
Applied Flood Exposure, Vulnerability, and Adaptation

University of Wisconsin-Madison

Fall 2026

Course Information

- **Course Subject/Number:** ENVIR ST 900.403
 - **Credits:** 3 Credits
 - **Designation:** Community-Based Learning (CBL)
 - **Meeting Time:** Wednesdays, 1:20 PM – 3:15 PM (plus group project meetings with instructor and community partner)
 - **Location:** 2106 Mech Engr
 - **Instructor:** Beth Tellman
 - **Email:** beth.tellman@wisc.edu
 - **Office Hours:** [Time TBD] or by appointment
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Course Description

This is a new community-based learning course for upper division undergraduates, cross-listed with graduate courses, to holistically understand the social, biophysical, economic, and infrastructural dynamics of floods and how they impact people and communities. The course will start with hydrologic foundations to what a flood is and how to measure it, the role of a changing climate in shaping flood hazards, and how land use changes influence floods. We will work with different data sources- from stream gauges to flood models to satellite-based flood maps made with AI- to understand this hydrologic basis. After developing a hydrologic basis for estimating flood hazard, students will learn flood exposure and vulnerability assessment, to understand how to estimate people and assets exposed to floods, and their susceptibility to harm and damage from extreme events. In addition to quantitative data analysis, this section will examine the root causes of flood vulnerability, and the essential role of qualitative methods to unpack how systemic inequality shapes who gets flooded, how they recover, and who gets to rebuild (and where). The last part of the course addresses flood adaptation- what works to address flooding and who benefits or loses with different solutions? Here we will review the role of insurance, land use policy, grey/green infrastructure, buyouts, and other attempts to mitigate damage to lives and livelihoods in current and future climates. This course includes a community-based learning component, that will be developed with two course flood fellows. The two fellows coming from a civic organization funded to collaborate in this course, will attend

four virtual sessions and two in person sessions. The fellows will work with students on the final assignment to develop a theory of change around flood justice in their community and co-develop final data analysis projects students will undertake in groups as their final project. Flood fellows are likely coming from two regions in the US- one in South Texas along the US Mexico border (to extend the FLUJOS project see <https://assets.rgvflood.arizona.edu/>) and one in Wisconsin.

The "Flood Justice Fellow" Model

Unique to this course is a **co-production model** funded by The Brittingham Trust and Fall Research Competition from the University of Wisconsin. We move beyond standard service learning by integrating **Flood Justice Fellows**—community leaders from flood-impacted regions—as paid co-educators. These Fellows will guide student teams with the instructor to ensure projects are grounded in lived experience and meet real community needs. We are currently recruiting partner organizations and fellows from two regions: 1) **The Rio Grande Valley (US-Mexico Texas Borderlands)**: Partnering with **LUPE (La Unión Del Pueblo Entero)** or a similar organization to address flood justice in *colonias*—informal settlements facing poor drainage, discriminatory recovery funding, and climate injustice. 2) **Wisconsin**: We aim to target **The Driftless Region** (Wisconsin) with an organization such as the **Coon Creek Community Watershed Council** to address rural flood vulnerability, repetitive loss, and watershed management in a changing climate.

Reflections

Reflection is a core component of community-based learning and a central part of this course. Rather than treating community engagement as simply a project delivery exercise, structured reflection asks you to slow down and examine your assumptions, your role, and the power dynamics at play when researchers and students engage with communities facing environmental injustice. In this course, you will complete a Positionality Statement early in the semester and three reflective journal entries timed to key moments of community partner interaction. These assignments ask you to consider questions such as: What do I bring to this partnership—in terms of training, identity, and privilege—and how might that shape what I see or miss? What did I learn from this community member that I could not have learned from a dataset or paper? What tensions arose between the community's needs and what I, as a researcher or analyst, was able to provide?

