Confirming Tidal Marshes as One-Way Outwelling Nutrient Pumps: Observations and Mechanisms

Randall Etheridge, François Birgand, Mike Burchell

Nutrient 'outwelling': A 50 year old tale

Autumn 1962 Ecology, Vol. 43, No. 4

ENERGY FLOW IN THE SALT MARSH ECOSYSTEM OF GEORGIA[1]

JOHN M. TEAL
Woods Hole Oceanographic Institution, Woods Hole, Massachusetts

At the same time the tides remove 45% of the production before the marsh consumers have a chance to use it and in so doing permit the estuaries to support an abundance of animals.

A Research Challenge: Evaluating the Productivity of Coastal and Estuarine Water

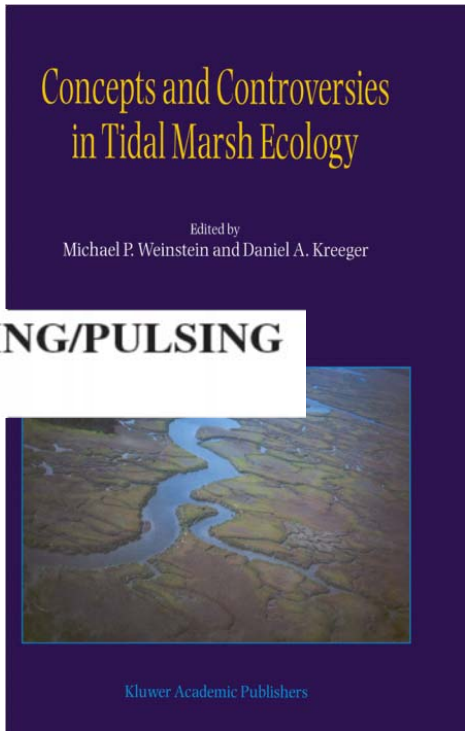
Eugene P. Odum

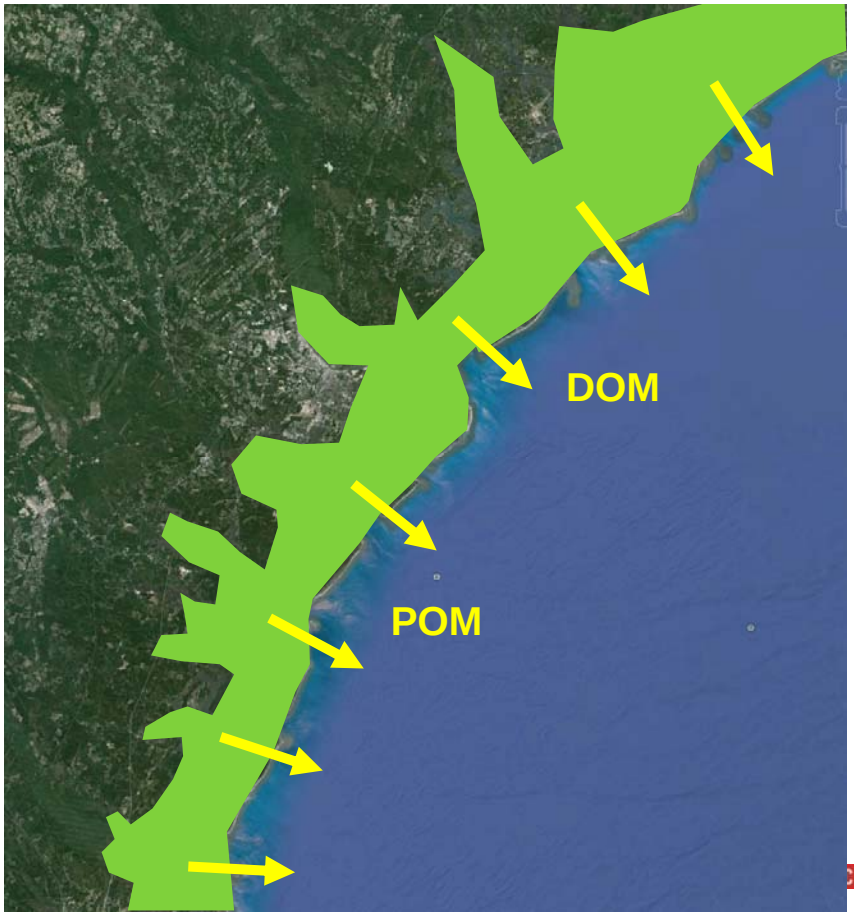
1968.
Proceedings of the 2nd Sea Grant Conference,
University of Rhode Island, Kingston, pp. 63-64.

Most fertile zones in coastal areas capable of supporting expanded fisheries result either from the "upwelling" of nutrients from deep water or from "outwelling" of nutrients and organic detritus from shallow-water nutrient traps such as reefs, banks, seaweed or sea grass beds, algal mats and salt marshes. The importance of the latter as "primary production pumps" that "feed" large areas of adjacent waters has only been recently recognized, and

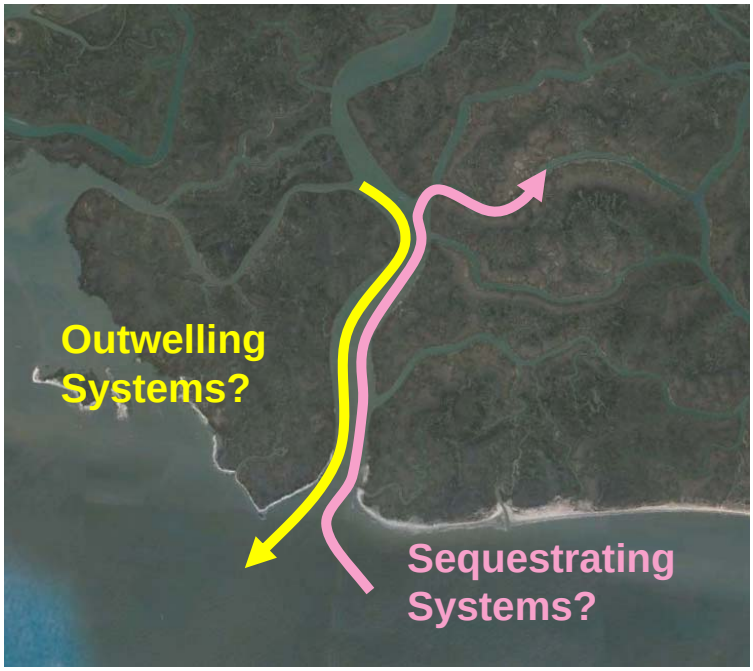
TIDAL MARSHES AS OUTWELLING/PULSING SYSTEMS

Odum, 2002





Google Earth, off the coast of Georgia



Google Earth, off the coast of NC

INTRIGUING DATA FUELING THE DEBATE

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Restored marsh studied

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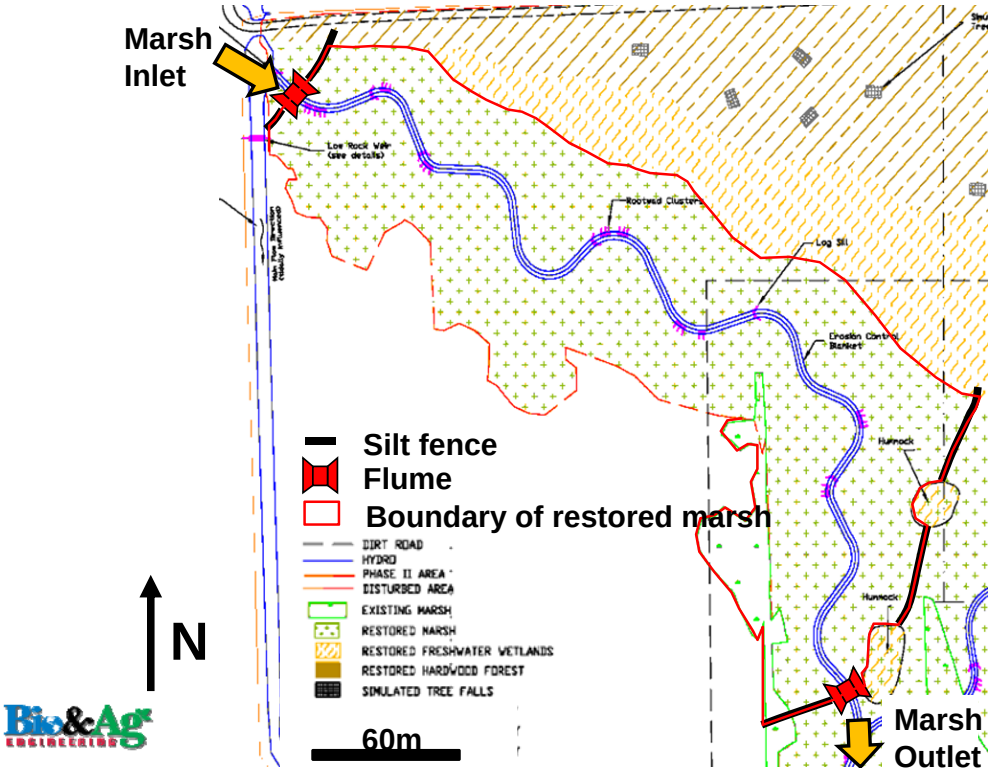
One of the Project Goals

- Ability of a restored coastal marsh to provide ecosystem services, including
  - water quality: dissipate excess nutrients from upstream agricultural drainage

