Climate Change *vs.* Everything Else Causing Ecosystem Impairments: *What is driving global change?*

Syllabus of August 9, 2021
Fall - EAS 519 (2 credit hrs) *Section 001 "in-person"* *Section 002 "remote"*
Wed 5:30 – 7:10 pm
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Rationale

This course tackles the oft' ignored reality that while ecosystems are being subjected to climate change-related impacts (e.g., increases in droughts, wildfires, flooding, heat), there remain a plethora of co-occurring physical, chemical and biological stressors. *How is climate change affecting these unknown and well-known stressors? What role do 1) land uses, 2) societal and political norms and media biases, 3) economic constraints, 4) the sensitivity and resilience of local/regional ecosystems, and ecosystem context have in this issue?*

These components vary across geographies and vary as system drivers. As environmental managers, assessors, educators and stewards it is critical to have an understanding how these issues are intertwined in the face of climate change. Many corporations and governmental agencies are now mandating that plans to manage or restore sites have climate change contingencies included, in the event of flooding, drought, wildfires, etc.

Examples of common-place stressors in human-dominated systems include: Excess nutrients; Harmful algal blooms; Habitat alteration (e.g., erosion and turbidity, siltation, loss of riparian vegetation and trees, flows, channelization); Toxic chemicals such as metals, methyl mercury, pesticides, PFAS, PCBs, pharmaceuticals and personal care products); Macro- and microplastics; Water withdrawals for irrigation and fracking; Untreated sewage with viral, bacterial and fungal pathogens; Parasites; and Invasive species.

Climate change is exacerbating the effects of all these stressors on ecosystems, including altering biodiversity; yet environmental managers and assessors have been remiss in considering the role climate change is having on these well-known environmental issues. These stressors tend to be addressed in a piece-meal, "silo" approach due to regulatory frameworks and the challenge of implementing interdisciplinary frameworks.

This class will not focus on the sources of greenhouse gases or approaches to reduce their output.

Class Learning Objectives

The Teaching Goals of all my classes are:

- Develop an awareness of primary issues: interdisciplinary ecosystem elements, chemical/physical/biological stressors, sociological and economic drivers, regional political drivers;
- Understand a systems approach of issues and their qualitative interactions and relationships;
- Understand the trigger points of systems that initiate change;
- Developing solutions and rank them using Weight-of-Evidence based approaches;
- Understanding of what is involved in solution facilitation along with associated impediments; and how to rank them in a strategic manner;
- Maintaining improving action inertia with adaptation; and
- Understand how to evaluate outcomes: Is positive change occurring? Is it sustainable? How can it be improved/optimized? How can impediments be minimized/circumvented?
- *Understand and commit to always continuing to grow in knowledge and wisdom – throughout your life – to stay abreast of the interdisciplinary sciences and using that knowledge to improve life and ecosystems.*

More specifically, the learning objectives for this class are for students to develop an understanding of the relative importance of physical, chemical and biological stressors in the face of climate change, across a range of ecoregions and hydrology types. Students will also generally consider the role of land uses, societal and political norms, economic constraints and disease outbreaks (such as COVID-19) and how these may affect priority setting on ecosystem restoration actions and the ranking of stressors.

An important focus will be understanding how regional ecosystems along with geopolitical boundaries vary in their sensitivity to stress and subsequent resilience to resist impairments. These considerations should drive the development of pragmatic approaches for ranking and managing the most important stressors in the face of climate change. This allows for science-based decision making addressing appropriate restoration and remediation strategies that are place specific.

Specifically, students should achieve the following learning outcomes from this course:

- An understanding of likely ecosystem stressors typical of a range of regions, land uses and hydrologic systems; while considering their context in a range of societal and economic conditions (resource rich to resource poor countries);
- An understanding of how stressors may interact with each other, ecosystems and human populations;
- An understanding of the role climate change may have on human-dominated ecosystems, in the face of co-occurring stressors; and

- An understanding of how to make science-based decisions for improved restoration and remediation strategies by prioritizing adaptation and stressor management.

Student Skill Requirements

This course is open to any SEAS, CEE, ClaSP, SPH, EES or EEB graduate student. No specific course background is needed other than being associated with these (or similar) graduate programs at the University of Michigan.

Class Format and Pedagogical Tools

The class will consist of two separate formats using in-person lectures (Section 1) and remote learning (Section 2) using live lectures and class discussions that are recorded and available on Zoom real time. There will be assigned readings and videos in addition to lectures. All class materials are on Canvas for access by enrolled students. Announcements, assignments and grades will be communicated via Canvas and lectures. Non-video Powerpoint files (.ppt) of lectures will also be placed on Canvas each week.