These reflections will be read and responded to by the instructor or course TA. Good reflective writing in this course does not require you to have the "right" answer—it requires honest engagement with complexity and discomfort. To prepare you for this kind of writing, Week 3 of the course is dedicated to community-based learning ethics and positionality, including a workshop facilitated in partnership with the Morgridge Center for Public Service. We will also draw on assigned readings that explore race, affect, and the ethics of community engagement. Students who are new to reflective writing or positionality statements should expect guidance and feedback throughout the semester; this is a skill we will build together.

What You Will Do

Rather than hypothetical papers, students will co-produce actionable data. Projects will be identified with the community partner and based on student skills and interest, but you might do something like:

- **Quantify Hazards:** Use stream gauges, flood models, and satellite imagery to analyzing existing or "make" new flood maps.
- **Assess Vulnerability:** Apply social vulnerability indices to identify who is most at risk and why.
- **Understand Climate and Flood Risk:** Analyze climate and future land use model signals and implications for the region
- **Analyze Infrastructure Function:** Look at flood patterns over time around levees and drainage canals to see if and where floods are mitigated locally, and if they push water downstream to new communities unintentionally
- **Drive Change:** Work with your Fellow to develop a "**Theory of Change**" and deliver a final data product—such as a historic flood map library or an insurance analysis—that supports local advocacy and grant-writing.

Learning Outcomes

By the end of the semester, students will be able to:

1. **Analyze Flood Dynamics:** Calculate return periods and discharge using stream gauge data and interpret flood models.
2. **Map Exposure:** Use satellite imagery and AI tools (e.g., Google Earth Engine) to "make" flood maps and estimate population exposure.
3. **Assess Vulnerability:** Apply quantitative and qualitative methods to understand the root causes of susceptibility and inequality, such as zoning and historic underinvestment.
4. **Evaluate Adaptation:** Critically assess flood mitigation strategies—from gray/green infrastructure to insurance and managed retreat—and determine who benefits or loses.
5. **Practice Co-Production:** Demonstrate the ability to work respectfully with community partners, engaging in reflexive practice regarding positionality, power, and privilege.

Credit Hours

This 3-credit course meets the UW-Madison credit hour policy standard. It includes 2 hours of direct instruction per week and an expectation of at least 2-3 hours of out-of-class work per week, including readings, labs, and community project collaboration. You will spend at least 25 hours working on your final project with a community partner.

Course Materials

- **Software:** We will use **R** or **Python** (Google Colab) and **Google Earth Engine** for labs. No prior coding experience is required; templates will be provided.
- **Readings:** All readings will be provided as PDFs on Canvas.

Assignments & Grading

Component	Weight	Description
Labs (x4)	30%	Technical assignments: 1) Flood frequency analysis, 2) Satellite flood mapping, 3) Vulnerability index creation, 4) Adaptation cost-benefit analysis.
Reflections	15%	Positionality Statement and 3 "journal entries" reflecting on power/privilege after key community partner interactions.
Theory of Change	20%	A group proposal co-developed with your Flood Justice Fellow outlining how specific data/analysis can (or cannot!) address flood injustice.
Final Project	25%	A comprehensive analysis (e.g., historic flood map library, insurance data review) delivered to the partner. Includes a final presentation.
Participation	10%	Active engagement in class discussions, partner workshops, and peer feedback.

Grading Scale: A (93-100), AB (88-92), B (83-87), BC (78-82), C (70-77), D (60-69), F (<60).

Weekly Schedule

(Subject to change based on partner availability)

- **Week 1 (Sept 2): Labor Day (No Class)**
- **Week 2 (Sept 9): Concepts of Exposure, Vulnerability, and Environmental Justice**
 - *Topic:* What is exposure? What are the components of risk? How do we measure vulnerability and adaptation? What does injustice have to do with who is exposed or vulnerable to flooding?
 - *Lab 1:* Quantifying social vulnerability

Readings:

- Goldsmith, Leo, Vanessa Raditz, and Michael Méndez. "Queer and Present Danger: Understanding the Disparate Impacts of Disasters on

LGBTQ+ Communities.” *Disasters* 46, no. 4 (2022): 946–73.

<https://doi.org/10.1111/disa.12509>.