Methods: mass balance



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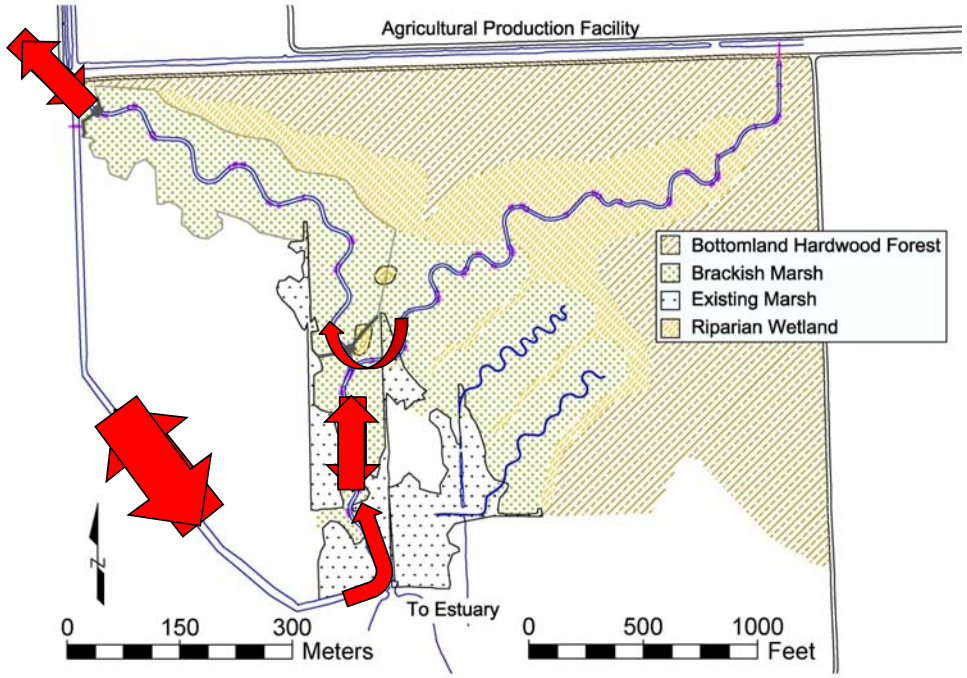
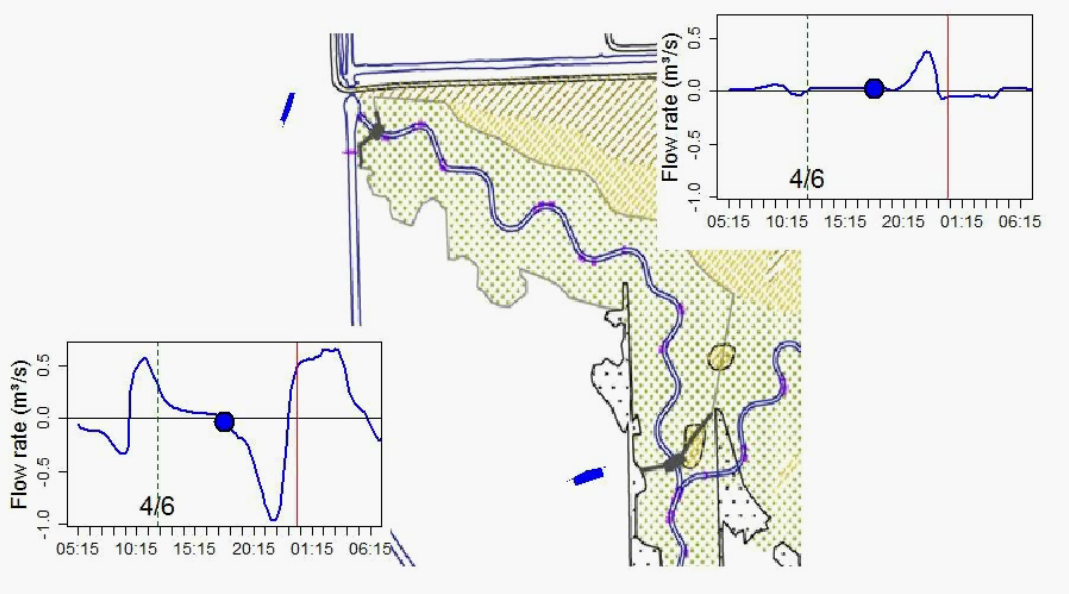
Water Movement in the Marsh



Flow dynamics



Flow Monitoring

- Doppler Velocity and water depth recorded every 15 minutes in flume
- Use manual stream gauging to relate Doppler velocity to actual flow in the flume

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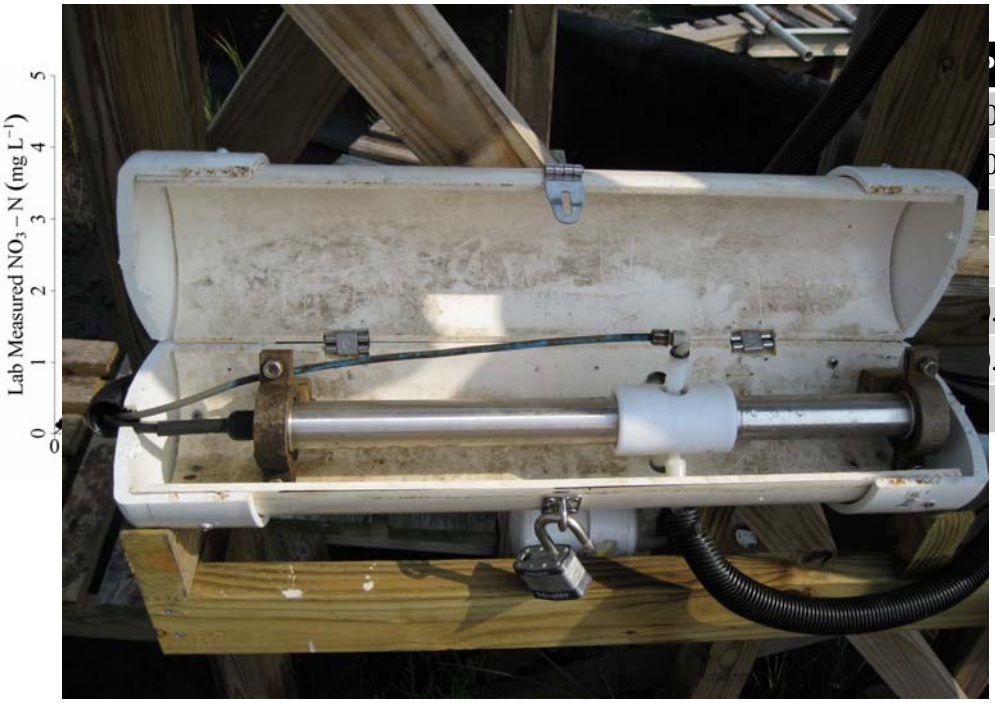
Nutrient Monitoring



P (mg L^{-1})
0.1
0.3
1
7
0.01
0.02
2

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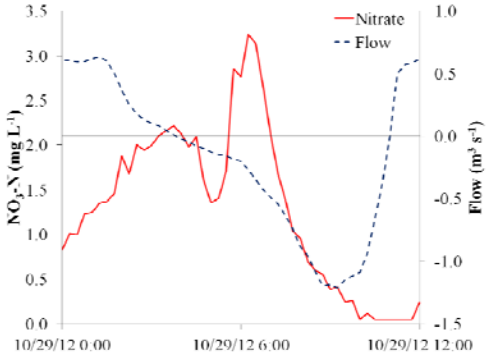
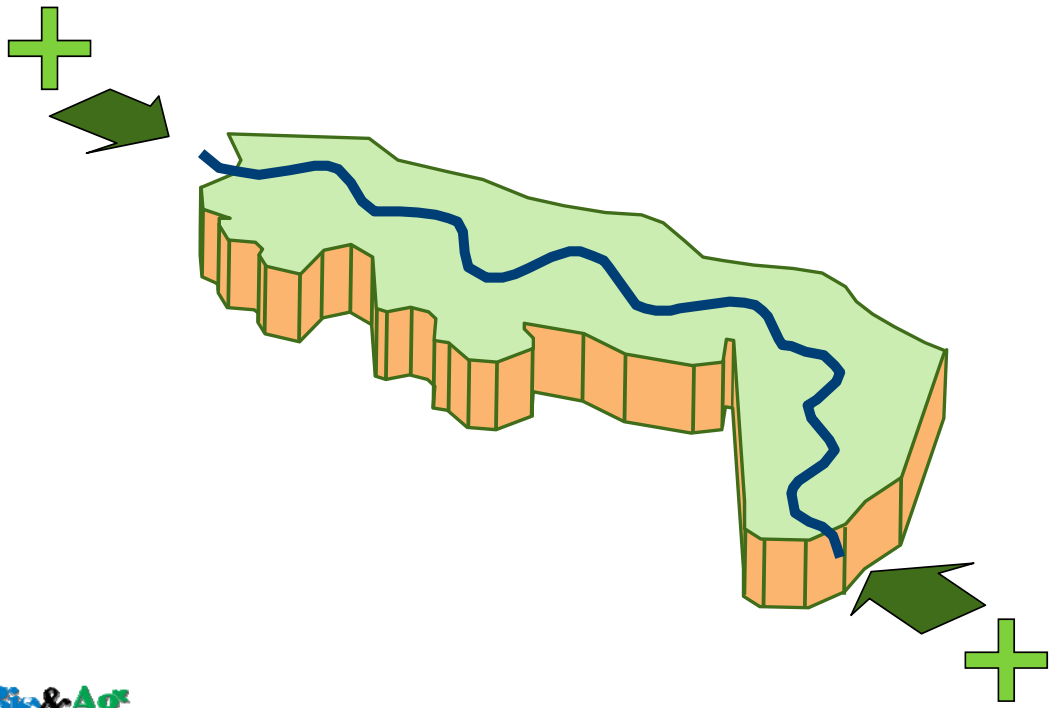
Load calculations

