

Wetlands, Flooding, and the Clean Water Act

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Resources for the Future

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Context

Clean Water Act (CWA) is the primary law regulating US waters

Wetlands are regulated under Section 404

→ Costly permit required to dredge/fill “waters of the United States” (WOTUS)

In 2020, the EPA and Army Corps narrowed the definition of WOTUS to exclude **isolated** wetlands, i.e. those lacking a surface water connection

→ Rollback affected ~50% of US wetlands (Sullivan et al. 2019)

In 2021, agencies proposed a return to the pre-2015 “significant nexus” standard

Cost-benefit analysis for wetland protections

Benefits

Recreation

Hunting and fishing

Flood mitigation

Water filtration

Carbon storage



Costs

Foregone economic returns

CWA monitoring and enforcement

Ecosystem services are often omitted because they lack monetary values

Cost-benefit analysis for wetland protections

Benefits

Recreation

Hunting and fishing

Flood mitigation

Water filtration

Carbon storage



Costs

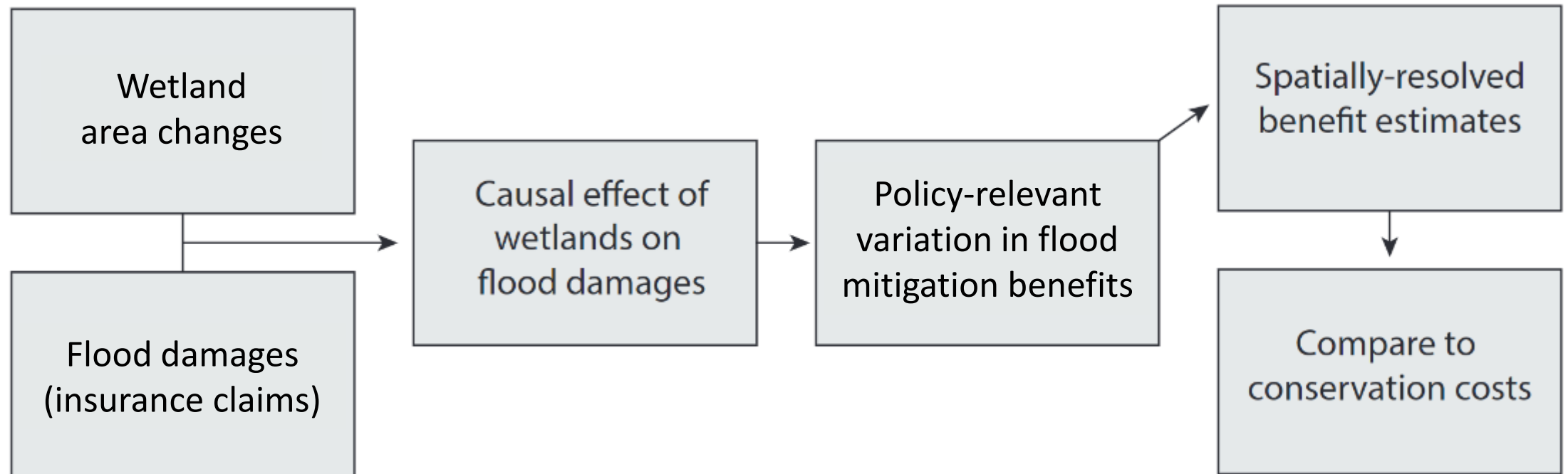
Foregone economic returns

CWA monitoring and enforcement

Quantifying these monetary values can tip the scales

This study

We estimate the value of wetlands for **flood mitigation** across the US



Existing evidence

Relationship between coastal wetlands and hurricane damages is well-studied:

- Engineering models by US Army Corps, FEMA quantify storm surge based on land use
- Empirical evaluations find one hectare of coastal wetlands reduces annual hurricane damages by ~\$8,000 (Costanza et al. 2008; Narayan et al 2017; Sun and Carson 2020)

But previous research did not:

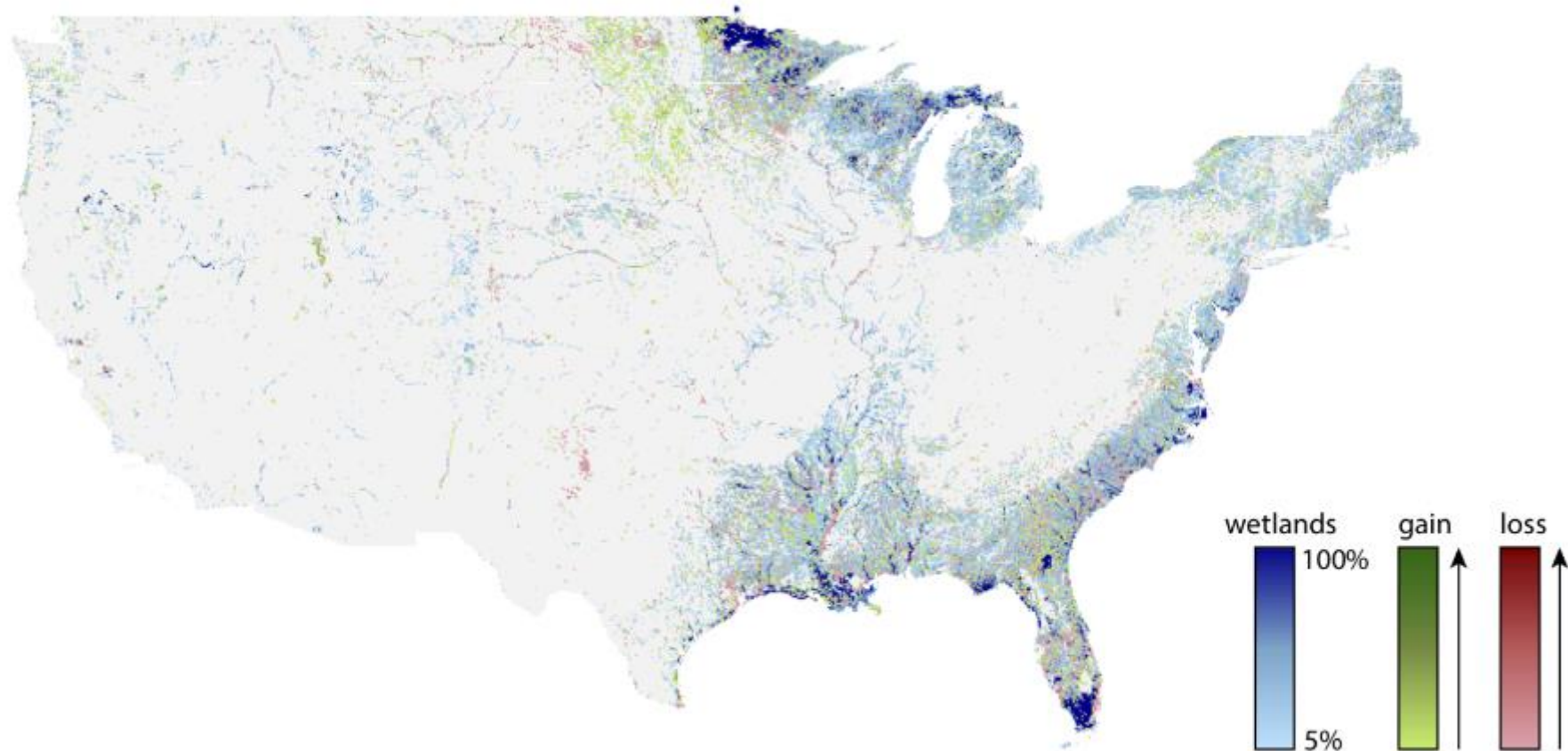
- Evaluate inland and freshwater wetlands (95% of US wetlands)
- Examine more typical flood events (16× more inland floods than hurricane disasters)

EPA cited lack of data-driven evidence of wetlands benefits in 2020 CWA rollback

Research design: How did we estimate the flood mitigation value of wetlands?

Data: National Land Cover Database

Wetland area changes for the period 2001 to 2016



Wetlands span 47 million hectares (6% of conterminous US)