- o Tate, Eric, Md Asif Rahman, Christopher T. Emrich, and Christopher C. Sampson. “Flood Exposure and Social Vulnerability in the United States.” *Natural Hazards* 106, no. 1 (2021): 435–57.
<https://doi.org/10.1007/s11069-020-04470-2>.
- o IPCC. *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, 2022.
- o Segura, Rocio L., Iris T. Stewart, David E. DeCosse, et al. “A Multidisciplinary Approach to Understanding Vulnerability and Building Climate Resilience to Levee Failures and Flooding in Historically Marginalized Communities.” *Journal of Environmental Studies and Sciences*, ahead of print, November 22, 2025.
<https://doi.org/10.1007/s13412-025-01063-y>.
- o Sullivan, Jonathan, Hannah Friedrich, Beth Tellman, Alex Saunders, and Lucas Belury. “Five Key Needs for Addressing Flood Injustice.” *Eos* 105 (February 2024). <https://doi.org/10.1029/2024EO240068>.
- **Week 3 (Sept 16): Community-Based Learning & Positionality**
 - o *Topic*: Ethical engagement
 - o *Readings*: tbd work with Morgridge Center
 - o *Assignment*: Positionality Statement.
- **Week 4 (Sept 23): Beth Traveling (No Class)**
- **Week 5 (Sept 30): Partner Case Studies – Rio Grande Valley & Wisconsin**
 - o *Topic*: Fellows present “seed ideas.” Students select their track (RGV or WI).
 - o *Readings*: TBD selected with Partners. Possibilities include reports from Coon Creek Watershed Council, Flood Justice in the Borderlands Podcast, LUPE documents about their history.
- **Week 6 (Oct 7): Flood Hydrology and Hydraulic Essentials**
 - o *Topic*: Return periods, discharge, inundation models, and catastrophe models. Guest Speaker Dr. Daniel Wright, UW Civil and Environmental Engineering
 - o *Readings*:
 - o Bates, Paul D. “Flood Inundation Prediction.” *Annual Review of Fluid Mechanics* 54, no. 1 (2022): 287–315.
<https://doi.org/10.1146/annurev-fluid-030121-113138>.
 - o Schubert, Jochen E., Katharine J. Mach, and Brett F. Sanders. “National-Scale Flood Hazard Data Unfit for Urban Risk Management.” *Earth’s Future* 12, no. 7 (2024): e2024EF004549.
<https://doi.org/10.1029/2024EF004549>.

- o Dusseau, Dominick, Zachary Zobel, and Christopher R. Schwalm. "Validation and Comparison of U.S. Loss Estimates from Catastrophe Flood Models." *Journal of Catastrophe Risk and Resilience*, ahead of print, 2026. <https://doi.org/10.63024/k6yh-a2v6>.
- o *Lab 2*: Calculate return periods from stream gauge data, analyze flood maps in your selected case study
- **Week 7 (Oct 14): Observing Floods with Satellite Data**
 - o *Topic*: Using remote sensing to map historic floods.
 - o *Readings*:
 - o Tellman, Beth, Jonathan A. Sullivan, Catherine Kuhn, et al. "Satellite Imaging Reveals Increased Proportion of Population Exposed to Floods." *Nature* 596, no. 7870 (2021): 80–86. <https://doi.org/10.1038/s41586-021-03695-w>.
 - o Kaushik, Saurabh, Lalit Maurya, Elizabeth Tellman, and ZhiJie Zhang. "Assessing Geo-Foundational Models for Flood Inundation Mapping: Benchmarking Models for Sentinel-1, Sentinel-2, and PlanetScope." *Journal of Special and Applied Topics in Earth Observations*, January 2025, 1–19. <https://doi.org/10.1109/JSTARS.2026.3656855>.
 - o Frame, Jonathan M., Tanya Nair, Veda Sunkara, et al. "Rapid Inundation Mapping Using the US National Water Model, Satellite Observations, and a Convolutional Neural Network." *Geophysical Research Letters* 51, no. 17 (2024): e2024GL109424. <https://doi.org/10.1029/2024GL109424>.
 - o Friedrich, H. K., B. Tellman, J. A. Sullivan, et al. "Earth Observation to Address Inequities in Post-Flood Recovery." *Earth's Future* 12, no. 2 (2024): e2023EF003606. <https://doi.org/10.1029/2023EF003606>.
 - o *Lab 3*: "Make" a flood map for your partner's region.
- **Week 8 (Oct 21): Flood Recovery in the US- from colonias in the borderlands to heirs' property in the South to the Houston's middle class**
 - o *Topic*: Flood recovery in the US, panel from scholars (Lucas Belury, University of Arizona, Hannah Friedrich, University of Arizona, Max Bresbis UW-Madison Sociology, Jon Sullivan UW-Madison Nelson Institute) from three topics and regions; colonias and procedural vulnerability in the Borderlands, rebuilding in Houston Suburbs, and Heir's property in the US South.
 - o *Readings*:
 - o Belury, Lucas. "POCO A POCO: POST-FLOOD SURVIVAL IN THE COLONIAS OF THE RIO GRANDE VALLEY." *Geographical Review*, April 26, 2022, 1–18. <https://doi.org/10.1080/00167428.2022.2061858>.
 - o Rhodes, Anna, and Max Besbris. *Soaking the Middle Class: Suburban Inequality and Recovery from Disaster*. Russell Sage Foundation, 2022.

