

I) Indicate whether course credits earned in the proposed program can also be counted toward another degree or certificate.

An affiliated Certificate of Professional Achievement (CPA) is being proposed concurrently with the Master of Science degree program. At present, course credits earned in the proposed program cannot be added toward another degree or the certificate.

Courses designed for this program will be made available for cross-registration by students from related degree programs, including the Master of Art in Ecology, Evolution and Conservation

Biology and towards other complementary Master degrees offered jointly by the School of Professional Studies and the Climate School (see section 1.B) The new courses developed for this program are relevant for students in the Masters programs in Sustainability Science and Sustainability Management, as well as the Sustainability Analytics CPA offered via the Sustainability Management (SUMA) program.

J) Please provide a proposed CIP code for the program. A full list of CIP codes can be found here. Please choose the CIP code that most closely aligns with the program. For CIP codes that are defined as STEM, the University requires 75% or more of a program curriculum to be STEM-related, particularly as regards to required courses that all students need to take.

CIP Code 26.1307 – Conservation Biology

4) Library Resources

Have you consulted with a library subject specialist about what library resources (e.g., books, databases, journals, streaming video or audio, data sets, etc.) or other support (research consultations, library instruction, etc.) you anticipate needing for this program? If yes, please list those resources expected.

Columbia Library provides access to relevant journals and textbooks in conservation biology, biostatistics and ecological modeling. We do not anticipate needs that are not currently met by the Columbia Library. Datasets and case studies will be sources from open-source repositories, such as github, Zenodo, EcoBank, MoveBank, GBIF, etc.

5) Faculty

A) Provide the name of the program director and the percent of time this individual will dedicate to leadership of the program.

Dr. Viorel Popescu, current Associate Research Scientist in E3B, will be hired as the Program Director and SPS intends to hire Dr. Popescu as a full-time Lecturer in Discipline to teach in the new Master of Science degree program. As a full-time faculty member with an administrative appointment as Program Director, the expectation will be to dedicate approximately 50% of time to leadership of the program. While serving as Program Director, Dr. Popescu will be expected to teach at least two Biodiversity Data Analytics program courses during both the fall and spring semesters and to oversee faculty academic advising for all students.

B) Indicate if the program will require the hiring of new faculty either at its inception or by the time it reaches steady state. If so, indicate the number of new faculty it will require, divided between full- and part-time, the subjects they will teach, and the year(s) of their initial appointment.

The program will require 1 full-time Lecturer in Discipline starting in Year 1 of the program. The full-time faculty member will be responsible for developing and teaching program courses (Core Requirements; section 3.C) and providing administrative leadership starting with the first year of their full-time faculty appointment, in July 2026.

Existing E3B full-time faculty will teach core and selective courses in the program and advise students as needed. Selective courses drawn from departments outside of E3B will be taught by faculty in those departments or new part-time faculty hired to teach new online sections for courses that are currently taught on-campus only. The new online sections will be open for cross-registration, serving students from a variety of graduate degree programs.

6) Students

A) Describe the requirements for admission to the program.

To be eligible for admission, applicants must have earned a bachelor's degree from an accredited institution by the date on which they enroll at the School of Professional Studies. Students whose native language is not English must include proof of English proficiency assessed through a TOEFL or IELTS examination. The minimum requirement is 100 (TOEFL iBT) or 7.0 (IELTS). The following materials be required as part of the application process:

- Completed online application form
- Nonrefundable application fee
- Video essay
- Transcripts from all post-secondary institutions
- Resume or CV
- Two letters of recommendation
- Statement of academic purpose
- Demonstration of English proficiency
- (Optional) Official scores on the Graduate Record Examination (GRE) general test or equivalent (GMAT or LSAT)

Due to the interdisciplinary nature of biodiversity and ecosystem services, the MS in Biodiversity Data Analytics will admit students from a wide variety of academic backgrounds. This includes applicants from undergraduate and graduate programs in sciences, engineering, public health, social sciences, humanities, public policy, law, and business.

Successful applicants will demonstrate a strong record of academic performance at the undergraduate level. Some undergraduate-level coursework in ecology or sustainability or the equivalent in professional experience is preferred. Knowledge of calculus and introductory statistics or data analysis is preferred, but not required.

Applicants will be asked to clearly articulate how they plan to use the skills developed in the program to advance their professional goals and careers after completion of the program.

B) Provide the anticipated enrollments of students in the program's first five years, and ultimate enrollment once it reaches steady state. Indicate the number of years it will take to grow the program to its full size.

Enrollment Projection				
Year 1 FY 2027	**Year 2 FY 2028**	**Year 3 FY 2029**	**Year 4 FY 2030**	**Year 5 FY 2031**
20	25	30	30	30

C) If this is a dual-degree program, either between schools of the University or a joint program in collaboration with another institution, describe the support the students will receive from the participating schools or institutions and how the program will ensure that they have access to the courses and resources they will need to complete its requirements.

This program is not a dual degree. It is a Master of Science degree developed in partnership between the department of Ecology, Evolution, and Environmental Biology (E3B) and the School of Professional Studies.

D) Describe the types of jobs or careers for which the program will qualify its students.

Biodiversity and nature analytics literacy is a requirement in job posting across various roles, including data analysts, ecologists, environmental scientists, GIS specialists, policy analysts, consultants, and researchers. The demand for skilled practitioners is expected to continue growing as the world places more emphasis on environmental sustainability and conservation efforts. Job opportunities may vary by region, but there is a global trend toward increased focus on biodiversity and environmental issues. Graduates of the program will be prepared to compete for existing positions and those expected to emerge skilled as the world places more emphasis on environmental biodiversity, conservation, and sustainability efforts.

Fast-growing sectors where there is an apparent need for biodiversity analytics literacy:

Conservation and Environmental NGOs: Non-governmental organizations dedicated to conservation and environmental protection often require experts with biodiversity analytics literacy to inform their advocacy efforts, research, and conservation projects.

Government Agencies: Government departments responsible for natural resource management, environmental protection, and wildlife conservation rely on experts in biodiversity analytics to make informed policy decisions and manage natural resources.

Corporate and finance: Most companies have sustainability and environmental offices that oversee efforts for environmental corporate responsibility. Industry often deals with biodiversity data and as implemented via guidelines from the Taskforce for Nature-related Financial Disclosures (https://tnfd.global/): directly through efforts to mitigate impacts of development, or indirectly via investments in carbon and biodiversity credits. Biodiversity data literacy is thus critical for informed financial decisions. The EU Corporate Sustainability Reporting Directive (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022L2464) requires all companies with EU subsidiaries to adhere to strict environmental reporting regulations.

Wildlife and Forestry Management: Biodiversity analytics is essential for managing and conserving wildlife, forests, and other natural resources. Jobs in these sectors involve data analysis, ecological modeling, and sustainable resource management.

Ecotourism: The ecotourism industry is growing, and businesses in this sector benefit from biodiversity analytics to develop sustainable and responsible tourism practices.

Agriculture and Sustainable Farming: Sustainable agriculture and agroecology are increasingly important for preserving biodiversity. Professionals with biodiversity analytics skills can help optimize land use and minimize environmental impacts.

Environmental Consulting: Environmental consulting firms use biodiversity analytics to assess the environmental impact of development projects, conduct ecological assessments, and ensure regulatory compliance.

Research and Academia: Biodiversity researchers and educators play a critical role in advancing our understanding of ecosystems and species. Biodiversity analytics is essential for scientific research.

Urban Planning and Land Use: Urban planners use biodiversity data to incorporate green infrastructure, parks, and conservation areas into urban development plans, enhancing the quality of life in cities.

Climate Change Mitigation and Adaptation: Understanding biodiversity's role in climate change and using data analytics to develop climate-resilient strategies is crucial in the fight against climate change.

Ecosystem Services Assessment: Ecosystem services, such as clean water, pollination, and carbon sequestration, rely on biodiversity. Assessing and valuing these services require data analysis and biodiversity expertise.

Eco-friendly Technology and Innovation: Companies focusing on sustainable technologies and innovations often seek professionals who can integrate biodiversity analytics into product development and business strategies.

Health and Pharmaceuticals: Biodiversity can play a role in discovering new medicines and bioactive compounds. Pharmaceutical companies may need experts to analyze biodiversity data for drug discovery.

Assuming previous career experience, graduates of the program will be competitive candidates for management and consulting roles at the Advisor, Manager, Associate Director, and Managing Director levels. Upon completing the degree, students without previous professional experience will possess skills and knowledge that will distinguish them as competitive applicants for entry level roles as Analyst, Specialist, or Research Associate. Below are active job postings as of August 2024 for which the program will qualify its graduates:

- Applied Scientist Worldwide Sustainability, Amazon (Seattle, WA)
- Climate Resilience Analyst, Booz Allen (Arlington, VA)
- NC Coastal Applied Scientist, The Nature Conservancy (Aroline, PR)
- Marine Conservation Scientist, Nature Positive, World Wildlife Fund (Washington, DC)
- Associate Data Science Specialist, University of CA Santa Barbara (Santa Barbara, CA)
- Principal Consultant - Nature Solutions, Anthesis Group (United States)
- Freshwater Project Manager, Conservation International (Arlington, VA)
- Data Management Specialist, National Fish and Wildlife Foundation (Washington, DC)
- Officer, Research Review and Support (Human Dimensions of Environment), Pew Charitable Trust (Washington, DC)
- Environmental Analyst, World Bank Group (Washington, DC)
- Forest Geospatial Analyst, The Westervelt Company (Tuscaloosa, AL)
- Wetlands | Natural Resources Specialist, Fuss & O’Neill (White River Junction, VT)

7) Online Delivery. If the proposed program will have an on-line component, answer the following questions.

A) Confirm whether the online and in-person programs will be identical with respect to content, admission criteria, student learning objectives, and assessment methods; and if not, indicate how they will differ.

This program will be designed as a 100% online program. Currently, there are no plans to offer a separate in-person program.

B) What percentage of the program will be offered online?

The program will be offered fully (100%) online.

C) Please describe:

a. The on-line platform you will be using to teach this program;

All online courses will be designed and hosted on Canvas, the University's learning management system. Optional class meetings and virtual office hours will be delivered over Zoom, the University's web conferencing platform, using the Zoom LTI integrated into Canvas.

b. Student support resources that will be available to the on-line students;

The services for students in the online program will be the same as those offered to SPS students on campus. SPS has already developed these resources to meet the demands of students in our online and hybrid programs.

All SPS students receive various academic and support services from their program and the Division of Student Affairs. The division consists of five key departments that provide services and support for SPS students: Admissions, Academic Advising, the Career Design Lab, Student Life, and Student Services.

These services are first introduced via an online orientation session before coursework begins. The orientation program provides a clear and comprehensive introduction to their program and the academic community and includes such details as:

1. Critical steps to enrolling in courses
2. Academic program review
3. Course information and registration
4. Financial aid
5. Immunization and health services
6. Professional and career development

Additionally, all SPS students must participate in an online, asynchronous Pre-Orientation portal before their online orientation session. This portal provides information on items such as Title IX, Sexual Respect, Gender-Based Misconduct, EOAA, Academic Integrity, Alumni Affairs, ISSO, Health Services, and others. The University requires presentations. Failure to complete the required sections will result in a registration hold placed on the student's account, preventing the student from registering for classes.