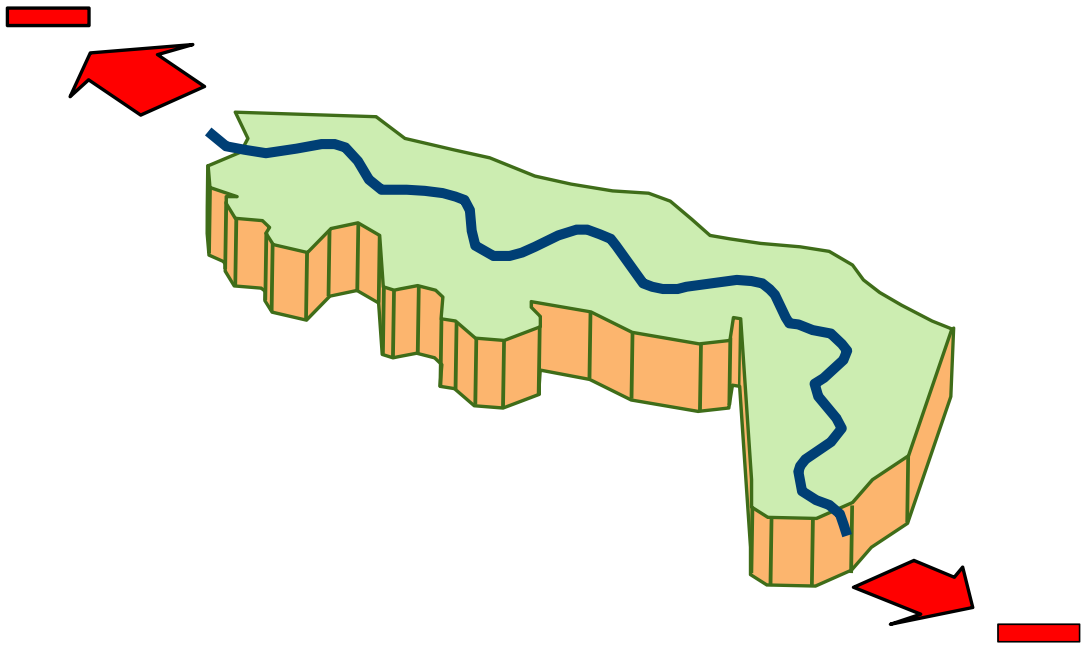
$$M = k\sum_{i=1}^{i=t} q_i c_i \Delta t$$



- M = total mass of N either exported or imported (kg)
- t = time (min)
- k = constant for converting units
- q_i = water flow at time i ($m^3\ s^{-1}$)
- c_i = concentration at time i ($mg\ L^{-1}$)



Positive Mass Balance = Retention
Negative Mass Balance = Release

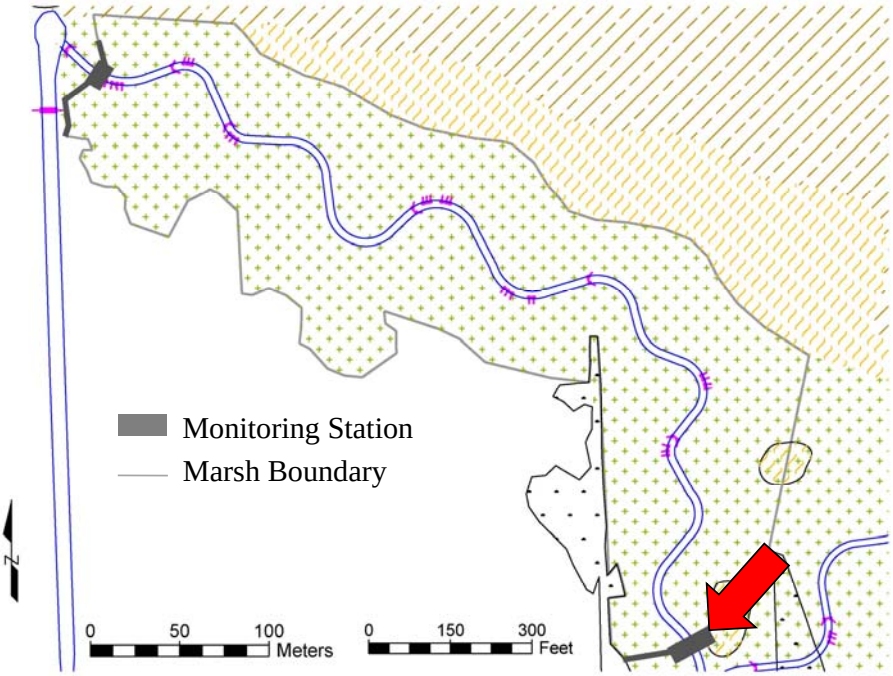


Mass Balance

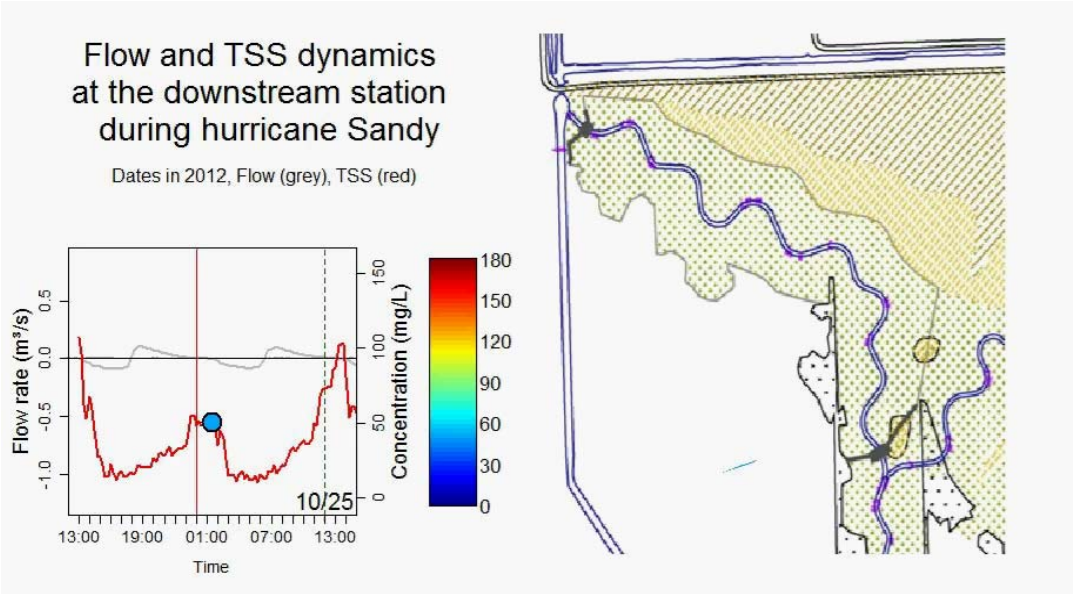
Positive Mass Balance = Retention
Negative Mass Balance = Release

Downstream Station

Long-term results



TSS dynamics



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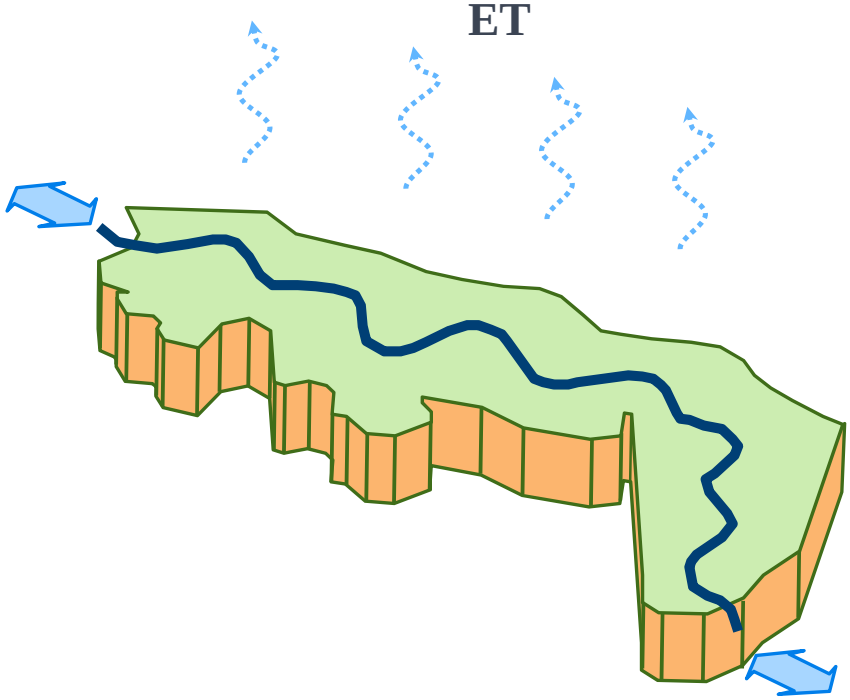