- o Rivera, Danielle Zoe, Bradleigh Jenkins, and Rebecca Randolph. “Procedural Vulnerability and Its Effects on Equitable Post-Disaster Recovery in Low-Income Communities.” *Journal of the American Planning Association* 88, no. 2 (2022): 220–31. <https://doi.org/10.1080/01944363.2021.1929417>.
- o Friedrich, Hannah K., Beth Tellman, Jason R. Jurjevich, Mark Kear, and Laura A. Bakkensen. “Do Battle with Insurance”: Post- Hurricane Insurance Litigation in Southwest Louisiana.” *RSF— The Social, Political, and Economic Consequences of Climate Hazards*, 2026.
- o Something on Heir’s property from Jon
- **Week 9 (Oct 28): Community Partner Workshop**
 - o *Event: Flood Justice Fellows* join class in person!
 - o *Activity:* Co-develop the **Theory of Change** for the final project.
- **Week 10 (Nov 4): Flood Mitigation; Green vs. Gray Infrastructure and the role of Urban Planning**
 - o *Topic:* Engineering solutions and trade-offs, zoning, and ecosystem services
 - o *Readings:*
 - o Johnson, Kris A., Oliver E. J. Wing, Paul D. Bates, et al. “A Benefit–Cost Analysis of Floodplain Land Acquisition for US Flood Damage Reduction.” *Nature Sustainability* 3, no. 1 (2020): 56–62. <https://doi.org/10.1038/s41893-019-0437-5>.
 - o Tellman, Beth, Robert I. McDonald, Joshua H. Goldstein, et al. “Opportunities for Natural Infrastructure to Improve Urban Water Security in Latin America.” *PLOS ONE* 13, no. 12 (2018): e0209470. <https://doi.org/10.1371/journal.pone.0209470>.
 - o Elliott, Rebecca. *Underwater: Loss, Flood Insurance, and the Moral Economy of Climate Change in the United States*. Columbia University Press, 2021.
 - o Lea, Devin, and Sarah Pralle. “To Appeal and Amend: Changes to Recently Updated Flood Insurance Rate Maps.” *Risk, Hazards & Crisis in Public Policy* 13, no. 1 (2022): 28–47. <https://doi.org/10.1002/rhc3.12222>.
 - o Agopian, Armen, Miyuki Hino, A. R. Siders, Christopher Samoray, and Katharine J. Mach. “A Nationwide Analysis of Community-Level Floodplain Development Outcomes and Key Influences.” *Earth’s Future* 12, no. 9 (2024): e2024EF004585. <https://doi.org/10.1029/2024EF004585>.
 - o Tellman, Beth. “The New Gerrymander: Flood Maps.” *The Commons*, September 15, 2025. <https://nelson.wisc.edu/the-commons/the-new-gerrymander-flood-maps/>.
- **Week 11 (Nov 11): Flood Adaptation**