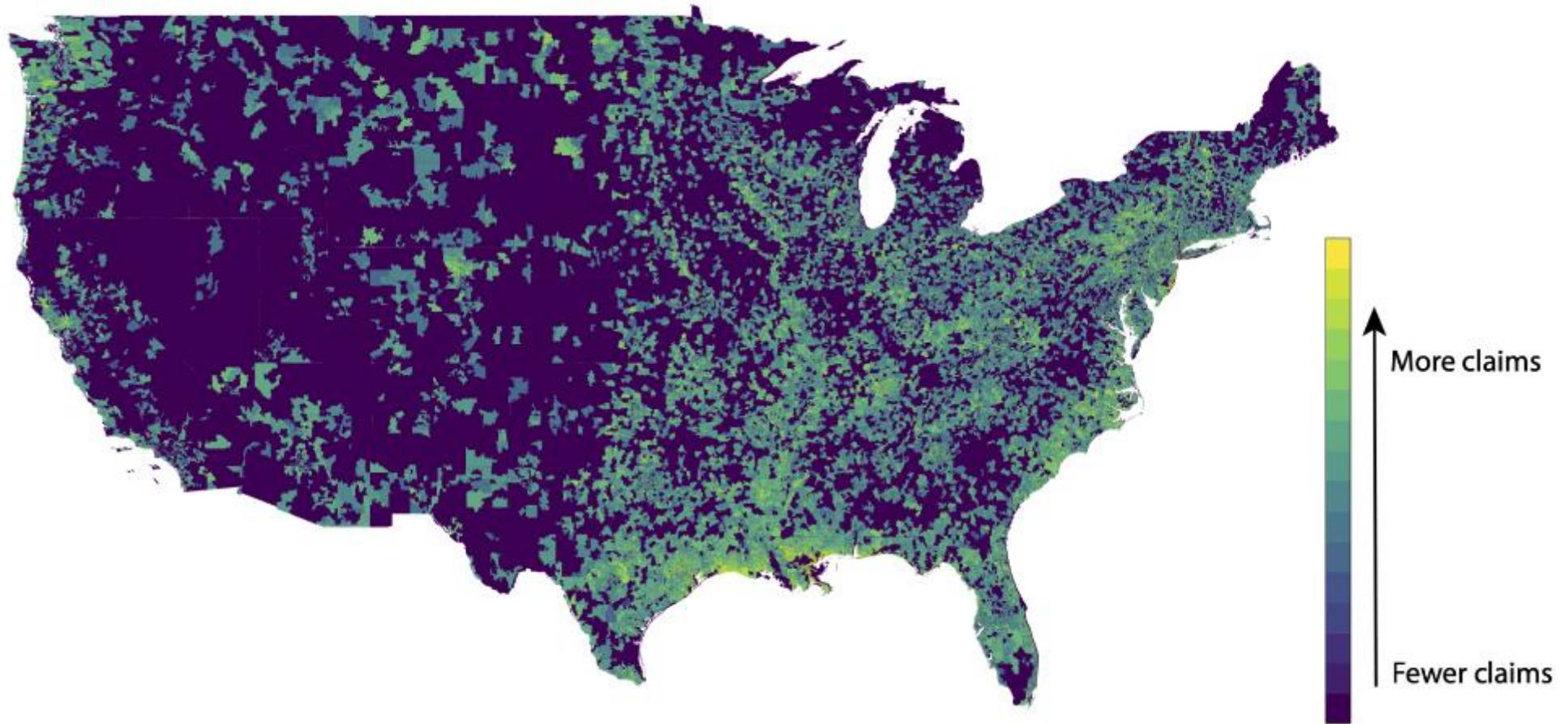
Data: National Hydrography Dataset

Distance of all wetlands from the water surface network



Data: National Flood Insurance Program

Zip code-level flood insurance claims from the NFIP



Research Design

Method 2: Upstream-downstream comparison

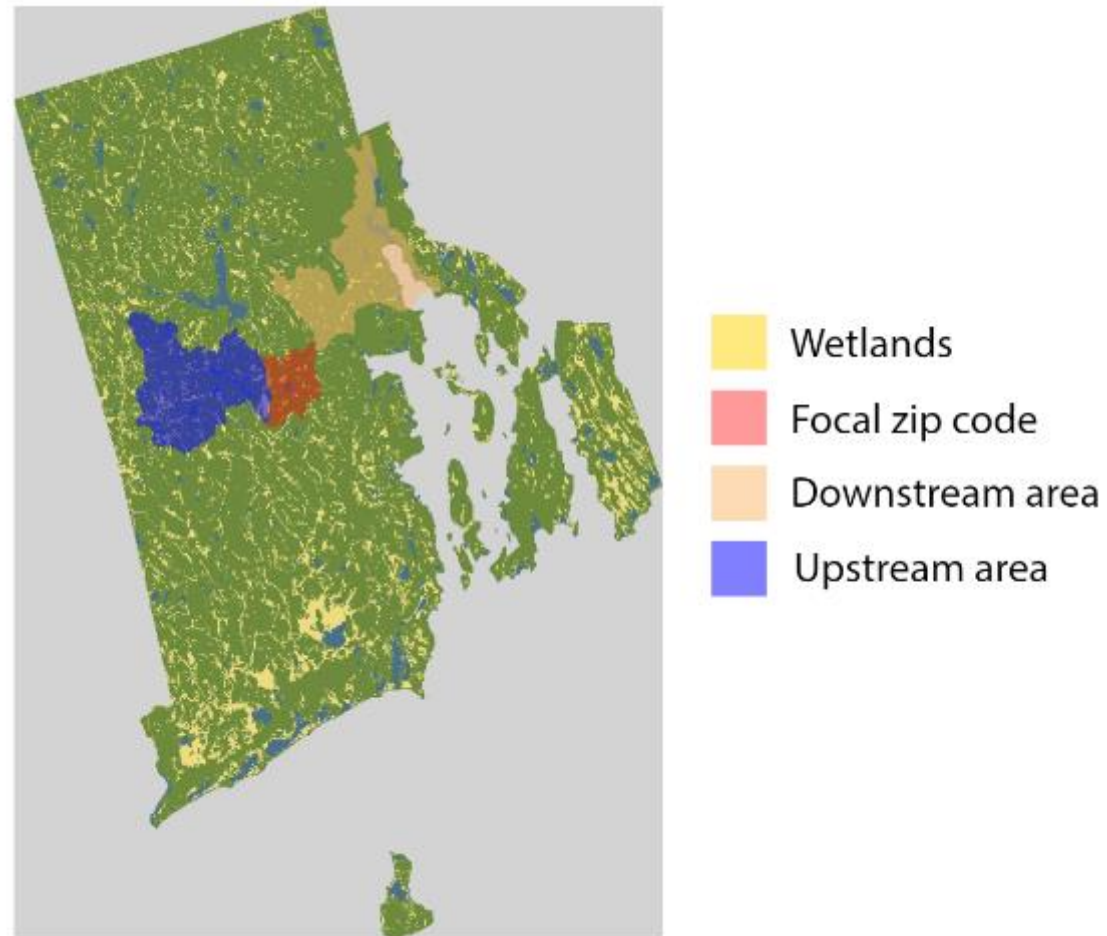
How do changes in upstream wetland area affect damages from flooding relative to changes in downstream wetland area?

→ Intuition: Only upstream wetland area changes should influence flooding



Data: National Hydrography Dataset

Quantify wetland area changes upstream vs. downstream of each zip code



Results: What did we find?