Office Hours are open with flexible availability on Zoom most times between 8:00 and 6:00 M-F, as long as the appointment is prescheduled via email.

Reading Materials

Hundreds of recent (2020-2021) journal papers, chapters, reports and news releases are located in folders on Canvas to support the lectures and provide options for your reading. Keystone papers and reports from before 2020 are also included, such as IPCC reports. These will be amended *each week* from current releases that I find or you provide me. The reading materials cover all aspects of emerging climate and global change issues dealing with extreme events, multi-stressor interactions with climate, resource scarcity, biodiversity loss, human migration, environmental justice, adaptive management, solutions and good news. Sources and reduction strategies for greenhouse gases (GHG) are only covered peripherally.

Class Topics

Students will be given 4 questions following each lecture that they will answer and submit via Canvas prior to the subsequent class (5:29 pm Wednesday).

The first class will consist of reviewing the Syllabus and an overview of common ecosystem stressors in human-dominated systems. We'll also briefly discuss the class problem assignment – *Ranking Multiple Site Stressors for Restoration*

We have the flexibility to discuss a wide variety of climate-related issues and their interaction with common physical, chemical and biological stressors; many of which are listed below:

- Overview of common stressors in human-dominated systems, such as: human-dominated land uses, habitat, flow, nutrients, dissolved oxygen, invasives/introduced species, temperature, pesticides, metals, synthetic organics, pharmaceuticals and personal care products.

- How do physical, chemical and biological stressors vary by ecoregion, hydrologic type, and political-socio-economic status?
- Overview of known climate change impacts, such as heat, extreme events (e.g., wildfires, drought, flooding, severe storms), food-web collapse, glacier and polar ice melt, pathogens, pests, invasive and introduced species, seasonal changes affecting reproduction and behavior, species loss and biodiversity declines.
- Where are climate-change hot spots? What are the indirect effects of climate-change on human populations, public health, environmental justice, pandemics, and economies and how might these affect regional ecosystems?
- How will ecosystem stressors likely be influenced by climate change? How will this vary across ecoregions?
- How should local to regional ecosystems be better managed and restored in the face of climate change and other stressors? Which stressors should be targeted first in a restoration or protection program? What are the key considerations?

Grading

1. At the end of each lecture there will be 4 questions on content to answer. Answers will be checked for plagiarism (4 points each x 10 wks) **40 points**
2. Student presentation using Powerpoint and video on *Ranking Multiple Site Stressors for Restoration* (details below) **40 points**
3. Participation (discussions, emails, *time spent* on Canvas) **20 points**
4. BONUS POINTS: Up to 10 summaries (150-200 words) of journal papers or chapters/reports from Canvas folder selections. (1 point each) **10 points max**

Project description: Ranking Multiple Site Stressors for Restoration. Each student (or pair of students) will prepare Powerpoint and video presentations (which may or may not be shared with the class) addressing the assignment. This will be presented as a Zoom video recording by the student and submitted for grading as both ppt and mp4 files. The Powerpoint should be 30 slides maximum and video presentation 15 mins maximum. Exceeding time limits will reduce grade by one letter.

The project will show how you would rank (worst to least harmful) stressors, based on their likely degree of ecosystem impairments in a specific ecoregion (of your choosing) that is subject to climate change drivers. *Note there is no one right way to do this*. Describe how the climate change drivers are likely to interact with dominate site stressors (non-climate such as: toxic chemicals, habitat degradation, excess nutrients, etc. (others noted above)). Also show how to decide which stressors to target for restoration, considering the cost to benefit ratio at your project site. How are the stressor rankings and restoration approaches affected by political, societal and economic traits of your ecoregion? Show how climate change affects your restoration strategy.
* *As graduate students, you should understand the more you put into a course, the more you increase your expertise and benefit professionally. A plethora of recent readings are provided*

which are not required – but will benefit your understanding of this subject. Materials submitted will be checked for plagiarism; but, other than that, the learning is up to you.