- o *Topic:* Insurance, managed retreat, and how to know if adaptation “works”
- o *Readings:*
- o Kreibich, Heidi, Anne F. Van Loon, Kai Schröter, et al. “The Challenge of Unprecedented Floods and Droughts in Risk Management.” *Nature* 608, no. 7921 (2022): 80–86. <https://doi.org/10.1038/s41586-022-04917-5>.
- o Tellman, Beth, and Hallie Eakin. “Risk Management Alone Fails to Limit Hazard Impact.” *Nature* 608 (2022): 41–43. <https://doi.org/10.1038/d41586-022-02031-0>.
- o Weill, Joakim A. “Flood Risk Mapping and the Distributional Impacts of Climate Information.” *American Economic Journal*, ahead of print, 2026. <https://doi.org/10.17016/feds.2023.066>.
- o Mach, Katharine J., Caroline M. Kraan, Miyuki Hino, A. R. Siders, Erica M. Johnston, and Christopher B. Field. “Managed Retreat through Voluntary Buyouts of Flood-Prone Properties.” *Science Advances* 5, no. 10 (2019): eaax8995. <https://doi.org/10.1126/sciadv.aax8995>.
- o Kousky, Carolyn. *Understanding Disaster Insurance: New Tools for a More Resilient Future*. Island Press, 2022.
- o *Lab: Adaptation and Insurance Cost-Benefit Analysis*
- **Week 12 (Nov 18): Future Floods & Uncertainty**
 - o *Topic:* Climate projections and urbanization impacts on flooding. Guest speakers- Phil Mulder UW-Madison Risk and Insurance Department, Andy Newman, NCAR
 - o *Readings:*
 - o Brown, Claire, and Mira Rojanasakul. *A Climate ‘Shock’ Is Eroding Some Home Values. New Data Shows How Much*. November 19, 2025. <https://www.nytimes.com/interactive/2025/11/19/climate/home-insurance-costs-real-estate-market.html>.
 - o Sebastian, Antonia, Avantika Gori, Russell B. Blessing, Karin Van Der Wiel, and Benjamin Bass. “Disentangling the Impacts of Human and Environmental Change on Catchment Response during Hurricane Harvey.” *Environmental Research Letters* 14, no. 12 (2019): 124023. <https://doi.org/10.1088/1748-9326/ab5234>.
 - o Wing, Oliver E. J., William Lehman, Paul D. Bates, et al. “Inequitable Patterns of US Flood Risk in the Anthropocene.” *Nature Climate Change* 12, no. 2 (2022): 156–62. <https://doi.org/10.1038/s41558-021-01265-6>.
- **Week 13 (Nov 25): Thanksgiving Recess (No Class)**
- **Week 14 (Dec 2): Virtual Community Partner Workshop**
 - o *Activity:* “Proof of Concept” presentations. Each group gets 30 mins with their Fellow for critique.
- **Week 15 (Dec 9): Final Project Presentations**

- o *Activity:* Final delivery of data products to partners.

Land Acknowledgement

The University of Wisconsin–Madison occupies ancestral Ho-Chunk land, a place their nation has called Teejop (Day-JOPE) since time immemorial. In an 1832 treaty, the Ho-Chunk were forced to cede this territory. We acknowledge the circumstances that led to the forced removal of the Ho-Chunk people and honor their legacy of resistance and resilience. We also acknowledge that the University has financially benefited from at least 235,530 acres of expropriated Indigenous land.

Class Anti-Discrimination Policy

Creating a respectful space and being anti-racist is an intentional act. Racism, discrimination, and microaggressions will not be tolerated. I encourage you to bring your whole self to the classroom. If you experience or witness disrespect, please let me know, or feel empowered to say "ouch" or "oops" in the moment to invite learning.