Effect of wetland changes on flood damages

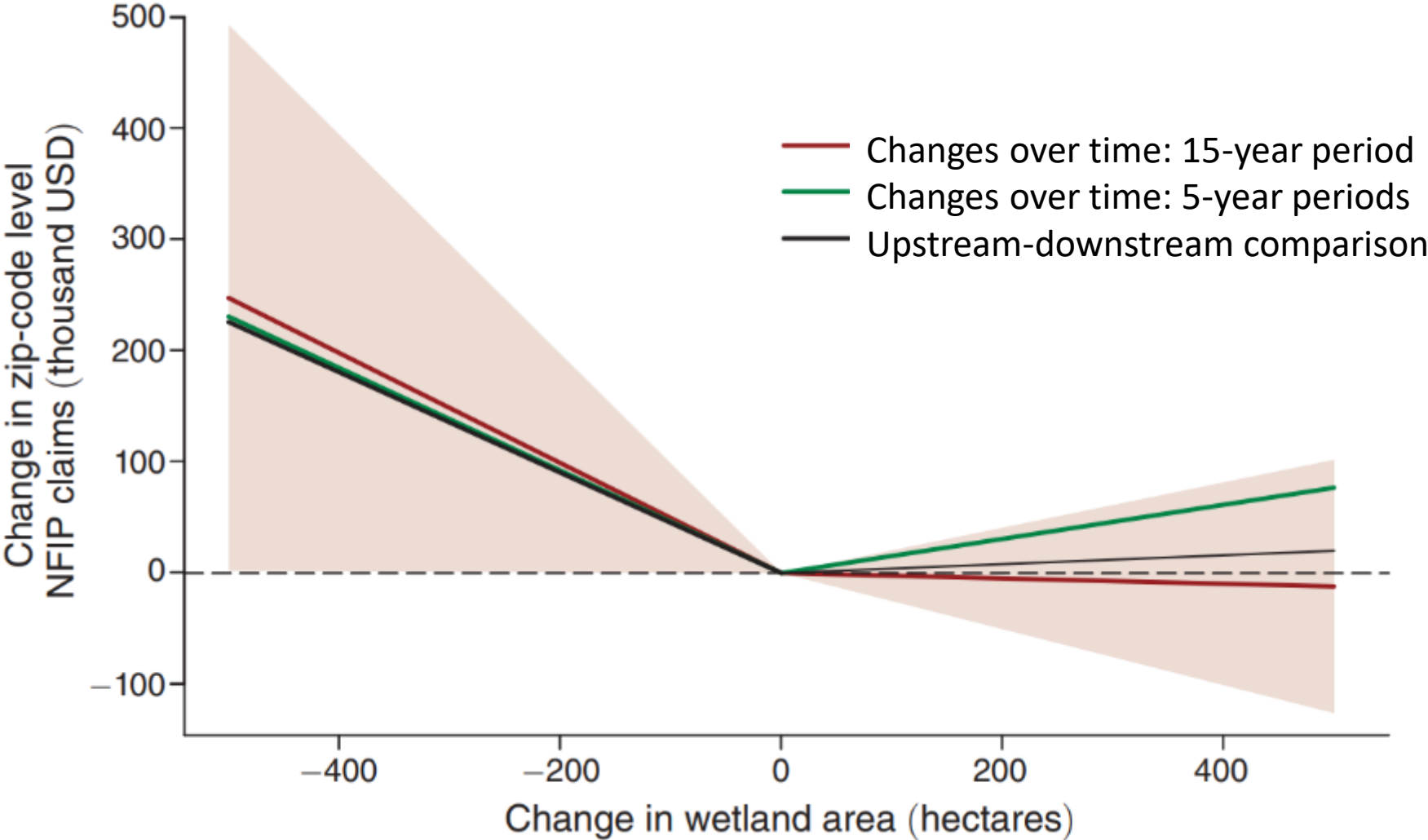
Average effect of losing one hectare of wetlands:

- Increases local flood damages by \$450-\$495/year
- Increases downstream flood damages by \$810/year
- Results are significant at 95% confidence level

Gaining one hectare of wetlands:

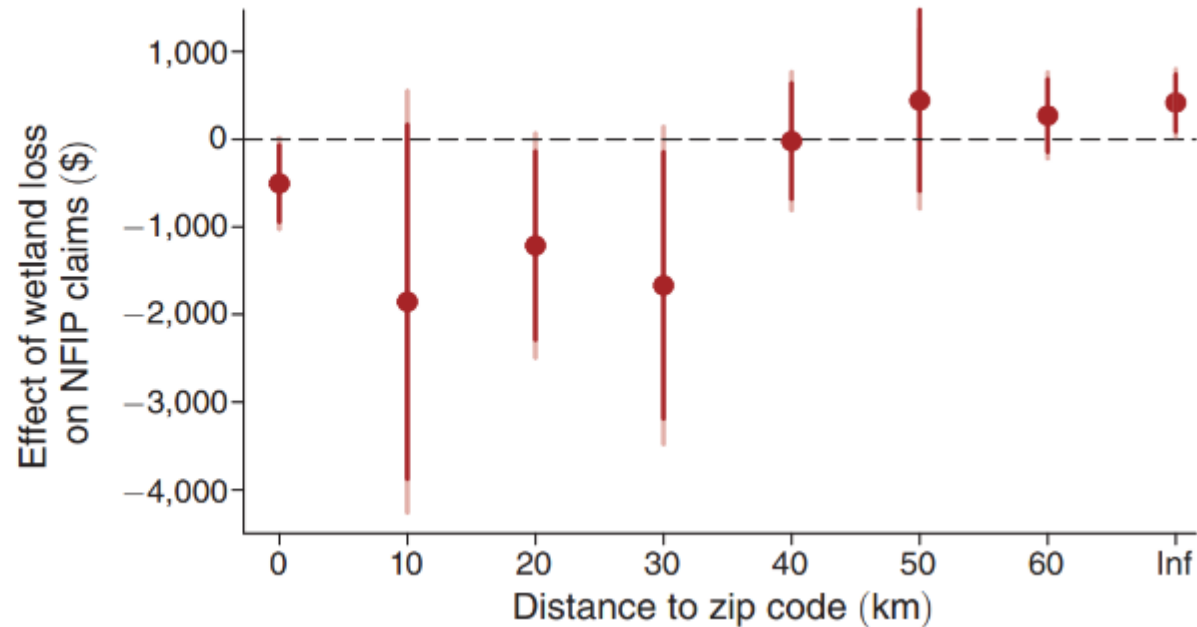
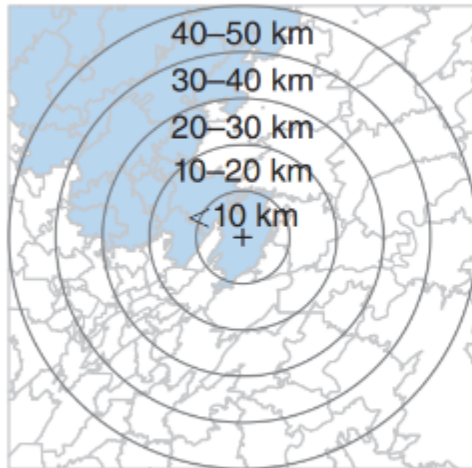
- No detectable effect on local or downstream flood damages