All students are integrated into the University's Student Services Online (SSOL) system, which provides on-demand information regarding student records and academic programs. Through SSOL, students can view their academic profile, register for classes, view their term bill, view grades, view holds, and order transcripts. Students receive comprehensive support as they transition through the academic program, including up-to-date information on course registration, satisfactory academic progress, and degree conferral.

Students in online programs are encouraged to develop and maintain active communities within the program. Students and program leadership work collaboratively in the Engage (CampusGroups) platform to develop and promote social, cultural, and academic events, such as career/industry panels, professional skills workshops, and capstone project working sessions.

The School of Professional Studies Career Design Lab provides comprehensive, quality services and access to Columbia University career resources. Students receive support through a comprehensive program that includes:

1. Workshop series on professional career development
2. Career fairs and featured speakers
3. Individualized career coaching, including:
    a. Career planning and research
    b. Personal branding and networking
    c. Resume and cover letter writing
    d. Agile internship job search strategies
    e. Interview skills and salary negotiations
    f. Career transitions

In addition to these services, all students have access to the vast resources of Columbia University, including the University Library system, composed of 22 libraries, including affiliates, a system that ranks as one of North America's top five academic libraries. The collections include over 12 million volumes, over 160,000 current journals and serials, and an extensive collection of electronic resources, manuscripts, rare books, microforms, maps, and graphic and audiovisual materials.

c. How you will authenticate the identity of the on-line students in the program.

The program's highly social course design enables students to establish distinct and recognizable identities. The visibility of these identities is extended through the development of asynchronous social learning activities — such as discussion forums, group projects, and reflections – and optional real-time meetings. These synchronous meetings are accessible via an LTI integrated into a password-protected learning management system. Only registered students and authorized guests can access the course materials and attend the real-time meetings.

Several security measures are employed to confirm identity and prevent unauthorized access and submission for activities where a recognizable identity is not a factor (e.g., exams). These include administering examinations with authentication technology, confirmed digitally. Columbia students access these systems by authenticating with their Columbia UNI.

In administering online examinations, SPS uses Proctorio, an automated proctoring solution that uses the computer's webcam, microphone, and sophisticated motion and eye-tracking technology to monitor students while taking exams online. Before administering an exam, faculty members work with the SPS Online Curriculum and Instruction team to determine the parameters and security measures for the exam using Proctorio. Proctorio records the entire exam – including the student's desktop, video, and audio – and generates a suspicion report based on an algorithm and a predefined set of parameters. The level of sensitivity can be adjusted for the following characteristics: multiple people, excessive eye and or head movement, audio abnormality, video abnormality, and web traffic, as well as browser lock-down options such as opening extra tabs or windows, right-clicking, copying, printing, and re-entry.

Additionally, Proctorio asks the student to use their webcam to show their physical space to ensure no materials are available for cheating; this is also recorded for inspection. Proctorio requires the student to present an acceptable form of photo identification (a university ID, driver's license, passport, etc.) and a unique password at the start of the exam, verified through the webcam recording. After the exams, a faculty member or their teaching assistant reviews the suspicion reports and takes action as needed.

8) Evaluation

A) Describe how the quality of the program will be evaluated, including the frequency of the reviews and who will conduct them. Describe how student input will be obtained as part of the evaluation of the program.

In preparation for fiscal year strategic planning and the budget cycle, academic programs at SPS conduct an Annual Curriculum Review (ACR) — a comprehensive review of overall curriculum effectiveness in achieving the program's stated purpose and alignment with current trends and market needs. Program Curriculum Committees (PCC) are the faculty body responsible for completing the ACR and developing a Curriculum Improvement Plan (CIP) designed to enhance the quality and rigor of the program and better prepare students to move their careers, communities, and industries forward. This process includes student feedback in the form of course evaluations, focus groups, and exit surveys.

The program will undergo an Academic Committee Review (ARC) on a 5-year cycle. This process will include a rigorous self-study and reviews by external and internal committees.

B) Include a learning outcomes and assessment plan for the proposed program, using the below template.

Program Learning Objectives (PLOs) for Students	Assessment of Learning Outcomes
PLO 1: Apply systems thinking for addressing the current biodiversity crisis	Direct: Embedded measures within courses, such as class participation and performance on assignments, group projects, and exams. Indirect: Course evaluations; End-of-program exit survey; Alumni surveys.

Program Learning Objectives (PLOs) for Students	Assessment of Learning Outcomes
PLO 2: Analyze and interpret biodiversity and other types of data, models and scientific results pertaining to biodiversity conservation and decision-making	Direct: Embedded measures within courses , such as class participation and performance on assignments, group projects, and exams); Experiential learning outcomes (capstone presentations, internship evaluations) Indirect: Course evaluations; End-of-program exit survey; Alumni surveys.
PLO 3: Apply open-source statistical and GIS software and public data repositories to analyze and report biodiversity data	Direct: Embedded measures within courses, such as class participation and performance on assignments, group projects, and exams); Experiential learning outcomes (capstone presentations, internship evaluations) Indirect: Course evaluations; End-of-program exit survey; Alumni surveys.
PLO 4: Critically evaluate the scientific underpinnings of conservation science and their relevance and applicability to specific policies, economic and social contexts	Direct: Embedded measures within courses, such as class participation and performance on assignments, group projects, and exams); Experiential learning outcomes (capstone presentations, internship evaluations) Indirect: Course evaluations; End-of-program exit survey; Alumni surveys.
PLO 5: Leverage data to identify sustainable market-based solutions for biodiversity and ecosystem services conservation	Direct: Embedded measures within courses, such as class participation and performance on assignments, group projects, and exams); Experiential learning outcomes (capstone presentations, internship evaluations) Indirect: Course evaluations; End-of-program exit survey; Alumni surveys.
PLO 6: Evaluate ethical considerations in biodiversity conservation, including the role of diversity and place-based solutions	Direct: Embedded measures within courses, such as class participation and performance on assignments, group projects, and exams); Experiential learning outcomes (capstone presentations, internship evaluations) Indirect: Course evaluations; End-of-program exit survey; Alumni surveys.

9) External Review for NEW Master's and Doctoral Programs.
Please provide the names of experts in the field of the program at institutions outside of New York State. Proposed reviewers should be specialists in the area of the program but should not have had an association with Columbia that would compromise the independence of their evaluations. NYSED considers that a conflict of interest exists if a proposed reviewer:

- has had an appointment at the University or is related to someone who has;
- was previously consulted about the development of the proposed program; or
- has a professional relationship with someone at the University such as collaborating on externally funded research and publications.

For new master's programs, the University must supply one external review; for doctoral programs, two external reviews are required. For this reason, please identify 3 potential reviewers for master's proposals, and 5 potential reviewers for doctoral proposals.

For each potential reviewer, include institutional affiliation, contact information and a link to the individual's website which lists his/her educational credential (including where his/her degrees were received) and employment history. If full information on degrees and employment cannot be viewed from the website, NYSED may require that we supply them with the individual's CV.

Please note that this requirement does not apply to new DUAL or JOINT degree programs, or to new BACHELOR's programs; we do not need to submit external reviews for these programs.

Dr. Erika Zavaleta, Howard Hughes Medical Institute Professor, University of California - Santa Cruz, Department of Ecology and Evolutionary Biology
email: zavaleta@ucsc.edu
Information: https://en.wikipedia.org/wiki/Erika_Zavaleta

Dr. Joshua Lawler, Professor, University of Washington, School of Environment
email: jlawler@uw.edu
Information: https://www.landecol.org/lab-members

Dr. Angela Fuller, Lead, USGS New York Cooperative Fish and Wildlife Research Unit, Cornell University, College of Agriculture and Life Science
email: angela.fuller@cornell.edu
Information: https://cals.cornell.edu/angela-fuller

Dr. David Wilcove, Professor, Princeton University, Department of Ecology and Evolutionary Biology
email: dwilcove@princeton.edu
Information: https://www.worldwildlife.org/leaders/david-s-wilcove

Dr. Joseph Kiesecker, Lead Scientist, The Nature Conservancy
email: jkiesecker@tnc.org
Information:
https://www.nature.org/en-us/about-us/who-we-are/our-people/nature-conservancy-experts-conservation-lands-joe-kiesecker/

APPENDIX A – NEW COURSE SYLLABI

Advanced Methods in Biodiversity Data Analysis I

MS Program in Biodiversity Data Analytics

Department of Ecology, Evolution and Environmental Biology &

School of Professional Studies

Columbia University

Instructor: XX

Teaching Assistant: XX

Locations and Time: XX

Office Hours: XX

BACKGROUND: A biodiversity data revolution is underway, aided by increases in computing capacity, ease of collecting data and advances in statistical models that allow for integrating many types of data. Simultaneously, there is increased scrutiny in the economic sector for biodiversity friendly practices, and a myriad of biodiversity metrics have been developed to evaluate the sustainability of human actions on biodiversity. In this course of the Biodiversity Data Analytics program, we consider what constitutes a robust biodiversity metric, learn how to interpret and evaluate biodiversity metrics in real-world contexts and conduct analyses of population and species level metrics commonly used in conservation decisions.

COURSE DESCRIPTION: This course focuses on understanding the concepts of science-based biodiversity metrics and demonstrates the application of advanced methods in deriving robust and data-backed metrics for populations and species. This course introduces students to the field of population ecology and the use of data in global, national, and regional policies responsible for the conservation of biodiversity. Students will learn how to use various statistical packages in program R to analyze biodiversity data for estimating metrics such as habitat occupancy, abundance and density trends through time while considering the effects of human actions. Species are the “currency” in most biodiversity-related policies and regulations. As such, students will also examine how species distributions can shift due to climate change and evaluate the use of species-level metrics, including extinction risk and genetic markers, for supporting sustainability and conservation goals. This course will provide students with a strong foundation of statistical models commonly used in biodiversity conservation and the use of such models for deriving metrics and indicators to support decision-making in terrestrial and marine environments.

Learning Objectives

LO1: Understand the importance of using robust and quantifiable biodiversity metrics to address sustainability and conservation targets in relation to various national and international biodiversity policies

LO2: Apply open-source statistical software and public data repositories to analyze and report biodiversity data and metrics

LO3: Analyze and interpret biodiversity and other types of data, models and scientific results pertaining to biodiversity conservation and decision-making

LO4: Critically evaluate the scientific underpinnings of biodiversity metrics used in specific policies, economic and social contexts

Learning Outcomes

This course will provide students with a foundation of biodiversity metrics and the development and implementation of population and species-level metrics. By the end of this course students will be able to:

1. Explain how and why biodiversity data is critical for formulating sustainable management strategies across sectors.
2. Understand the types and quality of data used to develop biodiversity metrics used in for various certifications of public and private enterprises
3. Perform statistics, data visualization and model validation with Excel and various packages of the statistical computing language R
4. Apply population or species-level biodiversity metrics to evaluate the feasibility of policy decisions and corporate sustainability
5. Communicate original research in applied population and community ecology via professional-style oral and written presentations
6. Evaluate the strengths and limitations of population and species-level biodiversity metrics in relation to their robustness, relevance and data requirements.

Learning materials:

Gotelli, N. J. (2008) A Primer of Ecology, 4th edition, Sinauer

Kery, M and A.J. Royle (2016). Applied hierarchical models in Ecology I: Prelude and statistical models. Academic Press

Miscellaneous peer-reviewed articles will be assigned on a weekly basis.