Policy Statements Mandated by UM

In regards to the COVID pandemic: For the safety of all students, faculty, and staff on campus, it is important for each of us to be mindful of safety measures that have been required for our protection. By returning to campus, you have acknowledged your responsibility for protecting the collective health of our community. Your participation in this course on an in-person basis is conditional upon your adherence to all safety measures mandated by the State of Michigan and the University, including maintaining physical distancing of six feet from others, and properly wearing a face covering in class. Other applicable safety measures may be described in the Wolverine Culture of Care, the University's Face Covering Policy for COVID-19 and SEAS Questions & Concerns document. Your ability to participate in this course in-person as well as your grade may be impacted by failure to comply with campus safety measures. Individuals seeking to request an accommodation related to the face covering requirement under the Americans with Disabilities Act should contact the Office for Institutional Equity. If you are unable or unwilling to adhere to these safety measures while in a face-to-face class setting, you will be required to participate on a remote basis (if available) or to disenroll from the class. Please review the Statement of Students Rights and Responsibilities and check-in with the Office of Academic Affairs Director to navigate support and resources for you. You may find the latest UM information on COVID-19 alerts and policies for UM at the Maize and Blueprint website**.** I will adapt the course as needed due to the COVID-19 outbreak and support each student's needs. All assignments and recordings are available to enrolled students on Canvas. Note UM's Recording and Privacy Concerns FAQ. *Students will not be recorded during Zoom discussions and presentations***.** *"Students are prohibited from recording/distributing any Class Activity without written permission from the instructor, except as necessary as part of approved accommodations for students with disabilities. Any approved recordings may only be used for the student's own private use."*

Chronological Lecture Topic Summary *(slight alterations possible)*

1. Review syllabus. Discuss the challenge of being a scientist or "expert" in this rapidly changing and growing field. Begin with an overview of pollutants and ecosystem stressors, with interactions of political, social and economic drivers, including environmental injustice. Which stressors identified by USEPA are worst on aquatic systems? Multiple stressors exposures are the norm in human-dominated ecosystems. How does one know which stressors are most important? Which ecosystems are most sensitive?
2. Major climate change drivers: temperature, drought, wildfires, ice melt, ocean acidification, extreme events. Intergovernmental Panel on Climate Change (IPCC) findings. Recent changes and literature support. Number of natural disasters increasing. Major climate change events cont'd. IPCC best/worst case predictions for biota (temp, acidification, sea rise).

3. Which regions are most vulnerable? IPCC predictions on regional impacts to physical, biological and human systems. Global changes by humans causing expanding land use changes for urbanization and agriculture, habitat degradation and fragmentation, excess nutrients, resource extraction, air pollution, water scarcity, altered flows, disease-pathogens-pests, contaminants and biocides, plastics, and introduced and invasive species. These impact ecosystems, human health, environmental justice and vulnerable human populations and climate migration.
4. Critical direct and indirect impacts to humans and ecosystems and linkages to other stressors: migration, economies, geopolitics, flooding, hurricanes, dam breakage, food and water scarcity, livestock vs GHG. Unknown unknowns.
5. Studies showing the linkages of environment and human activities: Living Planet 2020 report. Planetary Boundary and tipping points. How do climate and non-climate stressors interact (physical, chemical, biological, ecological – examples with drought, flooding, wildfire. Global risk rankings and interactions. Ecosystem vulnerability ranking for each stressor.
6. Great Lakes multi-stressor evaluation by the International Joint Commission.
7. Ranking system drivers: Regional characteristics, Quality of life, Economies and GDP drivers (e.g., agriculture, industry, mining, tourism), Racism and EJ, Stakeholder power, Societal values
8. Management issues: Now vs. future drivers, Conservation vs. political priorities, National alliances, Technological advances, Popular opinions, Education, etc.
9. Class project: (see below)

Assigned Readings

Numerous high quality, peer-reviewed publications are released each day addressing climate and global change which are directly relevant to this class. The sciences comprising this interdisciplinary field are growing rapidly, which is both wonderful and daunting when it comes to staying abreast of the science. Given the range of student interests in this class, I will attempt to broadly identify the most important and current science as it relates to both ecosystems and human populations and make these publications (or links) available on Canvas *each week*. I will identify a subset of the literature that will be *required reading* and focus on summaries of studies and Executive Summaries of critical reports, as there is simply *too much material* for reading all relevant current publications. Students are encouraged to read beyond the required reading, focusing on your particularly area of concentration. Due to the rapidly growing body of literature, only a few examples of excellent resources are provided below:

- Global efforts to protect biodiversity fall short. Sci 369:6510 2020
- Past perspectives on the present era of abrupt Arctic climate change. Nature Climate Change 10:714 2020
- An evaluation of stressor interactions in the Great Lakes. IJC. 2020
- Assessing the U.S. Climate in September 2020. NOAA.
- Increased extinction in the emergence of novel ecological communities. Sci 370:220. 2020

- Global Climate Change: Scientific consensus: Earth's climate is warming. NASA.
- Rising seas and agriculture created wetlands along the U.S. east coast. EOS. 2020.
- World Economic Forum. The global risks report 2020.
- World Wildlife Fund Living Planet Report. 2020
- Observed impacts of anthropogenic climate change on wildfire in California. AGU`00. 2019.
- Persistent quaternary climate refugia are hospices for biodiversity in the Anthropocene. Nature Climate Change. 2020
- IPCC reports.