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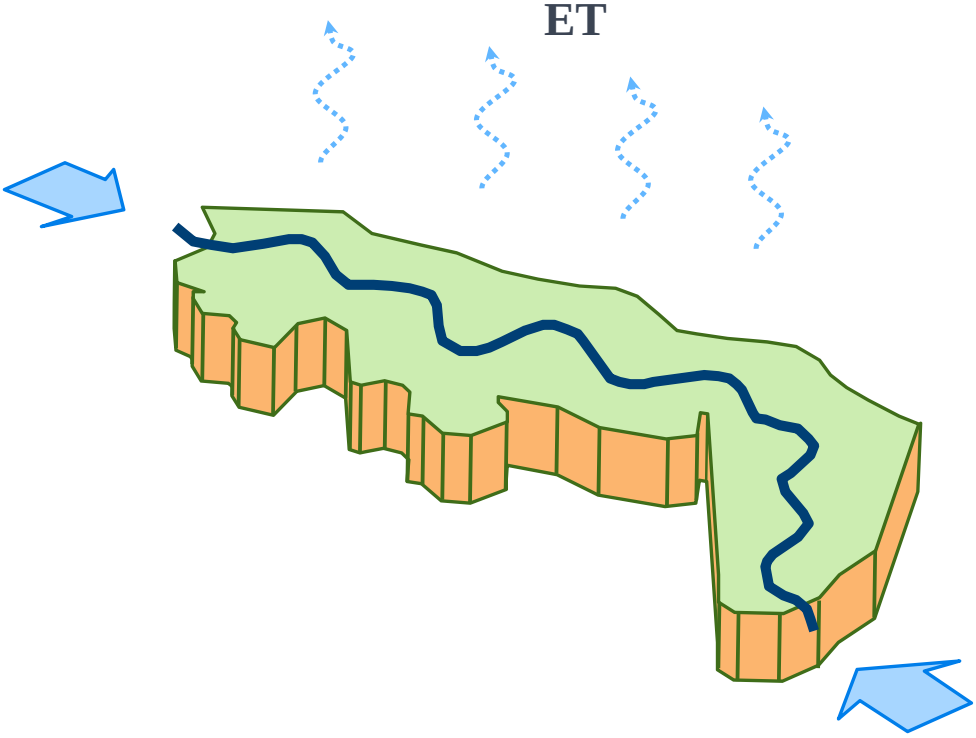
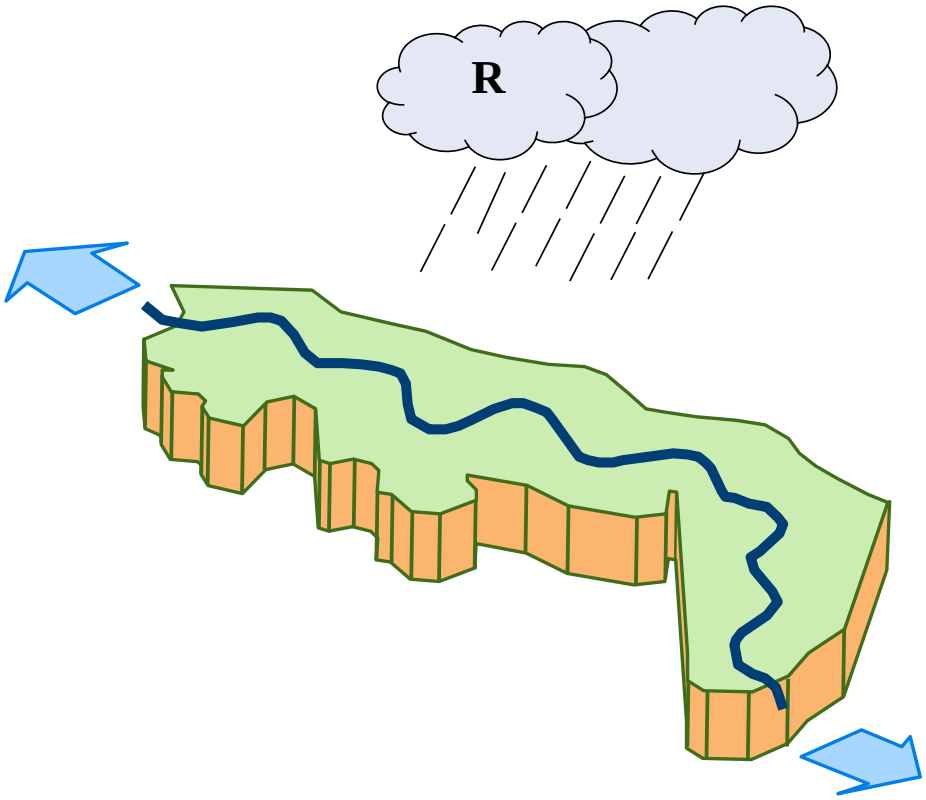
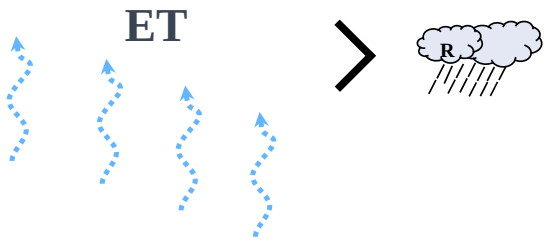
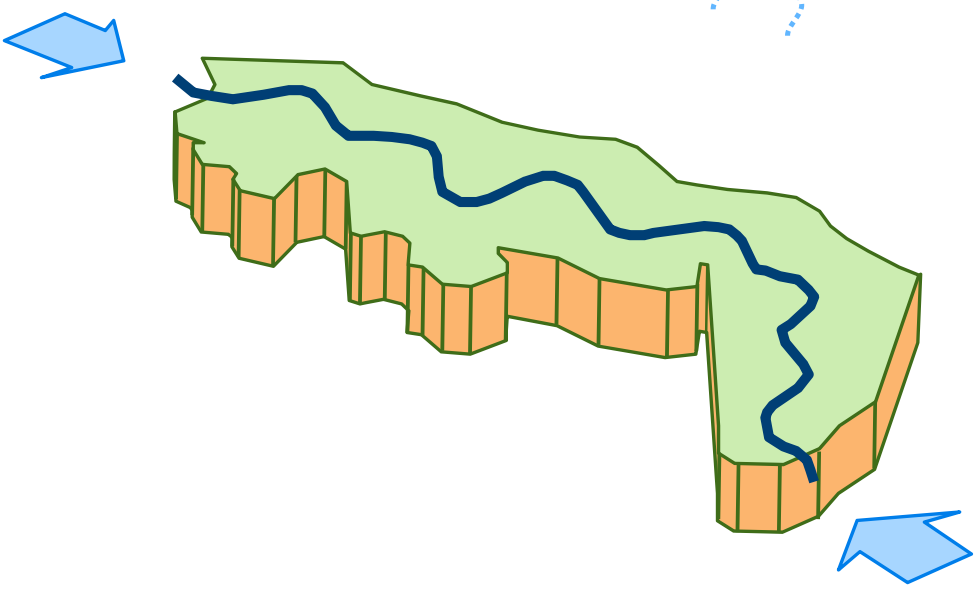




Spring/Summer:





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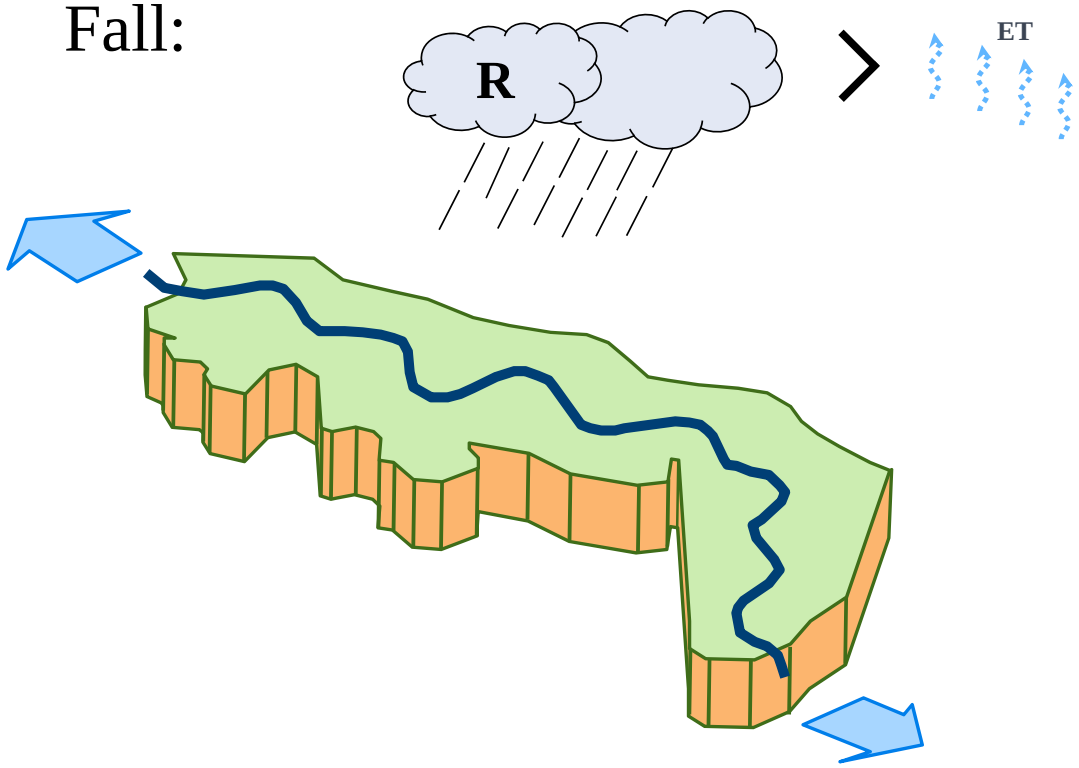
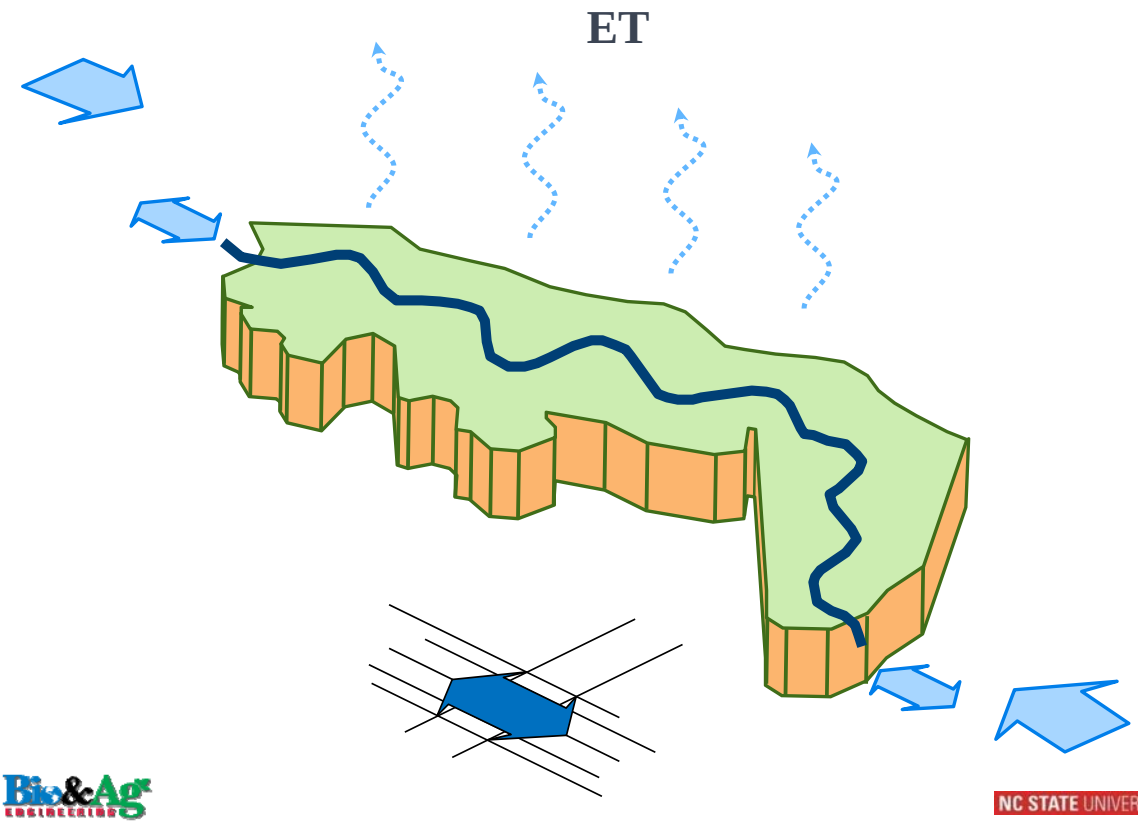
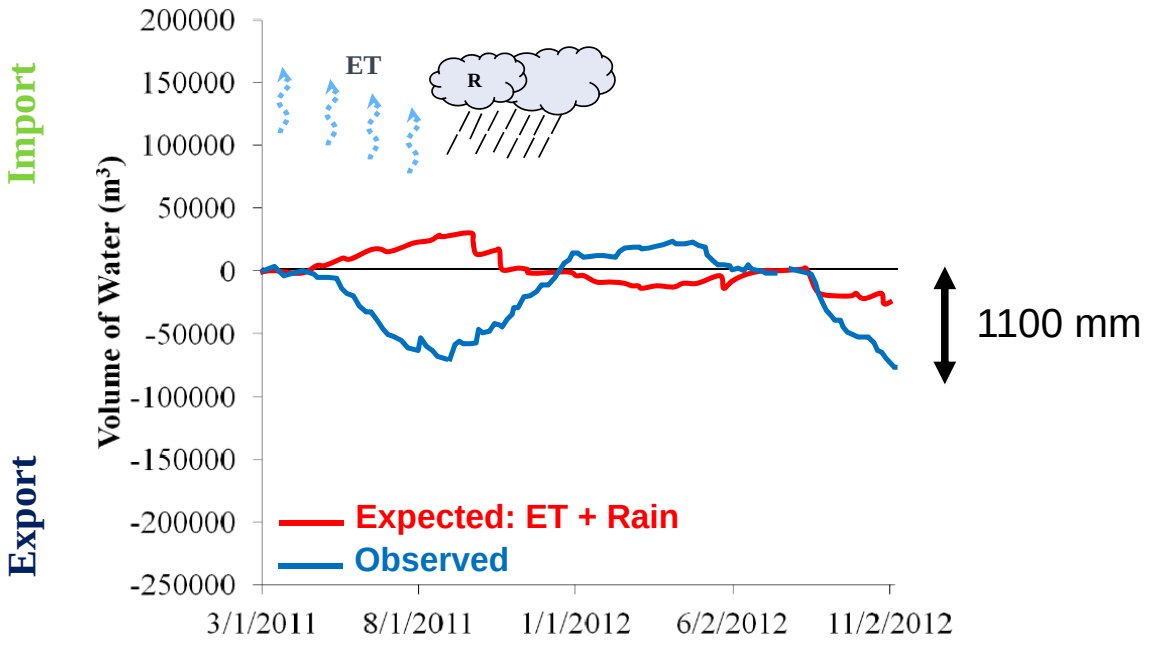