Software:

This course will involve quantitative assessments of a suite of population and species-level biodiversity metrics and the implementation of biodiversity data modeling. We will primarily use programming language R (various packages, such as *unmarked*, *spOccupancy*, *dismo*, *kuenm*), along with Excel and species distribution modeling software MaxEnt

Assessment:

Students will be evaluated based on their ability to solve several problem sets in which they will apply quantitative tools to conservation decision-making, class participation via weekly discussion boards and a final project (individual or group project)

- **Participation (20%)**
  - o 10% for participating in lecture discussions and questions
  - o 10% for discussion via Canvas discussion board weekly topics.

- **Applied Biodiversity Metrics Group Assignment (30%).** Frame a conservation problem or regulatory requirement for the private sector and identify a suite of biodiversity metrics that can evaluate the sustainability of management and long-term conservation goals (10% presentation, 20% research paper)
    - o 10% for the group presentation. Each student will present one component of the problem
    - o 20% for the group essay. Each student is expected to lead at least one component of the essay.
- **Population trends lab (10%)**. Completion of a problem set focused on evaluating population growth models and population trends
- **Occupancy modeling lab (10%)**. Completion of a problem set focused on habitat occupancy modeling of a species of your choice.
- **Trends in occupancy lab (10%)**. Completion of a problem set focused on forecasting changes in extinction and occupancy through time due to human activities
- **Abundance and density lab (10%).** Completion of a problem set focused on estimating changes in abundance of a species of interest and relation to national and global conservation targets
- **Species distribution models lab (10%)**. Completion of a problem set focused on forecasting species distributions under climate change scenarios

TENTATIVE SCHEDULE OF CLASSES

Wk	Date	Topic	Readings / Case studies
1		Course Intro / Value of modeling and data for biodiversity conservation	Gotelli (2008) Ch1 Sequeira et al. 2018
2		Biodiversity metrics I: definition, context (biodiversity credits, TNFD, CSRD), simple diversity metrics	Santini et al. 2017 Hunter, Gibbs and Popescu 2021 (Ch 1, 2, 3) TNFD and CSRD guidelines for biodiversity
3		Biodiversity metrics II: what makes a good biodiversity metric; data types for developing biodiversity metrics (bioacoustics, environmental DNA, camera traps, citizen science) and role of monitoring	Xie et al. 2021 Johnston et al. 2023 Oliver et al. 2023 James et al. 2024
4		A compendium of biodiversity metrics	Skidmore et al. 2021 Marshall et al. 2020 Mandle et al. 2021 Nicholson et al. 2020
5		Population-level metrics: population trajectories and trends in abundance; simple population growth models – includes ***quantitative lab***	Gotelli 2008 Ch2 Kery and Royle 2016
6		Population-level metrics: static habitat occupancy and abundance estimation – includes ***quantitative lab***	MacKenzie et al. 2002 MacKenzie et al. 2005 Doser et al. 2023

			Kellner et al. 2023
7		Population-level metrics: habitat occupancy and abundance dynamics through time – includes ***quantitative lab***	Mackenzie et al. 2003 Doser et al. 2023 Kellner et al. 2023 Kery and Royle 2016
8		Population-level metrics: survival estimation and extinction risk– includes ***quantitative lab***	Fieberg and Ellner 2000 Roman-Palacios and Wiens 2020 Rossberg et al. 2024 Miranda et al. 2022
9		Population-level metrics: spatial models for survival and population density	Tourani 2022 Dupont et al. 2021
10		Species-level metrics: basics of species distribution modeling	Elith and Leathwick 2009 Melo-Merino et al. 2020 Crego et al. 2022 Sillero et al. 2021
11		Species-level metrics: forecasting effects of climate change on species distributions – includes ***quantitative lab***	Santini et al. 2021 Peterson et al. 2018 Zachariah and Barney 2021
12		Species-level metrics: genetic variation	Frankham 2021 Frankham 2022 Willi et al. 2022 Nielsen et al. 2020
13		Evaluating performance of management and conservation actions using biodiversity metrics	Maxwell et al. 2020 Soykan and Lewison 2015 Khorozyan 2020 Bracy Knight et al. 2020
14		Course wrap-up and Student presentations	
15		Student presentations	

READINGS

Week	Readings
1	Ch1 Gotelli, N. J. (2008) A Primer of Ecology, 4th edition, Sinauer Sequeira, A. M., Bouchet, P. J., Yates, K. L., Mengersen, K., & Caley, M. J. (2018). Transferring biodiversity models for conservation: Opportunities and challenges. *Methods in Ecology and Evolution*, *9*(5), 1250-1264.
2	Santini, L., Belmaker, J., Costello, M. J., Pereira, H. M., Rossberg, A. G., Schipper, A. M., ... & Rondinini, C. (2017). Assessing the suitability of diversity metrics to detect biodiversity change. *Biological Conservation*, *213*, 341-350. Hunter, Gibbs and Popescu (2021) Fundamentals of Conservation Biology, 4th ed. Wiley (Ch1, 2, 3) https://tnfd.global/ https://www.pwc.com/us/en/services/esg/library/eu-corporate-sustainability-reporting-directive.html
3	Xie, J., Hu, K., Zhu, M., & Guo, Y. (2020). Data-driven analysis of global research trends in bioacoustics and ecoacoustics from 1991 to 2018. *Ecological Informatics*, *57*, 101068. Johnston, A., Matechou, E., & Dennis, E. B. (2023). Outstanding challenges and future directions for biodiversity monitoring using citizen science data. *Methods in Ecology and Evolution*, *14*(1), 103-116. Oliver, R. Y., Iannarilli, F., Ahumada, J., Fegraus, E., Flores, N., Kays, R., ... & Jetz, W. (2023). Camera trapping expands the view into global biodiversity and its change. *Philosophical Transactions of the Royal Society B*, *378*(1881), 20220232. James, J., Moore, E. M., Naden, R., Aston, B., Bradbeer, S. J., & Stebbing, P. D. (2024). The use of

	environmental DNA for biodiversity monitoring in lentic and lotic ecosystems. *Ecological Solutions and Evidence*, *5*(3), e12361. Optional: Aucone, E., Kirchgeorg, S., Valentini, A., Pellissier, L., Deiner, K., & Mintchev, S. (2023). Drone-assisted collection of environmental DNA from tree branches for biodiversity monitoring. *Science robotics*, *8*(74), eadd5762.
4	Nicholson, E., Rowland, J., Sato, C., Stevenon, S., & Watermeyer, K. (2020). A review of potential metrics to support an ecosystem goal and action targets in the Post-2020 Global Biodiversity Framework. IUCN Report Skidmore, A. K., Coops, N. C., Neinavaz, E., Ali, A., Schaepman, M. E., Paganini, M., ... & Wingate, V. (2021). Priority list of biodiversity metrics to observe from space. *Nature ecology & evolution*, *5*(7), 896-906. Marshall, E., Wintle, B. A., Southwell, D., & Kujala, H. (2020). What are we measuring? A review of metrics used to describe biodiversity in offsets exchanges. *Biological Conservation*, *241*, 108250. Mandle, L., Shields-Estrada, A., Chaplin-Kramer, R., Mitchell, M. G., Bremer, L. L., Gourevitch, J. D., ... & Ricketts, T. H. (2021). Increasing decision relevance of ecosystem service science. *Nature Sustainability*, *4*(2), 161-169.
5	Ch1 Gotelli, N. J. (2008) A Primer of Ecology, 4th edition, Sinauer
6	MacKenzie, D. I., Nichols, J. D., Lachman, G. B., Droege, S., Andrew Royle, J., & Langtimm, C. A. (2002). Estimating site occupancy rates when detection probabilities are less than one. *Ecology*, *83*(8), 2248-2255. MacKenzie, D. I., & Royle, J. A. (2005). Designing occupancy studies: general advice and allocating survey effort. *Journal of applied Ecology*, *42*(6), 1105-1114. Doser, J. W., Finley, A. O., Kéry, M., & Zipkin, E. F. (2022). spOccupancy: An R package for single-species, multi-species, and integrated spatial occupancy models. *Methods in Ecology and Evolution*, *13*(8), 1670-1678. Kellner, K. F., Smith, A. D., Royle, J. A., Kéry, M., Belant, J. L., & Chandler, R. B. (2023). The unmarked R package: Twelve years of advances in occurrence and abundance modelling in ecology. *Methods in Ecology and Evolution*, *14*(6), 1408-1415.
7	MacKenzie, D. I., Nichols, J. D., Hines, J. E., Knutson, M. G., & Franklin, A. B. (2003). Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. *Ecology*, *84*(8), 2200-2207. Doser, J. W., Finley, A. O., Kéry, M., & Zipkin, E. F. (2022). spOccupancy: An R package for single-species, multi-species, and integrated spatial occupancy models. *Methods in Ecology and Evolution*, *13*(8), 1670-1678. Kellner, K. F., Smith, A. D., Royle, J. A., Kéry, M., Belant, J. L., & Chandler, R. B. (2023). The unmarked R package: Twelve years of advances in occurrence and abundance modelling in ecology. *Methods in Ecology and Evolution*, *14*(6), 1408-1415.
8	Fieberg, J., & Ellner, S. P. (2000). When is it meaningful to estimate an extinction probability?. *Ecology*, *81*(7), 2040-2047. Román-Palacios, C., & Wiens, J. J. (2020). Recent responses to climate change reveal the drivers of species extinction and survival. *Proceedings of the National Academy of Sciences*, *117*(8), 4211-4217. Rossberg, A. G., O'Sullivan, J. D., Malysheva, S., & Shnerb, N. M. (2024). A metric for tradable biodiversity credits quantifying impacts on global extinction risk. *Journal of Industrial Ecology*. Miranda, R., Miqueleiz, I., Darwall, W., Sayer, C., Dulvy, N. K., Carpenter, K. E., ... & Böhm, M. (2022). Monitoring extinction risk and threats of the world's fishes based on the Sampled Red List Index. *Reviews in Fish Biology and Fisheries*, *32*(3), 975-991.