Class Project: *Ranking Multiple Site Stressors vs. Climate Change for Restoration*
Show how to rank multiple stressors and their interaction with climate in human-dominated systems. Pick a region with climate change issues. Describe all major stressors and their likely interactions, threatened ecosystems and ecological services, and societal groups. Suggest adaptive management strategies for dealing with climate and non-climate stressors.

Grading Rubric (30 points)

a) Conceptual model showing stressors, stressed systems, and linkages. 5 points
b) Stressors ranked considering magnitude, frequency and duration. Additional stressor ranking criteria described and logical. 10 points
c) Stressor interactions with climate/global change is logical, including likely future scenarios 5 points
d) Stressors linkages to political-socio-economic issues noted 5 points
e) Adaptive management strategy
f) Decision making framework logical for stressor and restoration action ranking 5 points

<u>Overview</u>

- The project can provide examples to be used by Site Managers, Consultants or Regulators to guide decisions on the most efficient and effective restoration approach, considering climate/global change interactions in the near future.
- Show how you would rank (most to least harmful) five stressors, based on their likely contribution to ecosystem impairment (such as failing fish populations) at a site in a human-dominated watershed or coastline. This will be in a region already showing climate change impacts. Examples of stressors: Climate change related extreme events vs. toxic chemicals, habitat degradation, excess nutrients, altered flows, invasive species, pathogens, pests, resource extraction, over-harvesting, etc.
- Which species/populations/communities are most vulnerable? Does their impairment cause secondary effects (i.e., cascading effects) to other species or ecosystem components?

- Suggest how the top "non-climate" stressors are affected by climate change and how this likely affects restoration efforts at your study site. Conceptual models and flow diagrams showing interconnections is suggested.
- Show linkages likely with local political-socio-economic traits and include in decision-making.
- For the stressor ranking, have an explanation of the weighting/scoring rationale (see below).
- Show how you decide which stressors to target for restoration, considering cost effectiveness (assume the restoration will be done by a local government agency).
- Describe possible adaptive management approaches for dealing with the growing threats.

<u>*Examples of possible stressor ranking indices and considerations*</u>

- Here is a ranking method *example*: Assign values (0-5 = from no worries to high concern) to each stressor in a weight-of-evidence based ranking. Sum all indices and rank stressors by severity, with and without climate change.
- What is the degree of stressor exposure? Measured by magnitude, frequency of occurrence, and duration of exposure.
- To what degree is the stressor connected to other stressors? For example, farming is linked to habitat alteration, nutrients, HABs, pesticides, and soil erosion. Among connected stressors – which dominates? Is this ecoregion dependent?
- Is the non-climate stressor likely to grow in magnitude due to climate change? How likely will the stressor appear and increase its exposure impact in the near future? For example, increasing extreme events can degrade habitat and transport pathogens and chemicals downstream.
- Examples of climate stressor interactions/linkages: Such as additive, synergistic or antagonistic responses that can be direct or indirect effects. For example – Warmer temperatures melt Arctic ice, thus increasing UV absorption and further water warming, thereby altering major ocean currents, thereby impacting aquatic life, terrestrial wildlife and societies.
- Relationship of stressor vs. political-socio-economic status of residents in the area affected. What percentage of the population is most affected (e.g., environmental justice and vulnerability considerations). For example: Lawn care fertilizer and pesticide applications in high socio-economic residential areas versus litter and engine oil dumping in low socio-economic areas. Lower income homes are more likely in flood zones with exposure to industrial emissions.

Presentation files (ppt and video) must be submitted no later than 5:00 pm Tuesday November *30*th. Submit via Canvas under "Assignments". A subset of projects will be randomly selected for the remaining class periods. Those selected must be present to lead the discussion of their project. Projects randomly selected for presentation will receive an *additional 5 bonus points*. There is not time for all students to present.