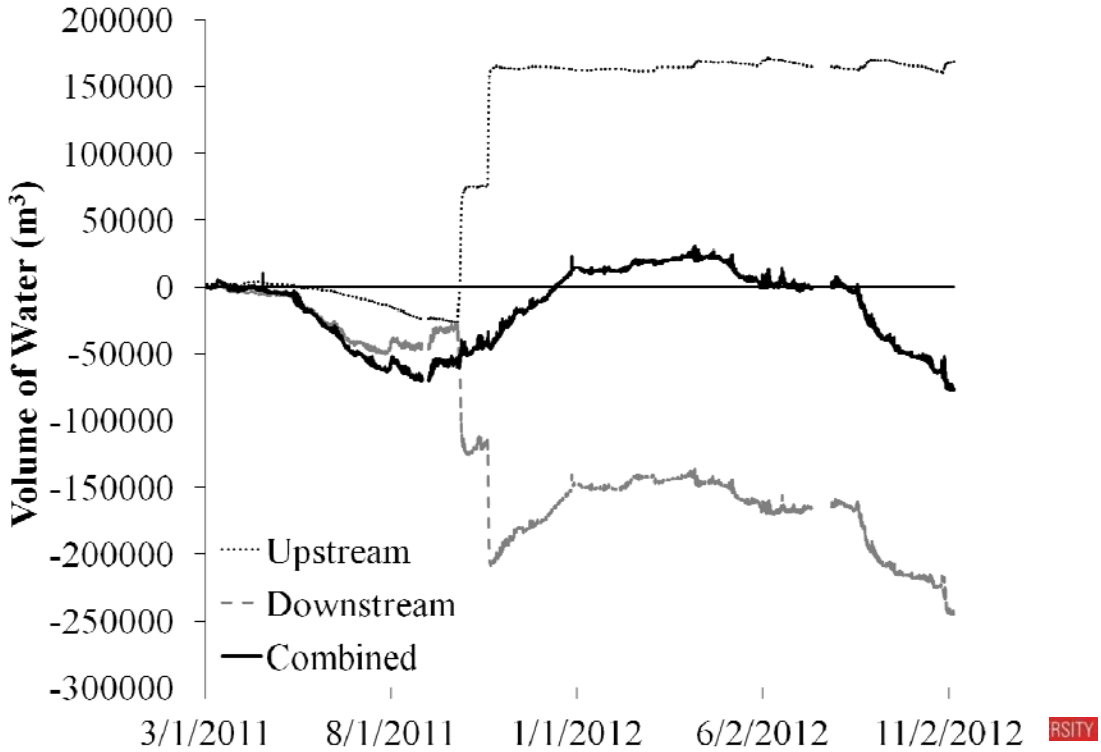


Water balance intrigue…

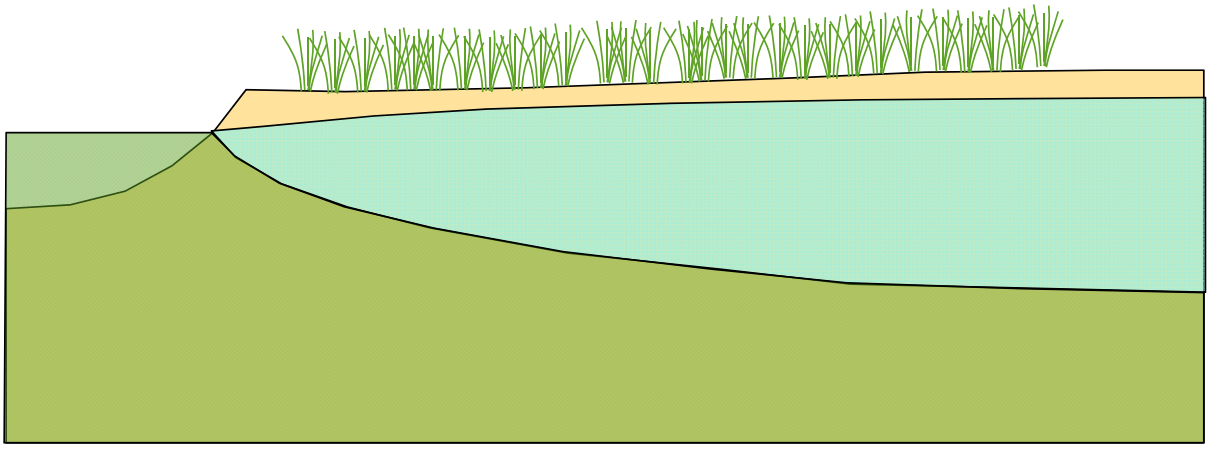


2-way water pump!