9	Tourani, M. (2022). A review of spatial capture–recapture: Ecological insights, limitations, and prospects. *Ecology and Evolution*, *12*(1), e8468. Dupont, G., Royle, J. A., Nawaz, M. A., & Sutherland, C. (2021). Optimal sampling design for spatial capture–recapture. *Ecology*, *102*(3), e03262. Optional: Hastings, R. A., Rutterford, L. A., Freer, J. J., Collins, R. A., Simpson, S. D., & Genner, M. J. (2020). Climate change drives poleward increases and equatorward declines in marine species. *Current Biology*, *30*(8), 1572-1577. Crossley, M. S., Meier, A. R., Baldwin, E. M., Berry, L. L., Crenshaw, L. C., Hartman, G. L., ... & Moran, M. D. (2020). No net insect abundance and diversity declines across US Long Term Ecological Research sites. *Nature Ecology & Evolution*, *4*(10), 1368-1376.
10	Melo-Merino, S. M., Reyes-Bonilla, H., & Lira-Noriega, A. (2020). Ecological niche models and species distribution models in marine environments: A literature review and spatial analysis of evidence. *Ecological Modelling*, *415*, 108837. Crego, R. D., Stabach, J. A., & Connette, G. (2022). Implementation of species distribution models in Google Earth Engine. *Diversity and Distributions*, *28*(5), 904-916. Elith, J., & Leathwick, J. R. (2009). Species distribution models: ecological explanation and prediction across space and time. *Annual review of ecology, evolution, and systematics*, *40*(1), 677-697. Sillero, N., Arenas-Castro, S., Enriquez-Urzelai, U., Vale, C. G., Sousa-Guedes, D., Martínez-Freiría, F., ... & Barbosa, A. M. (2021). Want to model a species niche? A step-by-step guideline on correlative ecological niche modelling. *Ecological Modelling*, *456*, 109671.
11	Santini, L., Benítez-López, A., Maiorano, L., Čengić, M., & Huijbregts, M. A. (2021). Assessing the reliability of species distribution projections in climate change research. *Diversity and Distributions*, *27*(6), 1035-1050. Peterson, A. T., Cobos, M. E., & Jiménez-García, D. (2018). Major challenges for correlational ecological niche model projections to future climate conditions. *Annals of the New York Academy of Sciences*, *1429*(1), 66-77. Zachariah Atwater, D., & Barney, J. N. (2021). Climatic niche shifts in 815 introduced plant species affect their predicted distributions. *Global Ecology and Biogeography*, *30*(8), 1671-1684.
12	Frankham, R. (2022). Evaluation of proposed genetic goals and targets for the Convention on Biological Diversity. *Conservation Genetics*, *23*(5), 865-870. Frankham, R. (2021). Suggested improvements to proposed genetic indicator for CBD. *Conservation Genetics*, *22*(4), 531-532. Willi, Y., Kristensen, T. N., Sgrò, C. M., Weeks, A. R., Ørsted, M., & Hoffmann, A. A. (2022). Conservation genetics as a management tool: The five best-supported paradigms to assist the management of threatened species. *Proceedings of the National Academy of Sciences*, *119*(1), e2105076119. Nielsen, E. S., Beger, M., Henriques, R., & von der Heyden, S. (2020). A comparison of genetic and genomic approaches to represent evolutionary potential in conservation planning. *Biological Conservation*, *251*, 108770.
13	Maxwell, S. L., Cazalis, V., Dudley, N., Hoffmann, M., Rodrigues, A. S., Stolton, S., ... & Watson, J. E. (2020). Area-based conservation in the twenty-first century. *Nature*, *586*(7828), 217-227. Soykan, C. U., & Lewison, R. L. (2015). Using community-level metrics to monitor the effects of marine protected areas on biodiversity. *Conservation Biology*, *29*(3), 775-783. Khorozyan, I. (2020). A comparison of common metrics used to quantify the effectiveness of conservation interventions. *PeerJ*, *8*, e9873. Bracy Knight, K., Seddon, E. S., & Toombs, T. P. (2020). A framework for evaluating biodiversity mitigation metrics. *Ambio*, *49*(6), 1232-1240.

Advanced Methods in Biodiversity Data Analysis II

MS Program in Biodiversity Data Analytics

Department of Ecology, Evolution and Environmental Biology &

School of Professional Studies

Columbia University

Instructor: XX

Teaching Assistant: XX

Locations and Time: XX

Office Hours: XX

BACKGROUND: A biodiversity data revolution is underway, aided by increases in computing capacity, ease of collecting data and advances in statistical models that allow for integrating many types of data. Simultaneously, there is increased scrutiny in the economic sector for biodiversity friendly practices, and a myriad of biodiversity metrics have been developed to evaluate the sustainability of human actions on biodiversity. In this course of the Biodiversity Data Analytics program, we will continue our exploration of biodiversity metrics by investigating higher levels of biological organization, communities and exploring ecosystem services metrics commonly used in conservation decisions.

COURSE DESCRIPTION: This sequel course focuses on understanding the concepts of science-based biodiversity metrics and demonstrates the application of advanced methods in deriving robust and data-backed metrics for communities and ecosystem services. This course introduces students to the field of community ecology and ecosystem services and the use of such concepts in global, national, and regional policies responsible for the conservation of biodiversity (IPBES, CBD). Students will learn how to use various statistical packages in program R to analyze community biodiversity data for estimating metrics such as community habitat occupancy, species richness and diversity. We will delve into composite biodiversity metrics, which are commonly used in the field of econometrics and aim to reduce multi-dimensional data to single metrics (tensor-to-scalar problem). As such, students will also learn how to integrate many sources of data and quantify composite metrics of environmental footprints of various economic development activities (renewable energy, agriculture, forestry). This course will also provide a primer of quantifying ecosystem services from publicly available data sources and explore the practical implementation of ecosystem services models in platform InVEST to support economic development and conservation decisions. Overall, this course will provide students with a strong foundation of statistical models commonly used in biodiversity conservation and the use of such models for deriving metrics and indicators to support decision-making in terrestrial and marine environments.

Learning Objectives

LO1: Understand the importance of using robust and quantifiable biodiversity metrics to address sustainability and conservation targets in relation to various national and international biodiversity policies

LO2: Apply open-source statistical software and public data repositories to analyze and report biodiversity and ecosystem services data

LO3: Analyze and interpret community-level and ecosystem services data, models and scientific results pertaining to biodiversity conservation and decision-making

LO4: Critically evaluate the scientific underpinnings of biodiversity metrics used in specific policies, economic and social contexts

Learning Outcomes

This course will provide students with a foundation of biodiversity metrics and the development and implementation of population and species-level metrics. By the end of this course students will be able to:

1. Understand the types and quality of data used to develop higher-level (community) biodiversity and ecosystem services metrics used in for various certifications of public and private enterprises
2. Develop a strong understanding on ecosystem services and their use for decision-making in international and national contexts and in corporate sustainability
3. Perform statistics, data visualization and model validation with Excel and various packages of the statistical computing language R
4. Communicate original research via professional-style oral and written presentations
5. Apply community or ecosystem service-level metrics to evaluate the feasibility of policy decisions and corporate sustainability
6. Evaluate the strengths and limitations of community-level and ecosystem service-level metrics in relation to their robustness, relevance and data requirements.

Learning materials:

Mittelbach, G. G., & McGill, B. J. (2019). Community ecology. Oxford University Press.

Kareiva, P. et al. (2011). Natural Capital: Theory and Practice of Mapping Ecosystem Services. Oxford University Press

Gotelli, N. J. (2008) A Primer of Ecology, 4th edition, Sinauer

Miscellaneous peer-reviewed articles will be assigned on a weekly basis.

Software:

This course will involve quantitative assessments of a suite of population and species-level biodiversity metrics and the implementation of biodiversity data modeling. We will primarily use programming language R (various packages, such as *unmarked*, *spOccupancy*, *vegan*), along with Excel and ecosystem services modeling software InVEST

Assessment:

Students will be evaluated based on their ability to solve several problem sets in which they will apply quantitative tools to conservation decision-making, class participation via weekly discussion boards and a final project (individual or group project)

- **Participation (20%)**
    - o 10% for participating in lecture discussions and questions
    - o 10% for discussion via Canvas discussion board weekly topics.

- **Applied Biodiversity Metrics Group Assignment (30%).** Frame a conservation problem or regulatory requirement for the private sector and identify a suite of biodiversity metrics that can evaluate the sustainability of management and long-term conservation goals (10% presentation, 20% research paper)
    - o 10% for the group presentation. Each student will present one component of the problem
    - o 20% for the group essay. Each student is expected to lead at least one component of the essay.
- **Community diversity metrics (10%)**. Completion of a problem set focused on evaluating community diversity and richness
- **Community occupancy (10%)**. Completion of a problem set focused on habitat occupancy for communities using environmental DNA or other sources of data
- **Composite metrics lab (10%)**. Completion of a problem set focused on integrating multi-dimensional data into robust and simple biodiversity metrics
- **Ecosystem services valuation and mapping (20%).** Completion of a problem set focused on estimating ecosystem services and tradeoffs between ecosystem services using InVEST

TENTATIVE SCHEDULE OF CLASSES

Wk	Date	Topic	Readings / Case studies
1		Biodiversity metrics and their relation to national and global policies and corporate sustainability	Santini et al. 2017 TNFD, CSRD von Zedlitz 2024 Zhang and Noronha 2023 Burgess et al (in review)
2		Intro to community ecology	Ficetola et al. 2023 Mittelbach and McGill 2019 Ch2, 3
3		Primer of community-level metrics: simple diversity metrics	Gotelli 2008 Ch9 Mittelbach and McGill 2019 Ch2
4		Community-level metrics: community occupancy and richness estimation – includes ***quantitative lab***	Tingley et al. 2020 Devarajan et al. 2020 Doser et. al 2023 Ji et a. 2022 Tingley et al. 2020
5		Landscapes I: Fragmentation and connectivity metrics	Keeley et al. 20221 Fletcher et al. 2023 Mony et al. 2022
6		Landscapes II: Fragmentation and connectivity metrics includes ***quantitative lab***	Da Silva et al. 2021 Fischer et al. 2021 Hesselbarth et al. 2019 Turner et al. 2015
7		Composite metrics: the gap between biodiversity big data in and decision-making needs	Ruaro et al. 2020 Buckland et al. 2005

			Burgess et al. (in review) Crenna et al. 2020
8		Composite metrics: methods for reducing multi-dimensional data to single metrics – includes ***quantitative lab***	Nicholson et al. 2020 Dobbie and Dail 2013 Burgass et al. 2017 Mao et al. 2019
9		Primer of ecosystem services and IPBES	Kareiva et al. 2011 various ch McElwee 2017 Diaz et al. 2015 Ruckelshaus et al. 2020
10		Ecosystem-level metrics: quantifying ecosystem services from remote sensing data	Frank et al. 2012 Grafius et al. 2018 McVittie and Faccioli 2020 Syrbe and Walz 2012
11		Ecosystem-level metrics: trade-offs between ecosystem services using InVEST	InVEST website @Stanford Caro et al. 2020 Tallis and Polasky 2011 Tallis et al. 2012
12		Ecosystem-level metrics: trade-offs between ecosystem services using InVEST – includes ***quantitative lab***	Tallis et al. 2021 Nelson et al. 2009 Karp et al. 2015
13		Evaluating performance of management and conservation actions using biodiversity metrics	Blattert et al. 2017 Cipullo 2016 Sobkowiak 2023 Martinez-Jaregui et al. 2021
14		Course wrap-up and Student presentations	
15		Student presentations	

READINGS

Week	Readings
1	Santini, L., Belmaker, J., Costello, M. J., Pereira, H. M., Rossberg, A. G., Schipper, A. M., ... & Rondinini, C. (2017). Assessing the suitability of diversity metrics to detect biodiversity change. *Biological Conservation*, *213*, 341-350. von Zedlitz, G. (2023). Mind the gap?! The current state of biodiversity reporting. TRR 266 Accounting for Transparency Working Paper Series No. 130, SAFE Working Paper No. 95, https://ssrn.com/abstract=4538287 or http://dx.doi.org/10.2139/ssrn.4538287 Zhang, R., & Noronha, C. (2023). Biodiversity initiatives: theoretical and practical intersections among TNFD, biodiversity credits, and ESG reporting. In *Handbook of Research on Bioeconomy and Economic Ecosystems* (pp. 39-54). IGI Global.
2	Ficetola, G. F., & Taberlet, P. (2023). Towards exhaustive community ecology via DNA metabarcoding. *Molecular Ecology*, *32*(23), 6320-6329. Ch2 and 3 in Mittelbach, G. G., & McGill, B. J. (2019). Community ecology. Oxford University Press.
3	Ch 9 in Gotelli, N. J. (2008) A Primer of Ecology, 4th edition, Sinauer Ch2 in Mittelbach, G. G., & McGill, B. J. (2019). Community ecology. Oxford University Press.