Effect of wetland changes on flood damages



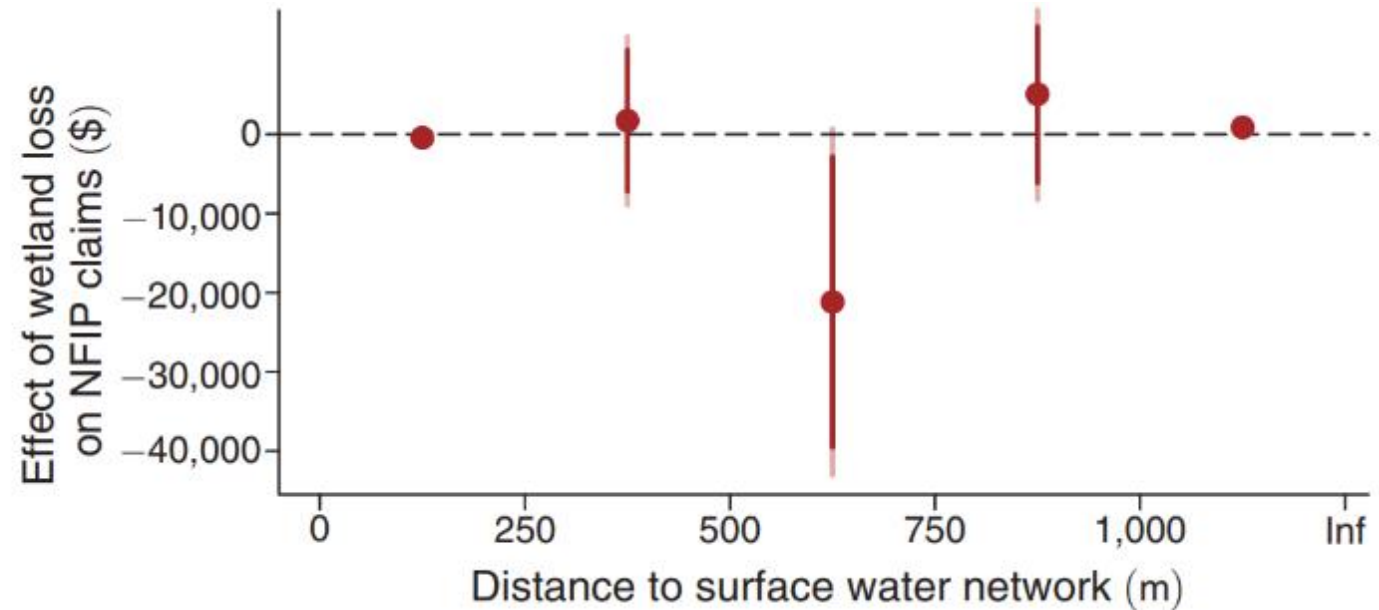
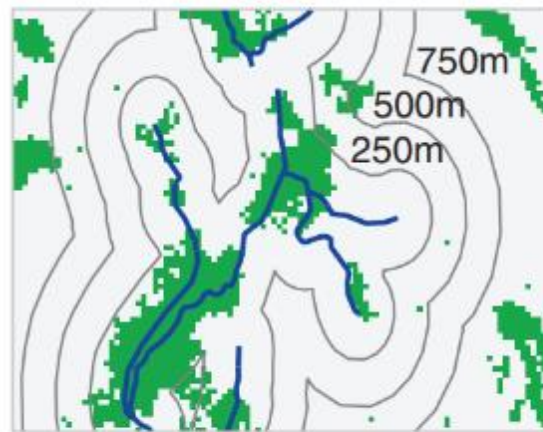
Effect of upstream wetlands

- One hectare of wetland loss increases NFIP claims by **\$1,900** per year
- Value of wetlands to local property owners is < 30% of the total benefits



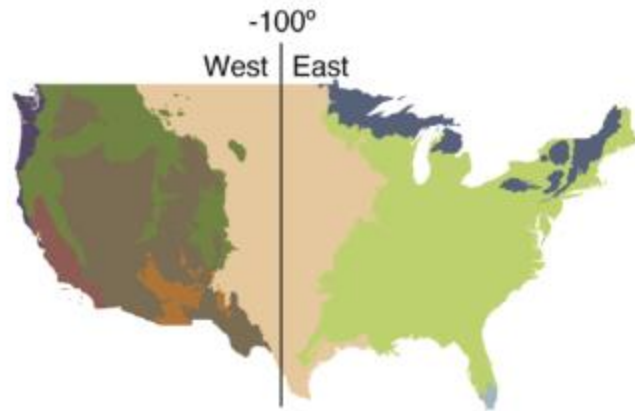
Distance to the surface water network

- Wetlands intermediate distances from water surface network have largest benefits
- Consistent with hydrological concept of wetlands “acting like a sponge”



Variation in wetland values

(1) By ecoregion

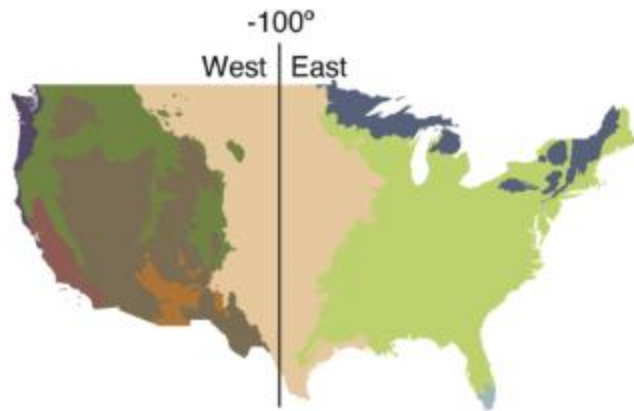


Greatest impact:

- East of 100th meridian
- Great Plains
- Eastern Temperate Forests

Variation in wetland values

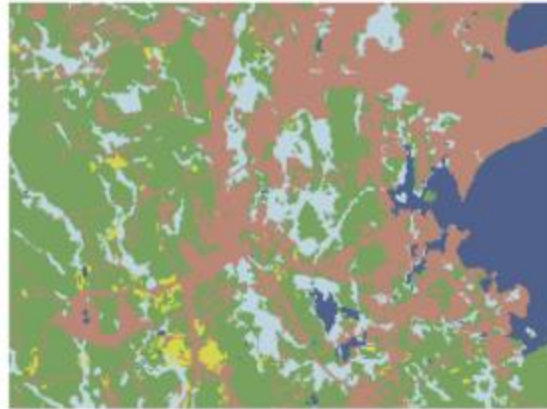
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Greatest impact:

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(2) By ultimate land use

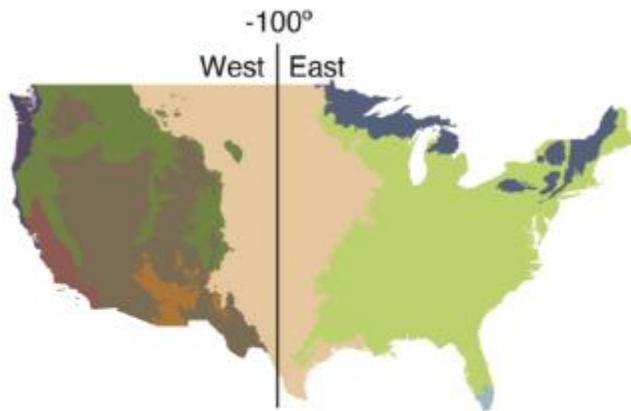


Greatest impact:

- Where wetlands are converted to developed area

Variation in wetland values

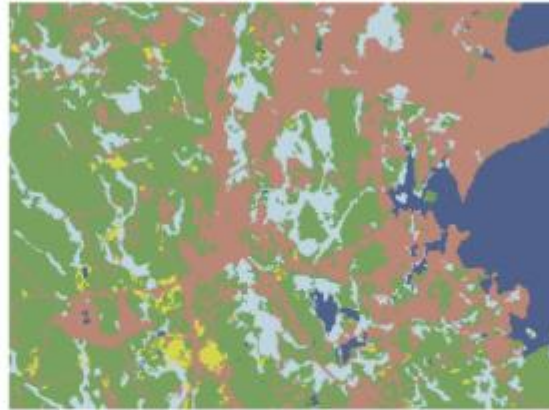
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Greatest impact:

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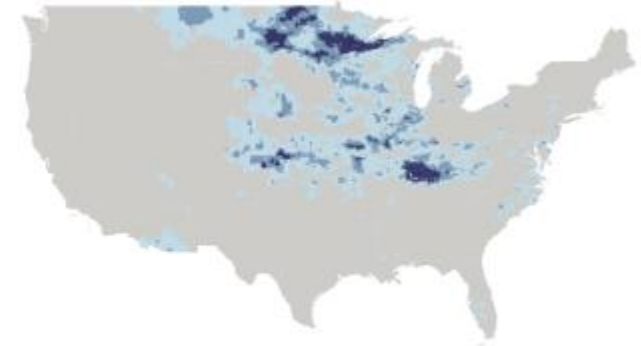
(2) By ultimate land use



Greatest impact:

- Where wetlands are converted to developed area

(3) By precipitation



Greatest impact:

- During extreme rainfall events (3+ sigma monthly rainfall)