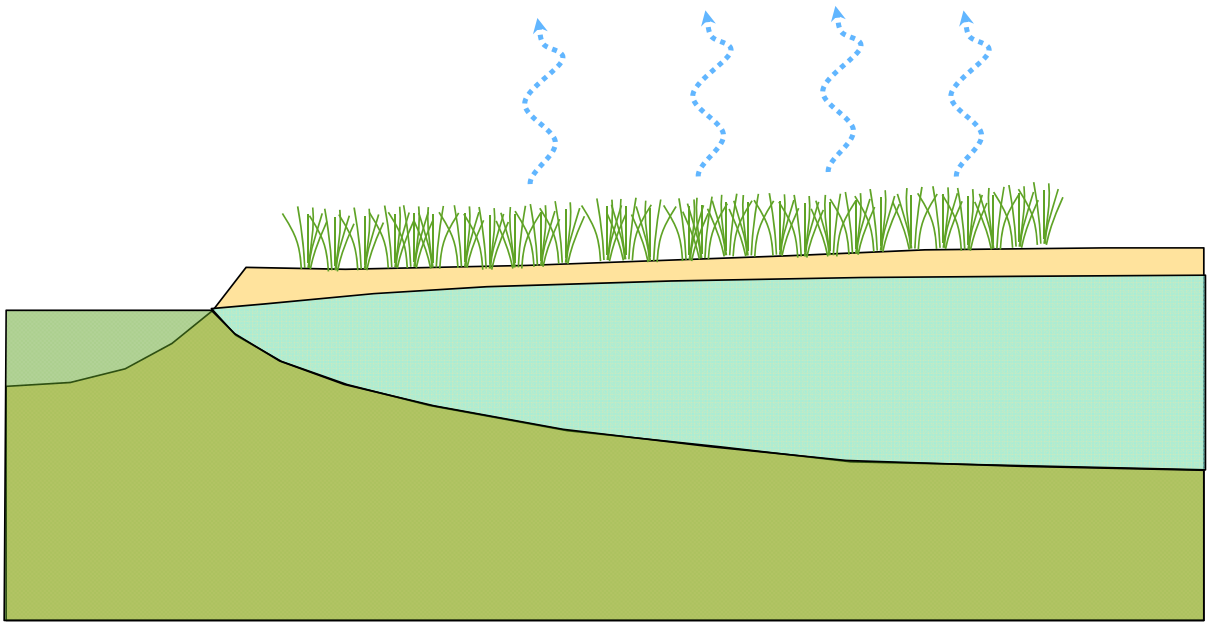
Water Balance at the Flow Stations



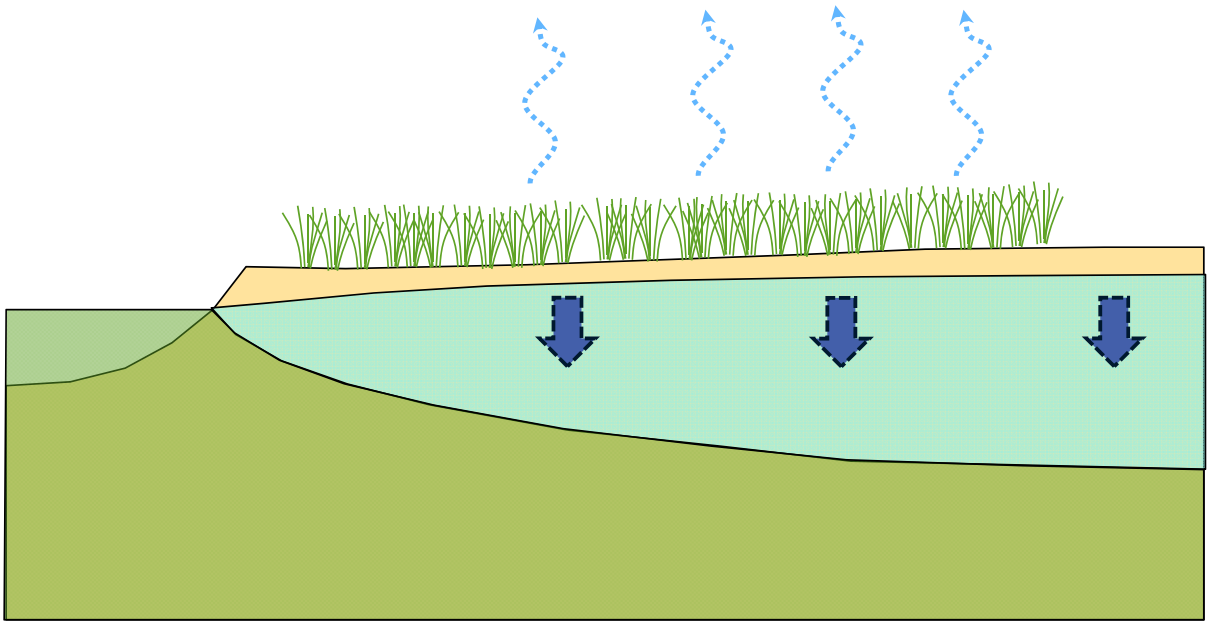
What mechanism?



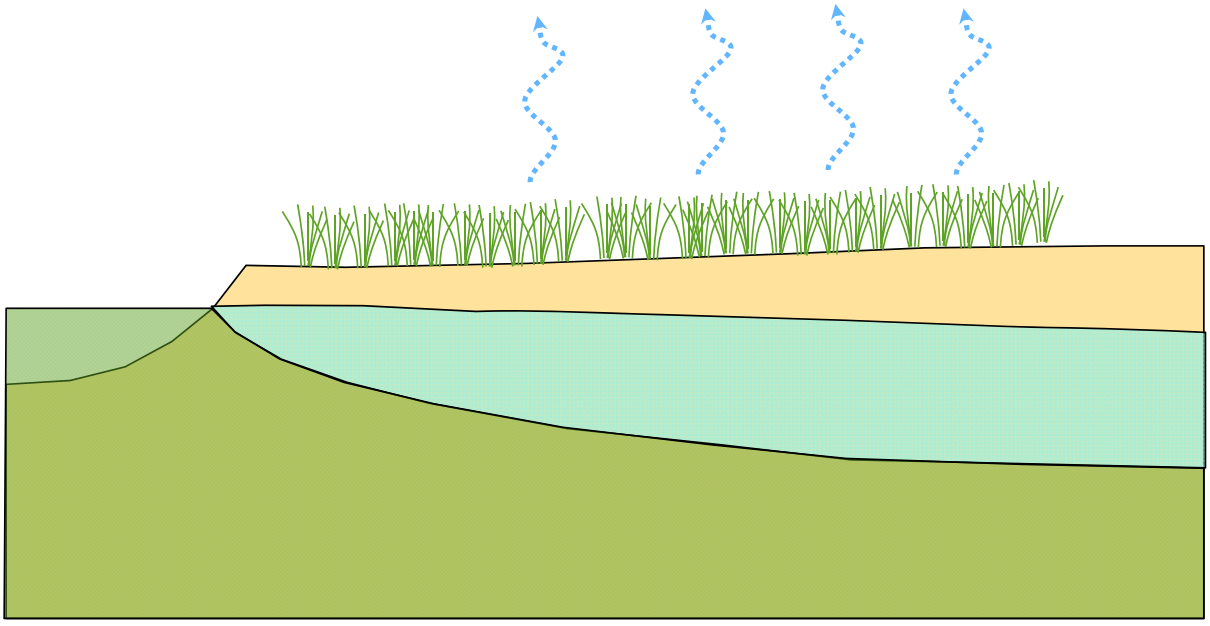
Spring-Summer



Spring-Summer



Spring-Summer



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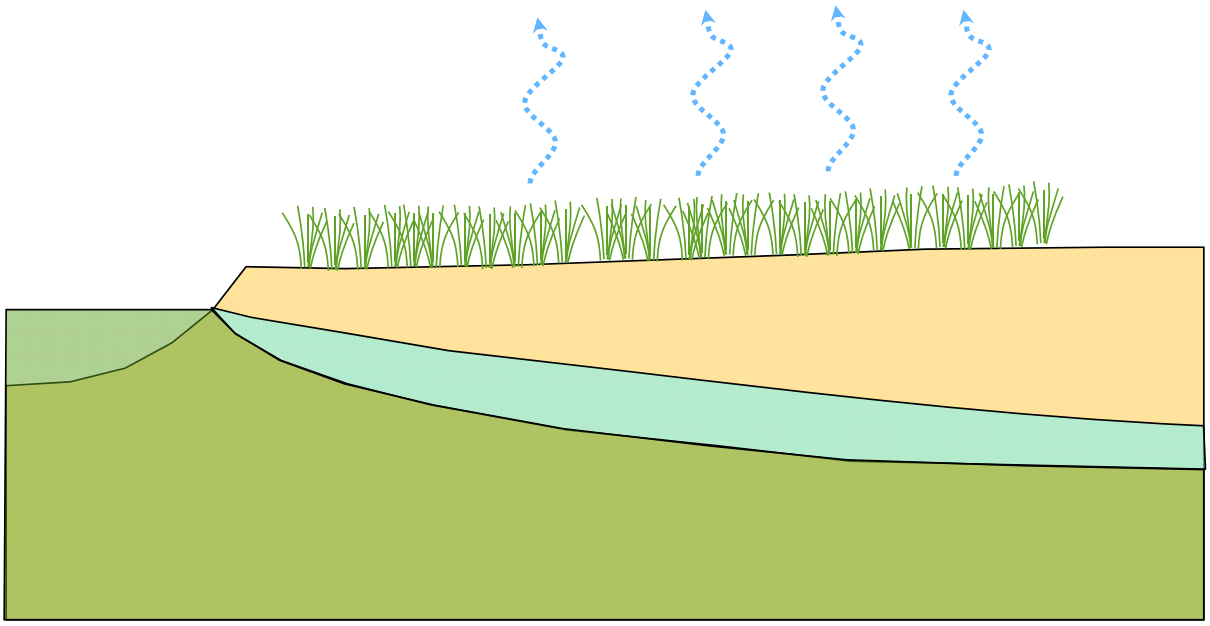
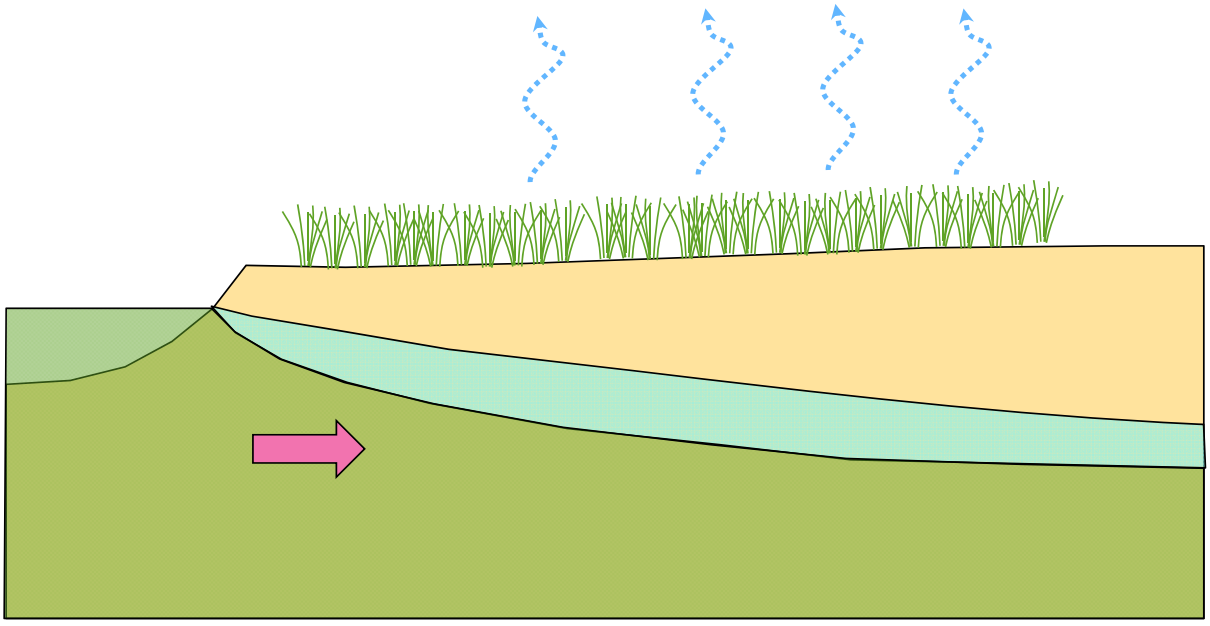
Spring-Summer