4	Tingley, M. W., Nadeau, C. P., & Sandor, M. E. (2020). Multi-species occupancy models as robust estimators of community richness. *Methods in Ecology and Evolution*, *11*(5), 633-642. Devarajan, K., Morelli, T. L., & Tenan, S. (2020). Multi-species occupancy models: Review, roadmap, and recommendations. *Ecography*, *43*(11), 1612-1624. Doser, J. W., Finley, A. O., Kéry, M., & Zipkin, E. F. (2022). spOccupancy: An R package for single-species, multi-species, and integrated spatial occupancy models. *Methods in Ecology and Evolution*, *13*(8), 1670-1678. Brodie, B. S., Popescu, V. D., Iosif, R., Ciocanea, C., Manolache, S., Vanau, G., ... & Rozylowicz, L. (2019). Non-lethal monitoring of longicorn beetle communities using generic pheromone lures and occupancy models. *Ecological Indicators*, *101*, 330-340. Ji, Y., Baker, C. C., Popescu, V. D., Wang, J., Wu, C., Wang, Z., ... & Yu, D. W. (2022). Measuring protected-area effectiveness using vertebrate distributions from leech iDNA. *Nature Communications*, *13*(1), 1555.
5	Keeley, A. T., Beier, P., & Jenness, J. S. (2021). Connectivity metrics for conservation planning and monitoring. *Biological Conservation*, *255*, 109008. Fletcher Jr, R. J., Betts, M. G., Damschen, E. I., Hefley, T. J., Hightower, J., Smith, T. A., ... & Haddad, N. M. (2023). Addressing the problem of scale that emerges with habitat fragmentation. *Global Ecology and Biogeography*, *32*(6), 828-841. Mony, C., Uroy, L., Khalfallah, F., Haddad, N., & Vandenkoornhuyse, P. (2022). Landscape connectivity for the invisibles. *Ecography*, *2022*(8), e06041.
6	da Silva, A. L., de Nunes, A. J. N., Marques, M. L., Ribeiro, A. Í., & Longo, R. M. (2021). Assessing the fragility of forest remnants by using landscape metrics. Comparison between river basins in Brazil and Portugal. *Environmental Monitoring and Assessment*, *193*(4), 172. Fischer, R., Taubert, F., Müller, M. S., Groeneveld, J., Lehmann, S., Wiegand, T., & Huth, A. (2021). Accelerated forest fragmentation leads to critical increase in tropical forest edge area. *Science advances*, *7*(37), eabg7012. Hesselbarth, M. H., Sciaini, M., With, K. A., Wiegand, K., & Nowosad, J. (2019). landscapemetrics: an open-source R tool to calculate landscape metrics. *Ecography*, *42*(10), 1648-1657. Turner, M. G., Gardner, R. H., Turner, M. G., & Gardner, R. H. (2015). Landscape metrics. *Landscape ecology in theory and practice: Pattern and process*, 97-142.
7	Buckland, S. T., Magurran, A. E., Green, R. E., & Fewster, R. M. (2005). Monitoring change in biodiversity through composite indices. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *360*(1454), 243-254. Burgess, N., Ali, N., Bedford, J., Bhola, N., Brooks, S., Cierna, A., ... & Butchart, S. (2024). Global metrics for terrestrial biodiversity. In Review Crenna, E., Marques, A., La Notte, A., & Sala, S. (2020). Biodiversity assessment of value chains: state of the art and emerging challenges. *Environmental Science & Technology*, *54*(16), 9715-9728. Ruaro, R., Gubiani, E. A., Hughes, R. M., & Mormul, R. P. (2020). Global trends and challenges in multimetric indices of biological condition. *Ecological Indicators*, *110*, 105862.
8	Nicholson, E., Rowland, J., Sato, C., Stevenon, S., & Watermeyer, K. (2020). A review of potential metrics to support an ecosystem goal and action targets in the Post-2020 Global Biodiversity Framework. IUCN Report Dobbie, M. J., & Dail, D. (2013). Robustness and sensitivity of weighting and aggregation in constructing composite indices. *Ecological Indicators*, *29*, 270-277. Burgass, M. J., Halpern, B. S., Nicholson, E., & Milner-Gulland, E. J. (2017). Navigating uncertainty in environmental composite indicators. *Ecological Indicators*, *75*, 268-278.

	Mao, F., Zhao, X., Ma, P., Chi, S., Richards, K., Clark, J., ... & Krause, S. (2019). Developing composite indicators for ecological water quality assessment based on network interactions and expert judgment. *Environmental Modelling & Software*, *115*, 51-62.
9	McElwee, P. (2017). The metrics of making ecosystem services. *Environment and Society*, *8*(1), 96-124. Kareiva, P. et al. (2011). Natural Capital: Theory and Practice of Mapping Ecosystem Services. Oxford University Press Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., ... & Zlatanova, D. (2015). The IPBES Conceptual Framework—connecting nature and people. *Current opinion in environmental sustainability*, *14*, 1-16. Ruckelshaus, M. H., Jackson, S. T., Mooney, H. A., Jacobs, K. L., Kassam, K. A. S., Arroyo, M. T., ... & Ouyang, Z. (2020). The IPBES global assessment: Pathways to action. *Trends in Ecology & Evolution*, *35*(5), 407-414.
10	Frank, S., Fürst, C., Koschke, L., & Makeschin, F. (2012). A contribution towards a transfer of the ecosystem service concept to landscape planning using landscape metrics. *Ecological indicators*, *21*, 30-38. Grafius, D. R., Corstanje, R., & Harris, J. A. (2018). Linking ecosystem services, urban form and green space configuration using multivariate landscape metric analysis. *Landscape ecology*, *33*, 557-573. McVittie, A., & Faccioli, M. (2020). Biodiversity and ecosystem services net gain assessment: A comparison of metrics. *Ecosystem Services*, *44*, 101145. Syrbe, R. U., & Walz, U. (2012). Spatial indicators for the assessment of ecosystem services: Providing, benefiting and connecting areas and landscape metrics. *Ecological indicators*, *21*, 80-88.
11	https://naturalcapitalproject.stanford.edu/software/invest Caro, C., Marques, J. C., Cunha, P. P., & Teixeira, Z. (2020). Ecosystem services as a resilience descriptor in habitat risk assessment using the InVEST model. *Ecological Indicators*, *115*, 106426. Tallis, H., & Polasky, S. (2011). Assessing multiple ecosystem services: an integrated tool for the real world. *Natural capital: theory and practice of mapping ecosystem services*, 34-50. Tallis, H., Mooney, H., Andelman, S., Balvanera, P., Cramer, W., Karp, D., ... & Walz, A. (2012). A global system for monitoring ecosystem service change. *Bioscience*, *62*(11), 977-986.
12	Tallis, H., Fargione, J., Game, E., McDonald, R., Baumgarten, L., Bhagabati, N., ... & Possingham, H. P. (2021). Prioritizing actions: spatial action maps for conservation. *Annals of the New York Academy of Sciences*, *1505*(1), 118-141. Nelson, E., Mendoza, G., Regetz, J., Polasky, S., Tallis, H., Cameron, D., ... & Shaw, M. (2009). Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Frontiers in Ecology and the Environment*, *7*(1), 4-11. Karp, D. S., Tallis, H., Sachse, R., Halpern, B., Thonicke, K., Cramer, W., ... & Wolny, S. (2015). National indicators for observing ecosystem service change. *Global Environmental Change*, *35*, 12-21.
13	Blattert, C., Lemm, R., Thees, O., Lexer, M. J., & Hanewinkel, M. (2017). Management of ecosystem services in mountain forests: Review of indicators and value functions for model based multi-criteria decision analysis. *Ecological Indicators*, *79*, 391-409. Cipullo, N. (2016). Biodiversity Indicators: the accounting point of view. *Procedia Economics and Finance*, *39*, 539-544. Sobkowiak, M. (2023). The making of imperfect indicators for biodiversity: A case study of UK biodiversity performance measurement. *Business Strategy and the Environment*, *32*, 336-352.

	Martínez-Jauregui, M., Touza, J., White, P. C., & Solino, M. (2021). Choice of biodiversity indicators may affect societal support for conservation programs. *Ecological Indicators*, *121*, 107203.

Data in Nature Conservation and Environmental Management Decisions

MS Program in Biodiversity Data Analytics

Department of Ecology, Evolution and Environmental Biology &

School of Professional Studies

Columbia University

Instructor: XX

Teaching Assistant: XX

Locations and Time: XX

Office Hours: XX

BACKGROUND: At the heart of applying conservation science to real world problems is making good decisions when resources and knowledge are insufficient. Deciding what to do, and where and when to do it, as at the heart of conservation. In this course of the Biodiversity Data Analytics program, we consider how to make good conservation decisions.

COURSE DESCRIPTION: This course focuses on understanding the concepts of conservation decision making and demonstrates the application of critical thinking techniques to decompose and articulate management or conservation problems. This course introduces students to the field of conservation decision science along with the global, national, regional policies responsible for the conservation of biodiversity in the US. The course focuses on real decisions faced by conservation agencies, managers, and policy makers, how to formulate decision science problems and how to solve them. Students will learn how to apply decision analysis through the application of PrOACT and explore the key frameworks of decision science: structured decision making; systematic conservation planning, priority threat management and adaptive management as well as key decision science tools including consequence tables, multi-criteria decision analysis, cost-effectiveness analysis and expert elicitation. Students will examine the policy context in which conservation decisions are made with respect to the protection of land and sea for biodiversity conservation, the protection and recovery of endangered species and protection of the rights of indigenous peoples, and how these decisions affect private and public sectors.

Learning Objectives

LO1: Identify the tools of conservation decision making in global and national contexts

LO2: Recognize the links between decision frameworks, policy and real-world outcomes

LO3: Apply analytical and strategic tools to real and complex conservation problems

LO4: Analyze complex decision-making problems through existing frameworks

LO5: Evaluate the importance and implications of systematic conservation planning and multi-criteria decision-analysis and risk assessments

Learning Outcomes

This course will provide students with a foundation in the field of conservation decision science and the underlying policies which guide conservation. By the end of this course students will be able to:

1. Identify common decision-classes and the types of analyses that might be required.
2. Understand common decision support frameworks: systematic conservation planning, priority threat management, project prioritization protocol and adaptive management, articulate the types of problems they may be useful for, and the basic steps to application.
3. Apply the following decision-support tools to a problem: structured expert elicitation, Delphi technique, portfolio optimization, multi-criteria decision analysis, cost-effectiveness analysis, systematic planning.
4. Apply and demonstrate how to consider values, uncertainty and risk attitudes in decisions.
5. Formulate and solve a conservation decision problem using decision analysis via the PrOACT framework.
6. Critically evaluate the strengths and limitations of theories, tools and frameworks introduced during the course.

Learning materials:

Gregory, R., L. Failing, M. Harstone, G. Long, T. McDaniels and D. Ohlson. 2012. Structured decision making: A practical guide to environmental management choices. Wiley-Blackwell: Hoboken, NJ. Available online through the Columbia University Library

Gray, S., M. Paolisso, R. Jordan and S. Gray. Environmental Modeling with Stakeholders: Theory, Methods and Applications. Spinger. Available online through the Columbia University Library

Miscellaneous peer-reviewed articles will be assigned on a weekly basis.