Flood mitigation value vs. conservation costs

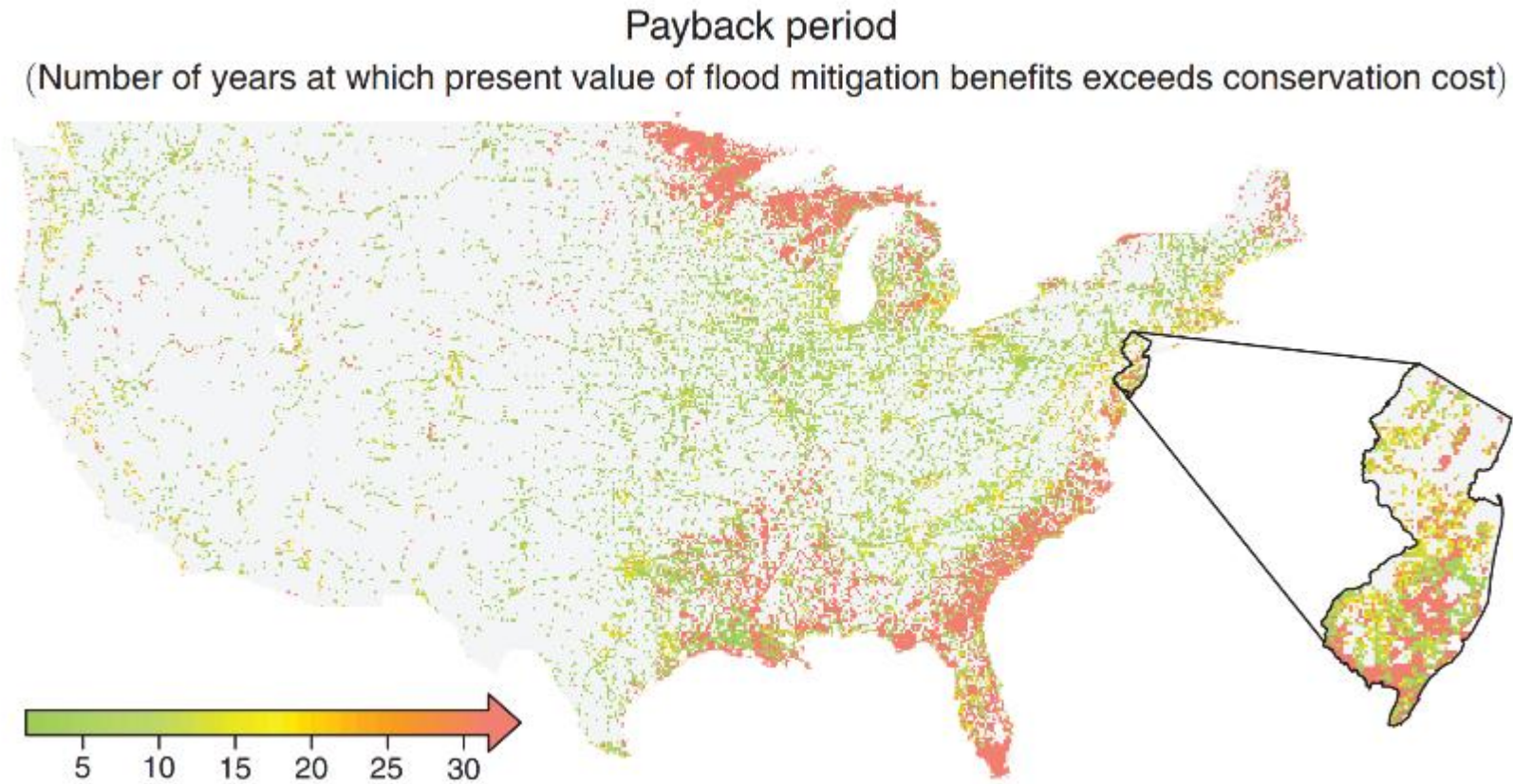
Wetland benefits and conservation costs depend on local development

- Wetland benefits: more exposed properties, higher flood mitigation value
- Conservation costs: More populated areas have higher real estate value

We account for this by:

1. Allowing estimates of wetland values to vary by local levels of development
2. Estimating conservation costs using high-resolution land value maps
 - Mean value across all US wetlands: \$12,700 per hectare
 - Wetlands lost between 2001 and 2016: \$31,6000 per hectare
3. Put costs (one-time) on same footing as benefits (annual) using a **payback period**

Flood mitigation value vs. conservation costs



Map available for viewing and download at hannahdruckenmiller.com/code

Take-aways: Implications for wetland management

Monetary value of wetlands

Estimate the flood mitigation value of wetlands, in monetary terms, so these benefits can be put on the same footing as costs of conservation.

We find that losing one hectare of wetlands (size of 2.5 football fields):

- Increases flooding insurance claims by \$1,840 annually
- This number jumps to more than \$8,000 in developed areas
- And more than \$12,000 if the wetland converted to built-up land

The 47 million hectares of wetlands in the US are worth **\$1.2-\$2.9 trillion**

Downstream benefits

Most flood mitigation benefits accrue to non-local users

- Tension between private property owners right to develop their land and public good of conserving wetlands
- Putting wetlands in public trust would preserve these benefits

For ~50% of US wetland area, the societal benefits from reduced flooding outweigh the cost of buying the land within 5 years.

Can we offset wetland losses?

We find no effect of gains in wetland area on flood insurance claims

- Calls compensatory mitigation into question
- Emphasizes need for conservation of existing wetlands

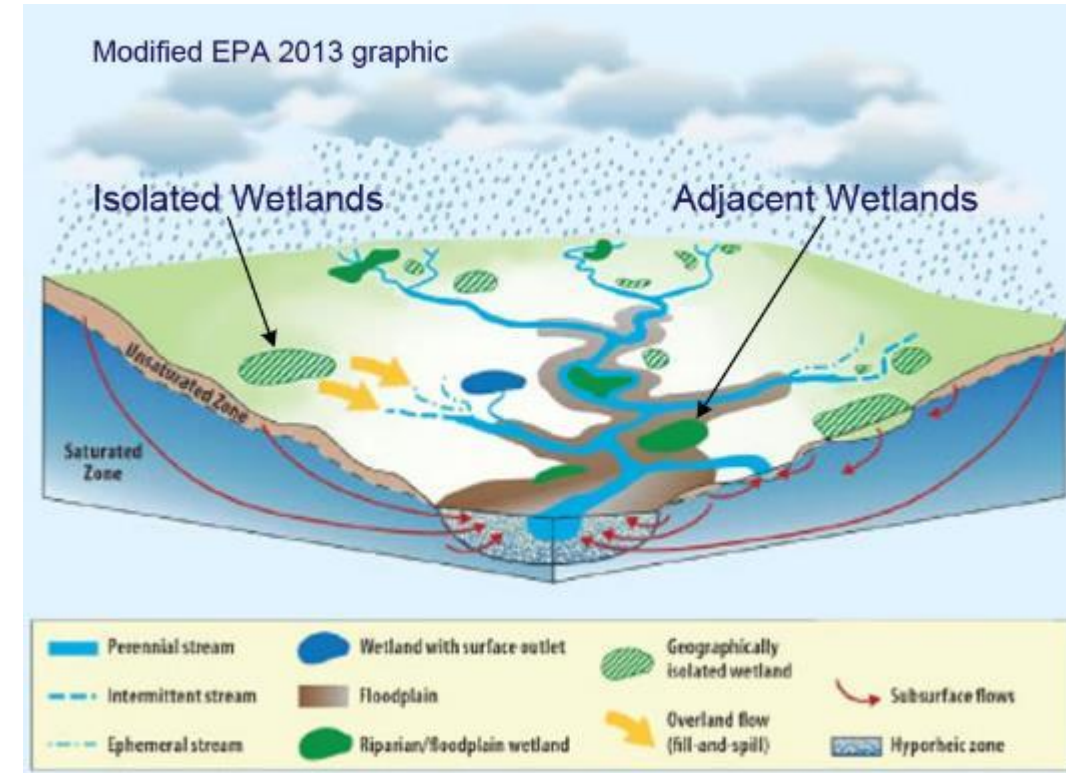
Limitation: We do not directly study compensatory mitigation