Spring-Summer



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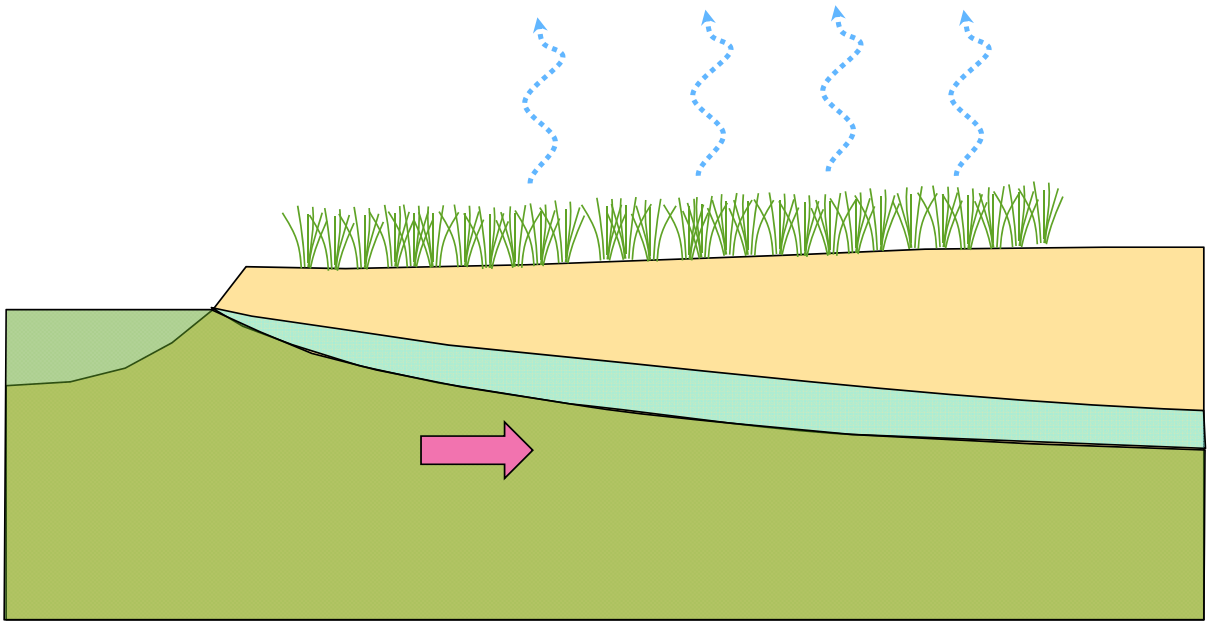

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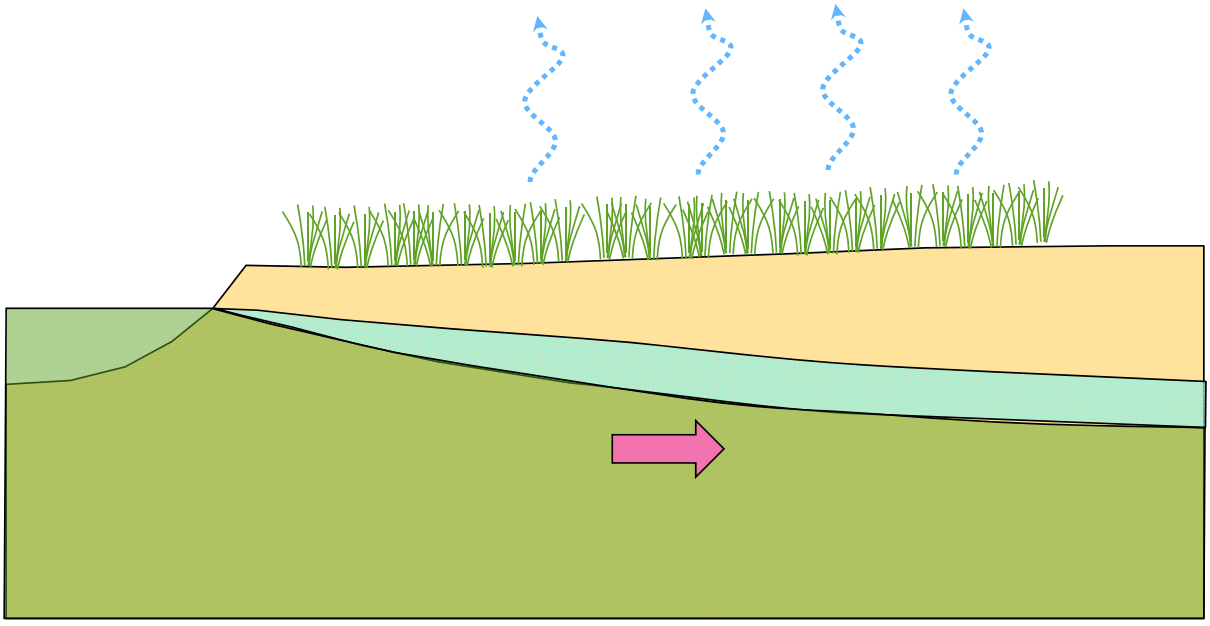
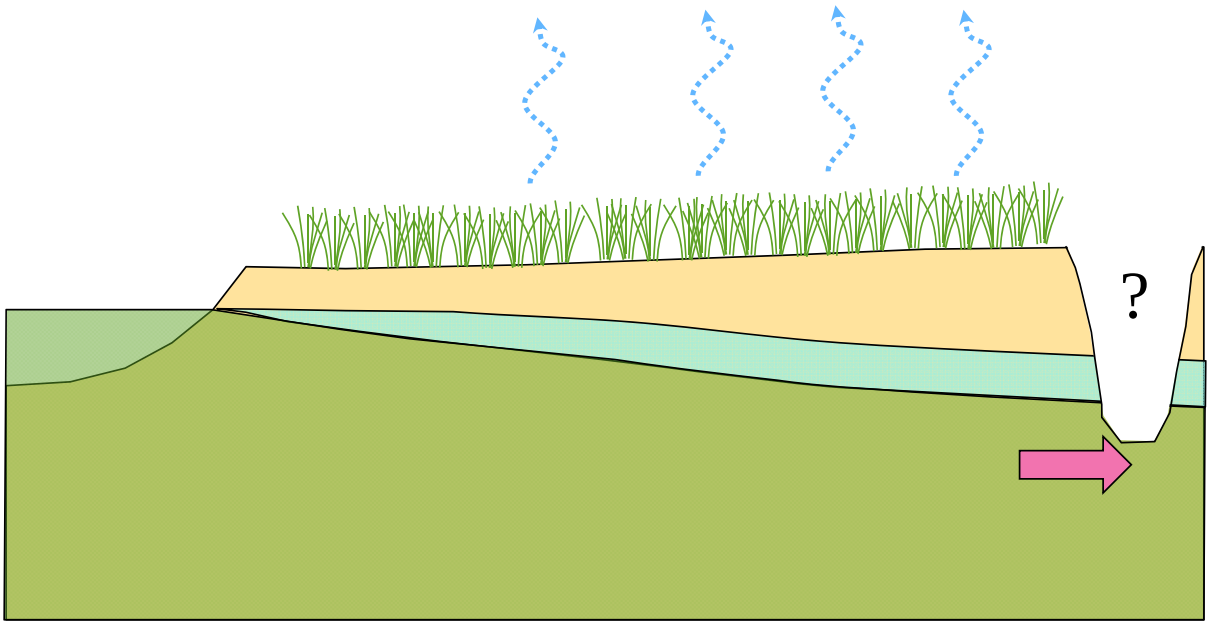


Spring-Summer



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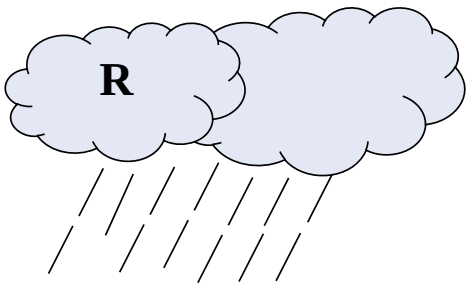