Assessment:

Students will be evaluated based on their ability to solve several problem sets in which they will apply quantitative tools to conservation decision-making, class participation via weekly discussion boards and a final project (individual or group project)

- **Participation (35%)**
    - o 10% for participating in lecture discussions and questions
    - o 25% for discussion via Canvas discussion board weekly topics.
- **Decision Science Group Assignment (35%).** Frame a conservation problem as a decision science problem following the PrOACT process (10% presentation, 25% research paper)
    - o 10% for the group presentation. Each student will present one component of the problem
    - o 25% for the group essay. Each student is expected to lead at least one component of the essay.
- **Systematic Conservation Planning lab (10%)**. Completion of decision problem using the Systematic Conservation Planning tool PrioritizR or Zonation.
- **Optimization / Trade-offs lab (10%)**. Completion of a multi-objective decision-problem using an optimization algorithm such as linear integer programming, Excel or RobOff.

- Designing a **protocol for eliciting stakeholder opinion** and integration into decision making **(10%)**

TENTATIVE SCHEDULE OF CLASSES

Wk	Date	Topic	Readings / Case studies
1		Course Introduction / State of global biodiversity / Why are we failing to protect biodiversity?	Soulé 1985 Steffan et al 2015 Game et al 2014 Ceballos et al 2020 WWF Living Planet Reports (Optional) 2020, 2022, 2024
2		Current approaches to assessing decline and informing decisions / Introduction to decision science	Martin et al 2012 Bottrill et al 2008 Hemming et al 2022 Possingham 2001 Smith 2020
3		Structured Decision-Making (SDM)	Gregory et al. Ch4 Gregory et al. Ch5 Smith 2020
4		Formulating conservation problems as decision problems I: Problem formulation, objectives, attributes and actions	Gregory and Keeney 2002 Gregory et al. Ch5 Gregory et al. Ch6 Martin & Game Video
5		Formulating conservation problems as decision problems II: Estimating consequences and quantifying uncertainty	Martin et al. 2012 Hemming et al. 2018
6		Making trade- offs / Judgements under uncertainty	Gregory et al. 2012 Ch9 Nelson et al. 2009
7		Conservation Decision Science Resource allocation I: Resource Allocation Problems / Prioritization / Portfolios	Lyons 2020 Wilson 2009 Joseph et al 2009 Carwardine et al 2019
8		Conservation Decision Science Resource allocation II: Decision Frameworks	Lyons 2020 Carwardine et al 2019 Martin et al 2018 McDonald-Madden et al. 2011
9		Conservation Decision Science Resource allocation, portfolios and prioritization III: Systematic Conservation Planning	Margules & Pressey 2000 Carwardine et al 2015 Davidson & Dulvy 2017 Pouzols et al. 2014
10		Conservation Decision Science Resource allocation, portfolios and prioritization IV: Systematic Conservation Planning (contd.)	Moilanen et al. 2022 Virtanen et al. 2022 Popescu et al. 2020
11		Decision Making and Working with Stakeholders	Gray et al 2016 Ch3, Ch4 and Ch5 Gregory et al. 2008

12		Structured Decision Making as Adaptive Resource Management (ARM)	Smith 2020 Ch 1&2 Williams et al. 2008 Nichols and Williams 2006 Runge et al. 2020
13		Conflict Resolution and Knowledge Acquisition through ARM	Butler et al. 2015 Butler et al. 2019
14		Course wrap-up and Student presentations	
15		Student presentations	

READINGS

Week	Readings
1	Soule, E. M. 1985. What Is Conservation Biology? BioScience **35**:727-734. Steffen, W., W. Broadgate, L. Deutsch, O. Gaffney, and C. Ludwig. 2015. The trajectory of the Anthropocene: The Great Acceleration. The Anthropocene Review 2:81-98. Ceballos, G., P. R. Ehrlich, and P. H. Raven. 2020. Vertebrates on the brink as indicators of biological annihilation and the sixth mass extinction. Proceedings of the National Academy of Sciences:201922686. Game, E. T., Meijaard, E., Sheil, D. & McDonald-Madden, E. 2014. Conservation in a Wicked Complex World; Challenges and Solutions. Conservation Letters 7, 271-277, doi:10.1111/conl.12050. Optional: WWF. 2018. Living Planet Report: Aiming Higher. Grooten, M. and Almond, R.E.A. (Eds). Gland, Switzerland. WWF. 2020. Living Planet Report Canada.
2	Bottrill, M. C., L. N. Joseph, J. Carwardine, M. Bode, C. Cook, E. T. Game, H. Grantham, S. Kark, S. Linke, E. McDonald-Madden, R. L. Pressey, S. Walker, K. A. Wilson, and H. P. Possingham. 2008. Is conservation triage just smart decision making? Trends in Ecology & Evolution 23:649-654. Martin, T. G., S. Nally, A. Burbidge, S. Arnall, S. T. Garnett, M. W. Hayward, L. Lumsden, P. Menkhorst, E. McDonald-Madden, and H. P. Possingham. 2012. Acting fast helps avoid extinction. Conservation Letters 5:274-280. Hemming et al 2022. An introduction to decision science for conservation. Conservation Biology. 36(1): e13868 Possingham, H. P., S. J. Andelman, B. R. Noon, S. Trombulak, and H. R. Pulliam. 2001. Making smart conservation decisions. 2001. Pages 225-244 in M. E. Soule and G. H. Orians, editors. Research priorities for nature conservation. Island Press, Washington DC. Smith, D.R., 2020. Introduction to Structuring Decisions. Structured Decision Making: Case Studies in Natural Resource Management 15.
3	Chapter 4: Understanding objectives. Gregory, R., Failing, L., Harstone, M., Long, G., McDaniels, T., Ohlson, D., 2012. Structured decision making: a practical guide to environmental management choices. John Wiley & Sons. Hemming et al 2022. An introduction to decision science for conservation. Conservation Biology. 36(1): e13868 Chapter 5: Identifying performance measures. Gregory, R., Failing, L., Harstone, M., Long, G., McDaniels, T., Ohlson, D., 2012. Structured decision making: a practical guide to environmental management choices. John Wiley & Sons. Smith, D.R., 2020. Introduction to Structuring Decisions. Structured Decision Making: Case

	Studies in Natural Resource Management 15.
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Capstone Course

MS Program in Biodiversity Data Analytics

Department of Ecology, Evolution and Environmental Biology &

School of Professional Studies

Columbia University

Instructor: XX

Teaching Assistant: XX

Locations and Time: XX

Office Hours: XX

COURSE DESCRIPTION: The capstone course is the culminating academic experience for students where they are afforded the opportunity to tackle a complex real-world biodiversity decision-making problem using data analytics for a sponsoring organization. Working in small teams while being mentored by a program faculty member, students synthesize, integrate, and apply core knowledge, concepts, and frameworks acquired through the program and practice the hands-on skills they have developed. Throughout the semester, student project teams interact with the sponsoring organizations as virtual consultants, scoping the problem, acquiring the data, conducting analyses, and presenting their findings and recommendations to the project sponsor.

LEARNING OBJECTIVES

After completing this course, you will be able to:

LO1: Recognize potential challenges to and opportunities for an organization's sustainability commitments with respect to biodiversity and ecosystem services

LO2: Identify analytical tools, methods and metrics that are appropriate to address different types of biodiversity conservation problems in a variety of contexts.

LO3: Source, store, and model the internal and external data needed to answer questions and produce robust biodiversity metrics.

LO4: Implement adaptive management principles to incorporate feedback in data-driven conservation decision making.

LO5: Evaluate and communicate the impact of data-driven biodiversity analytics to meeting current environmental challenges.

ASSESSMENT: Grades for this course will be assessed based on a series of deliverables that take the project from start to finish. The capstone project will be implemented during the last semester of the program, but the courses that you have taken prior to this one should put you in an excellent position to conceive and execute the project. From the very beginning of your time in the program, you will receive guidance and encouragement to prepare you for embarking on this project. Faculty teaching in the program will do their best to see that you already have a well-formed idea about projects prior to taking this course. We will provide you with a suggested set of projects to choose from and sponsoring organizations to work with, although students may want to mold their projects to their specific interests, organizations and contexts.

The required deliverables, percentage of grade, and timetable for completion are as follows:

Week 2 - Project proposal (15%): The proposal will identify the goal of the project, cite relevant literature, and sketch the design of the research, including theory, data, and methods to be employed.

Week 5 - Progress report (10%): The progress report is aimed at ensuring that the Capstone project is on track; the deliverable for the progress report will consist of: identifying data sources and metrics used to tackle the problem at hand, critical evaluation of why the selected data, metrics and methods are appropriate for the goal of the project and a summary of the discussions to date with the sponsoring organization

Week 9 - Preliminary draft of project write-up (15%): The draft write-up will expand on the text of the proposal, discussing in more detail the analysis and preliminary findings. It will discuss how preliminary findings are consistent or not with expectations. It will conclude with a discussion of work that remains to be done

Week 11 - Presentation (15%): Each team will present their projects to the class, identifying what audience role they want the class to take on (e.g., candidate seeking office, a lobbying group pursuing a legislative outcome, a social movement organization developing a strategic plan, a media outlet engaging in investigative reporting). The presentation will involve a slide deck that will be shared in advance with the class. The length of the presentation will depend on the number of teams, but teams should plan to communicate as much information as quickly and effectively as possible in a very short amount of time.

Week 12 - Final write-up (35%): This final draft will incorporate feedback received from the preliminary draft and during the presentations. An appendix to the document will indicate how the team used the feedback to improve the project. The final draft will be in "white paper" format, but will be more academically oriented, following conventions in the ecology/conservation discipline with regard to data presentation, citations, etc. The write-up will include a one-page executive summary of the project, its findings, and solutions (if any) that are justified by the work.

Class participation will account for the remaining **10%** of the course grade.

TENTATIVE SCHEDULE OF CLASSES

Each week will include a mixture of lectures focused on scientific writing and presentation, data visualization and peer learning. Readings will be light for this class because our focus is on original research and writing, but all readings must be completed before each class. Our main texts will be The Scientist's Guide to Writing by Stephen Heard (Princeton University Press, 2022) and Writing Effective Ecological Reports by Mike Dean (Pelagic Publishing, 2021).