“Isolated” wetlands

The most valuable wetlands are located intermediate distances from surface waters

- At odds with the 2020 NWPR
- Better aligns with “adjacency” thresholds of 1,500 feet and 4,000 feet in the 2015 WOTUS interpretation
- Implications for what constitutes a “significant nexus”



Limitation: only part of the picture

Our estimates represent a lower bound on the value of wetlands

We do not capture all protective services from flooding

- We only look at flood insurance claims
- CBO estimates that NFIP claim payments represent 16% of annual flood damages
- With many assumptions, this implies one hectare of wetland loss increases flood damages by \$12,000

Wetlands provide many other ecosystem services

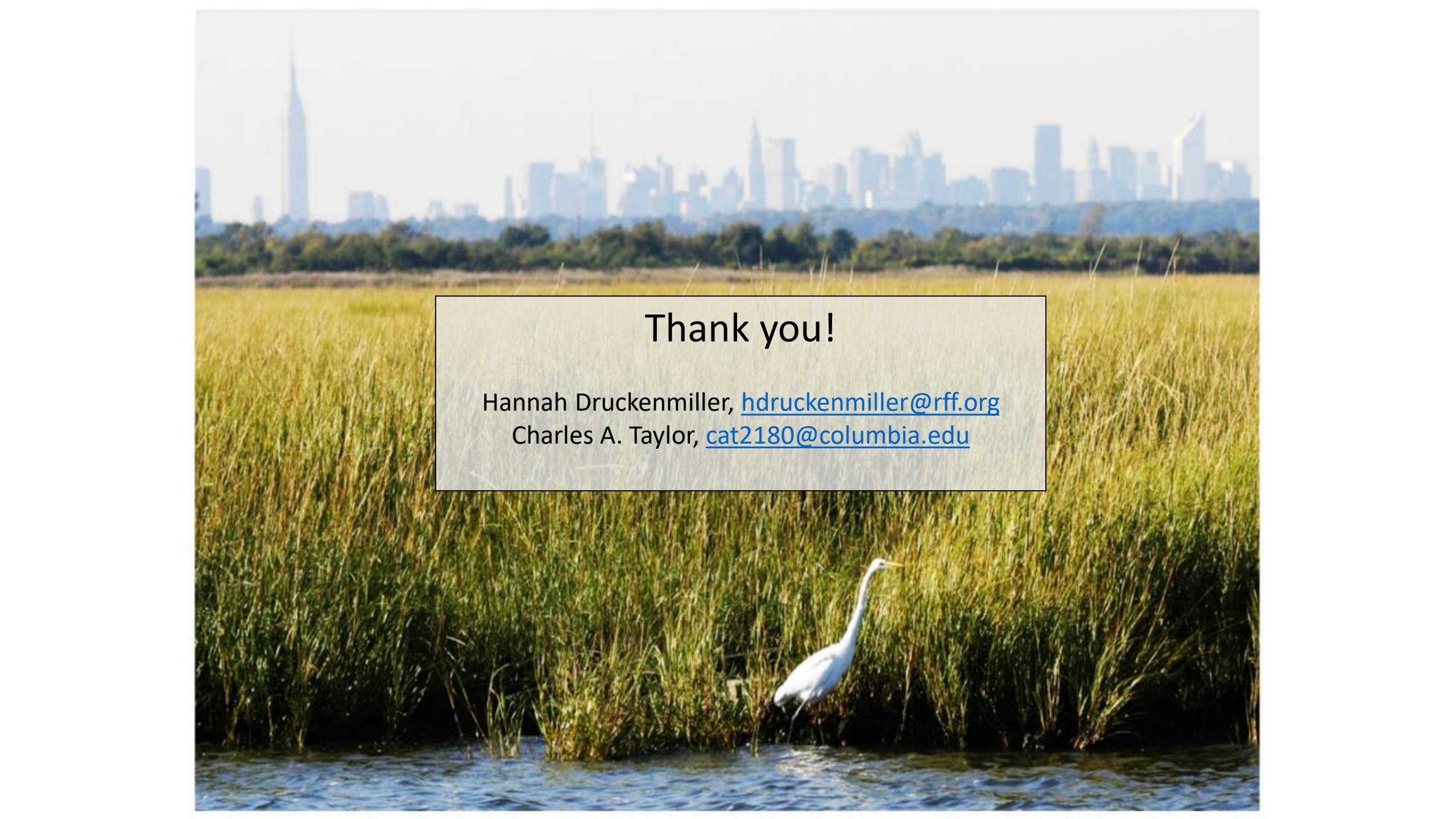
- Fishing, hunting, fur trapping, recreation, water filtration, aesthetics and wildlife habitat
- When researchers have Americans how much they would be willing to pay to conserve wetlands: > \$65,000 per hectare

Conclusion

Even as a lower bound on the value of wetlands, our estimates suggest many wetlands would quickly return the investment of conserving them.

We offer strong evidence for putting additional wetlands in public trust

As flood events intensify with climate change and development pressures continue, efficient flood mitigation policy that properly accounts for wetland-related public good provision becomes increasingly important.



Thank you!

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