Module/Week	Topics and Activities	Overview	Assignments

1	Overview of your project and the class	This week provides an overview of your Capstone Project and expectations for the course. We will examine and deconstruct your challenge and begin to formulate initial impressions and ideas. We will discuss learning objectives and assignments.	Identify the challenge and outline the boundaries of the problem tackled; formulate potential questions for sponsor
2	Understand the problem from multiple perspectives; define opportunities and challenges	This week delves into defining the goals and objectives of the project, understanding the biodiversity conservation challenge from multiple perspectives (economic, social, ecological). You will have the opportunity to discuss the project with the sponsor and participate in Q&A for understanding and clarification.	**Project outline** Teams present their preliminary objectives and questions
3	Biodiversity (and other) metrics and data analysis methodologies	This week delves into the data and methods required to support the development of relevant metrics used to address the sponsor organization problem We will explore and examine the data along a number of dimensions, including statistical description, quality, completeness and relevance	Evaluation of available data and metrics; does the data support the research question?
4	Storyboard and key messages; define final data and metrics	This week will build on the previous data and metrics session and further refine the questions and outline the key message, in line with the sponsor organization goals.	Final data and metrics and key messages (storyboard)
5	Peer review	This week continues the data analysis and methods, and includes with peer review of data, analytical methods and feasibility of the proposal and potential solutions	**Progress report** Each team presents their preliminary results and explores data gaps, challenges and opportunities with a peer group
6	Sponsor organization feedback	Your team will work on a short presentation for your sponsor(s) and request feedback and suggestions	Work on presentation Midterm Peer Evaluation

7	Recap / discussion of sponsor feedback (apply adaptive management principles)	In this session we will review and critique the sponsor and use adaptive management principles to finalize the You will continue to develop your plan, update your schedule of deliverables, and finalize the analyses and metrics	Update progress report
8	Work your plan, communicate with your sponsor, build your deliverable	We will continue to work your plan, update your schedule of deliverables if necessary, and prepare a communication update to your sponsor(s).	Update progress report
9	Work your plan, communicate with your sponsor, build your deliverable	We will continue to work your plan, update your schedule of deliverables if necessary, and prepare a communication update to your sponsor(s).	**Final draft / Proof-of-concept**
10	Presentation rehearsal	This week focuses on the presentation that you will deliver to the sponsor. We will conduct a full run-through of your presentation for timing and transitions.	Full presentation rehearsal
11	Presentation to sponsor	Your team will execute the presentation for your sponsor(s).	**Project presentation**
12	Course wrap-up; final check on project and deliverables	In the final session we will critique your final presentation, review the final projects, and discuss lessons learned.	**Final write-up** Final peer evaluation

Report of the Elections Commission to the University Senate

April 3, 2025

EXECUTIVE SUMMARY

On March 29, 2025, the Elections Commission received a challenge to the candidacy of Professor Jeanine D'Armiento for chair of the Senate Executive Committee. We have studied this challenge at length with the help of many excellent comments from Senators. We have decided that the bylaw provision under which the challenge was brought is ambiguous and now ask the Senate to assist the Elections Commission in our interpretation of the ambiguity. After this has occurred, we will rule expeditiously on the challenge.

In this document, we provide Senators with an explanation of how we came to this decision and information that may be helpful to them as they consider what to do.

1. **Note of thanks**

We begin by thanking all the Columbians, most of them Senators, who responded to our request for comments. We have been overwhelmed by both the volume of the comments and by their quality. Many ideas and viewpoints that we would never have thought of were included in these letters. In the discussion below we will sometimes quote and sometimes paraphrase the comments, but we will probably not reproduce the richness of the originals.

While we appreciate every comment we received, we obviously cannot make everyone happy with our recommendation. Every comment we received, though, has made us more aware of how important our decision is and how much it matters to many people. We have also learned how valuable the Senate and its tradition of shared governance are. By taking seriously all the divergent information we have received, we hope to show why these traditions need to be protected and nurtured.

In recognition of the current atmosphere of the university, we will not use the names of individuals unless necessary for a particular argument we are making.

2. **Basic facts**

A. Bylaw history

The bylaws under which the Senate operated before 2020 did not contain a term limit for the chair of the Executive Committee. Under the previous bylaws, at least two chairs were elected far more than three times. On December 11, 2020, however, the Senate adopted a large package of bylaw revisions that included the following sentence: "No person shall be elected as chair of the Executive Committee more than three consecutive times." It also included exceptions for chairs who served certain unexpired terms and other special circumstances. At its February 7, 2025, meeting, the Senate adopted amended language to add vice chairs to the coverage of the election limitation but the change did not affect the meaning of this provision for chairs. We call this the three-election limit. Notice that the provision is about elections, not terms.

B. Professor D'Armiento

Professor Jeanine D'Armiento was first elected chair in a proper election in November 2019.[1] She was subsequently reelected in spring 2021 and spring 2023. She filed for reelection in March 2025 with proper documentation for a preliminary nomination.

C. The challenge

On March 29, 2025, a Senator filed a timely challenge to Professor D'Armiento's candidacy on the grounds that her election would violate the three-election limit.

D. What we have done

After receiving the challenge, we notified Professor D'Armiento and asked her for a response; similarly we asked the challenger for a more detailed document. Because there were no basic facts in dispute and both Professor D'Armiento and the challenger are busy individuals during a tumultuous week, we asked both whether they would waive their right to a hearing. They agreed. The Elections Commission met on Tuesday, April 1 and decided that we would solicit comments from the Senate, read those comments, and reconvene on Thursday, April 3 to deliberate. We did so, and produced this statement.

D. The question we must answer

Because none of the basic facts are in dispute, the question we must answer in order to decide whether to sustain or reject the challenge is the following: does the election in November 2019 of the incumbent in December 2020 count against the three-election limit that was adopted after that election? We call this the "key question."

[1] In September 2019, the Tenured Caucus engaged in an exercise that it called an election and Professor D'Armiento won. The loser appealed to the Elections Commission, which voided the election by the Tenured Caucus because the then-existing bylaws said that the full Senate, not the Tenured Caucus, elected the chair. The Elections Commission ordered a new election, this time by the entire Senate, and Professor D'Armiento won that election in November 2019. Since the September exercise in the Tenured Caucus was both unconstitutional and voided, we do not count that as an election, and neither did the challenger.

3. **Principles of Interpretation**

Section 1a of the Senate bylaw states that "Subject to the provisions of these bylaws, the Senate shall establish its own rules of procedure." The Elections Commission is open to considering many different principles of interpretation, and the Senate is not bound by a particular method of interpretation. To address the challenge at hand, we have chosen Robert's Rules of Order because it is designed for lay people like most of us. Where other methods of interpretation might have provided different outcomes, we have tried to describe them so that each Senator may decide for themselves.

The relevant section of Robert's Rules of Order (12th edition) is in section 56:68, quoted below:

"1) *Each society decides for itself the meaning of its bylaws*. When the meaning is clear, however, the society, even by a unanimous vote, cannot change that meaning except by amending its bylaws. An ambiguity must exist before there is any occasion for interpretation. If a bylaw is ambiguous, it must be interpreted, if possible, in harmony with the other bylaws. The interpretation should be in harmony with the intention of the society at the time the bylaw was adopted, as far as this can be determined. Again, intent plays no role unless the meaning is unclear or uncertain, but where an ambiguity exists, a majority vote is all that is required to decide the question. The ambiguous or doubtful expression should be amended as soon as practicable."

Italics in the original.

4. **Arguments for upholding the challenge and our comments**

As mentioned above, we received many comments, and we can categorize them as follows:

A. *"It's obvious."* A number of comments argued that the "obvious" answer to the key question was yes or that the plain reading of the three-election rule vote could only lead to that conclusion. We do not accept this argument. The argument implies that no reasonable or conscientious people would ever answer the key question in a different way. The comments we have received as well as the history of Senate deliberation this year give us abundant evidence that reasonable and conscientious people can answer the key question differently.

B. *Interpretation of the 2019 election is a technicality*. Some letters said that we should not consider answering "no" to the key question because it was a technicality. We're not sure what they mean by "technicality." If they mean that the key question applied only to a rare instance, then we cannot accept this conclusion because the rare instance is the instance we have to deal with.

C.*The 22nd amendment.* The 22nd amendment (the two term limit on US presidents) explicitly states that the incumbent at a particular time is exempt. Under the principles of interpretation governing federal courts, this fact implies by analogy that the answer to the key question must be yes, according to experts we have communicated with. Thus if interpretation of the Senate bylaws follows federal court principles, the answer to the key question must be yes. However, as we have noted, the Senate is not bound to follow those principles, although it may choose to do so.

D. *RRO 57:16 "Time at Which a Bylaw Amendment Takes Effect."* Section 57 of RRO is about amendments to bylaws. Section 57:16 states in full:

"Amendments to the article on officers may raise difficulties in relation to the time at which adopted changes take place unless special care is taken. A society can, for example, amend its bylaws so as to affect the emoluments of the officers already elected, or even abolish an office, and if it is desired that the amendment should not affect officers already elected a motion so specifying should be adopted before voting on the amendment; or the motion to amend can have added to it the proviso that it shall not officers already elected. There is virtually a contract between a society and its officers, and while to some extent action can be taken by either party to modify or terminate the contract, such action must be taken with reasonable consideration of the other party."

Some people interpret this section as saying that in the absence of explicit language to the contrary, any bylaw change affecting the chair of the Executive Committee affects the incumbent. Because the statement specifies that *if* a society does not want an amendment to apply to current officers, it should explicitly say so, a logical conclusion is that when no such limitation is specified, the default would be to apply it to current officers. In the absence of a special carve out, the 2020 amendment to the bylaws affected Professor D'Armiento. The inference from this is that the answer to the key question is yes.

Other people may interpret this section differently in two ways. First, this is a section about <u>writing</u> amendments to bylaws, not interpreting them. Questions about interpretation are in section 56, not 57, and if RRO wanted to make this a rule or admonition about interpreting rather than writing, the authors could have placed it in section 56 explicitly as a statement about interpretation. As the first and last sentences make clear, the message of this section could be summarized as "If you amend bylaws about officers, be very careful"—good advice, as we now know. But not advice about interpretation.

The second area where a different reading is possible is in the jump from the second sentence of the paragraph above beginning "Some people…" ("In the absence…Professor D'Armiento") to the third ("The inference..yes"). The section says that the incumbent is affected, but it does not say how. Proponents of a no answer to the key question do not argue that Professor D'Armiento should be exempted from the three-term limit and permitted to serve eternally, only that elections prior to December 2020 should not be counted. In this view, even if this section is about interpretation, it is still not about the key question.

E. *Purposivism.* This argument focuses on the intent or purpose behind the bylaw. If the Senate, when voting in 2020, believed that the three-term limit was important, then that value should be held strong and there should be no exceptions. This argument may be contradicted by other arguments offered that suggest that the Senate in 2020 had an aversion to retroactively applying rules or limits, as described in Section 5C below.

5. **Arguments for upholding the candidacy and our comments**

A. *It's obvious.* Some comments have stated that the negative answer to the key question is "obvious." Our answer to this argument is the same as our answer to the opposite claim that the answer is obviously positive. Many reasonable and conscientious people do not believe that the answer is negative, either.

B. *The three-election limit is a technicality.* We reject this argument. The three-term limit was deliberately added to the bylaws because many Senators felt that long Chair tenures were deleterious to the Senate's operation.

C. *The retroactive argument.* Many comments argue that the answer to the key question should be no, because a yes answer would make the three-election limit retroactive legislation, and therefore unconscionable. In an interpretation framework, this argument's premise is a reasonable one: we should not interpret the three-election limit in a way that would force it to violate a basic tenet of fair legislation. It is possible, however, to wonder how strong the prohibition on retroactivity actually is.

Two variants of the retroactivity argument, however, do not suffer from this problem. One variant points to Senate actions dealing with the Rules of University Conduct where the Senate took very strong positions against punishment of students based on violations of rules that were not in force when the alleged infractions occurred. This argument is that whether the prohibition on retroactive legislation is universal or not, it is a very important consideration for the body whose intentions we are trying to understand, the University Senate. However, this argument addresses punishment, and a term limit is not a punishment.

Another variant of the retroactivity argument points to the exceptions that the 2020 bylaws did make for terms that did not commence with elections, and argues that these demonstrate an aversion to retroactivity on the part of the Senate at that time. Specifically, "…a reasonable case could be made to argue that the 2020 revisions should not be applied retroactively to terms already served by a Chair who was elected to serve their term without such term limitations prior to the revision of the by-laws. In other words, just like 'a person who held the office of chair for less than one year of a term to which some other person was elected,' a term served *before* the introduction of term limits for Chairs should give such a Chair holder the opportunity to serve a maximum of four consecutive times. The retroactive application of term limits to terms already served under different rules (namely no term limits) seems punitive in light of other exceptions made for cases in which one year between consecutive terms has lapsed or a person is granted to be elected for a fourth consecutive year if that person served less than one year of a term to which some other person was previously elected."

D. *The actions of the Structure and Operations Committee (S&O).* This argument is that the Structure and Operations Committee has officially adopted the negative answer to the key question. We do not believe that this is the case. More detail on this is in section 6B below and points to the ambiguity of the matter.

E. *Ambiguous, but let voters vote*. A number of comments stated they believed that the three-term limit as written was ambiguous, but that the ambiguity should be resolved by placing Professor D'Armiento's name on the ballot and letting voters decide for themselves whether or not she was eligible in their voting behavior. We reject this argument for two reasons. First, it misinterprets the intent of the term limit in the bylaws. This restriction is explicitly paternalistic: the Senate placed this in the bylaws to prevent future voters from voting for chair candidates who had served too long, in the opinion of the 2019 Senate. This Senate explicitly rejected the argument that future Senators on their own would unerringly reject candidates who had served too long—and the 2019 Senate rejected this argument because they had witnessed Tenured Caucuses that had in fact repeatedly chosen chairs who had served too long in the opinion of the 2019 Senate. We discuss this issue in greater detail in section 7D below.

F. *Only one candidate.* Some comments say that Prof. D'Armiento's candidacy should be allowed because otherwise only one candidate will be left in the election. This argument does not address the key question and so we are reluctant to engage with it. It also would be inconsistent not to allow the election for chair to go forward this year with only one candidate when it went forward that way in 2021 and 2023, and will go forward this year for the two vice chair positions. We also do not believe that scheduling the period for challenging before the end of the nominating period is a viable alternative to the current system. Suppose the challenging period ended before the nominating period. Then any would-be candidate whose credentials were weak would file between the end of the challenging period and end of the nominating period and escape scrutiny.

G. *The March 27 publication of names should be definitive.* On March 27, the Elections Commission circulated a list of aspiring candidates whose petitions appeared to be in order. We said then that we had not finalized those candidates and repeated on April 1: " First, we want to clarify that the names listed in our March 27th email were individuals who have been nominated, but they are not yet officially on the ballot." There were no official candidates on March 27 and so we could not have removed any candidates.

H. *Normal practice.* Several comments from Senators argue that normal practice in the organizations they are familiar with is to ignore previous elections of incumbents when bylaws change. This information is particularly relevant under an ordinary language theory of interpretation, and so it is a possible strong argument for upholding the candidacy.

6. **Arguments indicating ambiguity**

A. *Senators disagree.* The Oxford Languages Dictionary defines "ambiguous" as "open to more than one interpretation." If one believes as we do that Senators are highly intelligent, adept in the English language, well educated, and well meaning, then one must conclude that from the diversity of interpretations of the three-election limit that the three-election limit is indeed "open to more than one interpretation."

B. *S&O action.* The S&O Committee was the original sponsor of the bylaw revisions that included the three-election limit, and has often discussed this topic. Many of the members of the 2020 committee are still on this committee. In fall 2020, the committee prepared a revision of the bylaws that included adding to the three-election limit the phrase "after December 11, 2020." This package was presented to the Senate as a whole on October 25, 2020. The S&O committee said that "the [2020] amendment did not specify whether elections before its adoption counted against the limit of three," and. "It was an oversight of S&O at the time not to specify that the limit was meant to apply going forward, not retroactively." At that meeting, some Senators opposed this part of the revision package. No vote on the proposed revision package occurred on October 25, and the S&O committee revised its package in several ways as a result of the comments in the plenary. This is the normal practice on major revisions of important documents. One part of this revision was to divide the package in two with the amendment to the three-election limit separated from the other parts of the package. The package without the three-election limit was adopted by the Senate at the February 7, 2025, plenary, but amendment to the three-election limit has not been presented to the Senate.

From this history, two conclusions should be drawn. First, the S&O committee considers the phrasing that is in the bylaws now ambiguous. Second, the original intent was to exclude the 2019 election. According to RRO 56-68, original intent cannot override the plain language of the bylaw, but in the event the language is ambiguous, the body that is trying to disambiguate a phrase should seek "harmony with the intention of the society at the time at the time the bylaw was adopted, as far as this can be determined."

C. *Our own reactions.* Several of our members, in considering the language of the three-election limit, believe that it is "open to more than one interpretation."

7. **How to resolve the ambiguity**

A. *Ambiguity must be resolved.* The Elections Commission must either place Professor D'Armiento on the ballot or not. There is no third alternative. To do that responsibly, it must decide whether the answer to the key question is yes or no. Again, there is no third alternative.

B. *The Senate plenary has power to resolve the ambiguity under RRO 56-68.* This is clear from the language of RRO 56-68.

C. *Does the S&O have the power to resolve the ambiguity?* It could be the case that the Senate has delegated its power under RRO 56-68 to resolve ambiguity to the S&O Committee. The support for that claim is section 4k (xii) of the bylaws, which states in part that this committee "shall be the University Senate's committee on Senate's rules and procedures." We do not read this section as delegating any of the Senate's powers under RRO 56-68 to this committee. Nor do we believe that this committee has attempted to exercise any powers under RRO 56-68.

D. *Do the Senators have the power to resolve the ambiguity by voting directly in a single election where Professor D'Armiento runs against her opponent with the key question unresolved?* We believe the answer is no because the Senate must operate under its rules, not be driven by personalities. Professor D'Armiento can be elected chair only if the answer to the key question is no. Votes on whether Professor D'Armiento should be chair cannot be interpreted as votes for or against the key question. One can believe that the answer to the key question is no and vote against Professor D'Armiento because one disagrees with her policies. Similarly, one can believe that the answer to the key question is yes and still vote for Professor D'Armiento because one is enthusiastic about her policies. An election on question A does not resolve logically unrelated question B even if one believes that votes on the two questions are correlated. (For instance, rigorous research finds that Democrats are more likely to prefer cats and Republicans are more likely to prefer dogs, but holding a referendum on whether cats or dogs are better is not a good way to elect a president.) And it is insulting to Senators to believe that none of them are principled enough to separate their views on the key question from their preferences about who should be chair.

E. *Does the Elections Commission have the power to resolve the ambiguity unilaterally?* Possibly. The bylaws give the Elections Commission the duty to oversee elections, and Elections Code says it shall supervise, promulgate rules, and adjudicate certain disputes. "Adjudication" may imply interpretation: it is defined as making "a formal judgment or decision about a problem or disputed matter." But we are not sure and would prefer not to overstep our bounds on a matter on which so many Senators want to participate. Many of the comments we received emphasized that they thought the Senate should participate in the interpretation of this important matter, rather than leave a small group (whose actions are covered by Senate's confidentiality requirements of committee confidentiality) to make the decision.

8. **Our decision and request**

A. *Plenary to decide on interpretation, not the challenge.* Since the Senate is the only group we are sure has the authority to answer the key question, we request respectfully that you do so. We are not asking you to rule on the challenge we have received. That is our responsibility, not yours. We are asking only for an interpretation of the bylaws.

Elections Commission

Report to the University Senate

April 4, 2025

Offices being filled in these elections

- Chair of the Executive Committee (2 year term starting September 2025)
- Vice chair of the Executive Committee (interim term from May 1, 2025 through August 31)
- Vice chair of the Executive Committee (2 year term starting Sept. 1, 2025)

Elections timeline

- Call for election
- Nominating period
- Challenge period
- Decisions on challenges
- Formalize ballots
- Campaign period
- Voting period
- Counting votes
- Announcing results—May 1.

Elections timeline

- Call for election
- Nominating period
- Challenge period
- Decisions on challenges WE ARE AROUND HERE
- Formalize ballots
- Campaign period
- Voting period
- Counting votes
- Announcing results—May 1.

Status of elections

- Executive Committee chair
  - James Applegate, Filing documents in order, no challenge
  - Jeanine D'Armiento. Filing documents in order, challenge received
  - OUR REQUEST TODAY CONCERNS THIS CHALLENGE
- Vice chair (interim)
  - Henning Schulzrinne. Filing documents in order, no challenge
- Vice chair (full term
  - Holger Klein. Filing documents in order, no challenge

The challenge to Professor D’Armiento’s candidacy

- The challenge stated that Professor D’Armiento was not permitted to run for reelection because her candidacy violated the election limit provision of the Senate bylaws.
- That provision reads in part, “No person shall be elected as chair of the Executive Committee more than three consecutive times.”
- This bylaw amendment was adopted December 11, 2020.
- Professor D’Armiento was elected twice after this amendment was adopted and once before.

The interpretation question

- Which of those elections counts against the three-term limit?

How we have approached this question

- We have consulted widely.
- We have tried to use our best judgment.
- We have invited statements from the Senate.
- Many members have responded with detailed and thoughtful letters.
- We’ve read them all and thought about them.

Thank you all very much!

What we learned

- Many thoughtful, smart, well-intentioned people think the pre-amendment election counts against the three-election limit.

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- Many thoughtful, smart, well-intentioned people think the pre-amendment election does not count against the three-election limit.

What we learned

- Many thoughtful, smart, well-intentioned people think the pre-amendment election counts against the three-election limit.
- Many thoughtful, smart, well-intentioned people think the pre-amendment election does not count against the three-election limit.
- Several good arguments can be made that we should interpret the language as saying that the pre-amendment election counts against the three-election limit.

What we learned

- Many thoughtful, smart, well-intentioned people think the pre-amendment election counts against the three-election limit.
- Many thoughtful, smart, well-intentioned people think the pre-amendment election does not count against the three-election limit.
- Several good arguments can be made that we should interpret the language as saying that the pre-amendment election counts against the three-election limit.
- Several good arguments can be made that we should interpret the language as saying that the pre-amendment election does not count against the three-election limit.

Our report

- We prepared a detailed report summarizing our thoughts on these arguments and explaining our reasoning.
- It’s in the binder for this plenary, the last few pages.

Our conclusion

- The bylaws are ambiguous.
- The plenary has the power to resolve this ambiguity.
- We should ask the Senate to do resolve the ambiguity. This is done by majority vote.
- The key guidance can be found in Robert’s Rules of Order 56:68.

We’re not shirking

- We’re not asking you to rule on the challenge.
- That’s our responsibility.
- We’re asking you only to interpret your bylaws.
- As soon as this meeting adjourns, we will convene on zoom to rule on the challenge and officially adopt the ballots.
- And notify you about the start of the campaign period.

Your interpretation has to take the form of a yes-no vote

- So one possible answer has to be yes and the other has to be no.
- We can’t phrase a question that’s totally neutral.

Our suggested motion, on which Senators would vote yes or no

- “We interpret the Senate bylaws to mean that only elections that occur after December 11, 2020, shall be considered in counting the number of elections that a person seeking to be elected chair or vice chair has won.”

Thank you

Motion

Proposed: April 4, 2025
Adopted: April 4, 2025
52-19-3: in favor-opposed-abstained

- “We interpret the Senate bylaws to mean that only elections that occur after December 11, 2020, shall be considered in counting the number of elections that a person seeking to be elected chair or vice chair has won.”