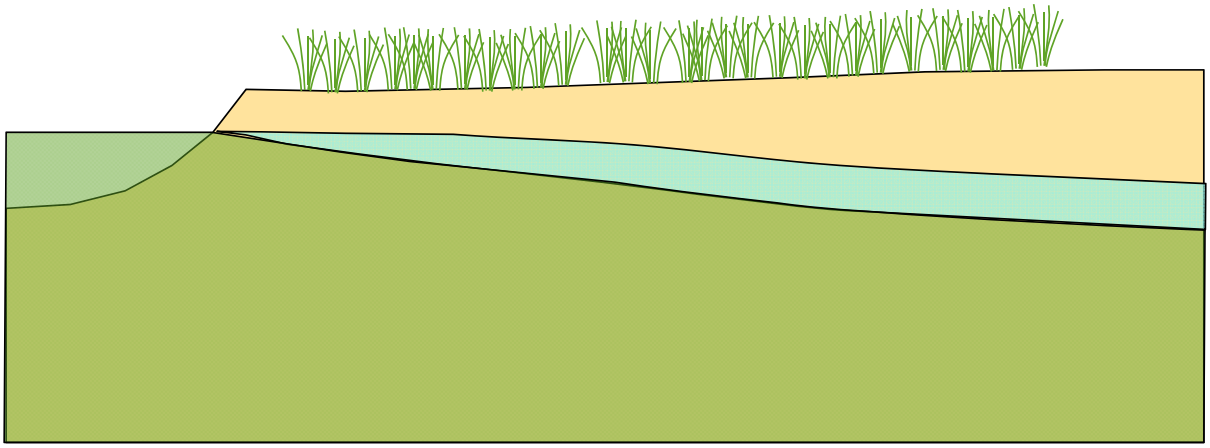

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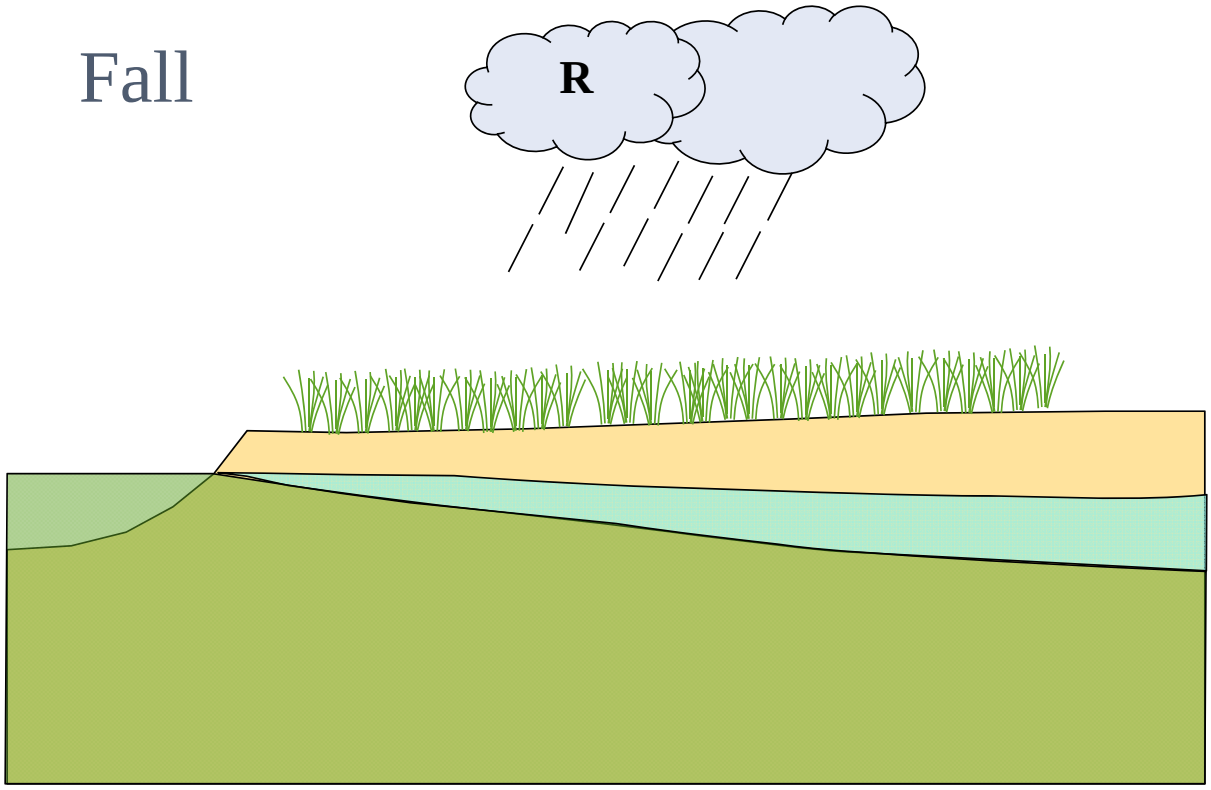
Fall



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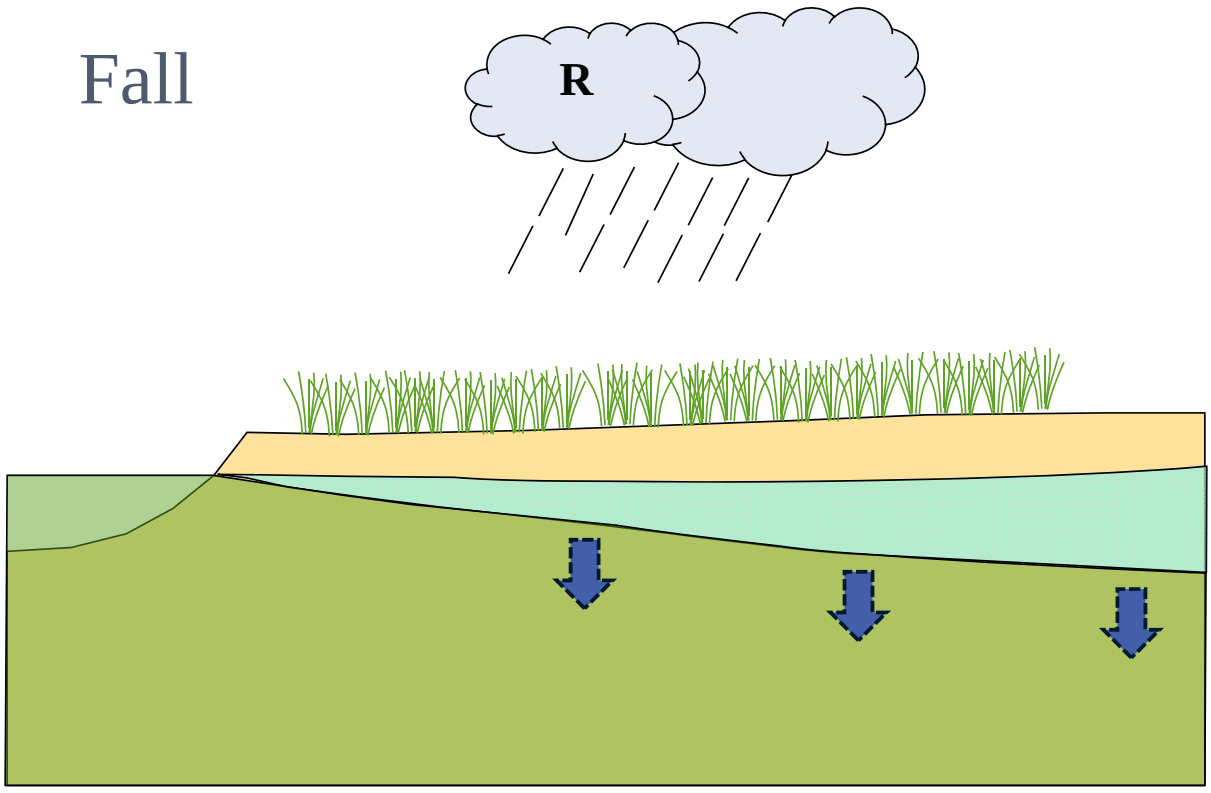

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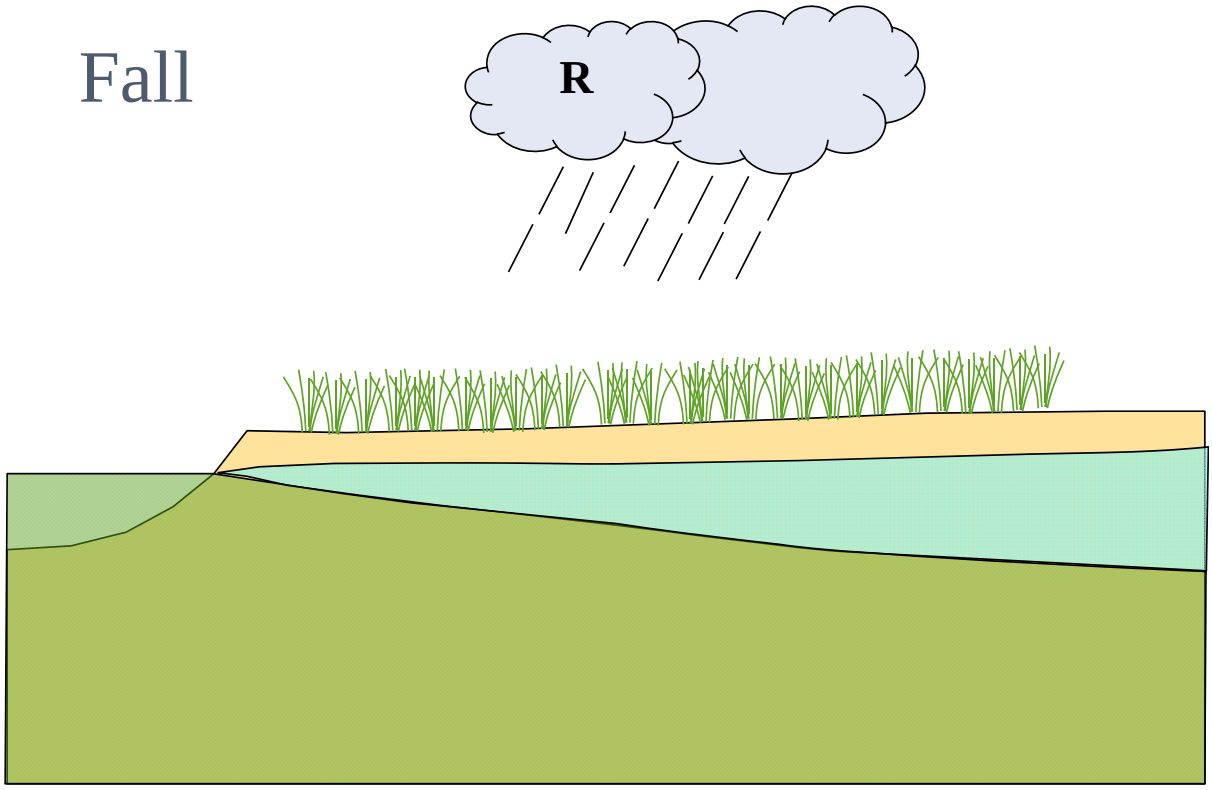

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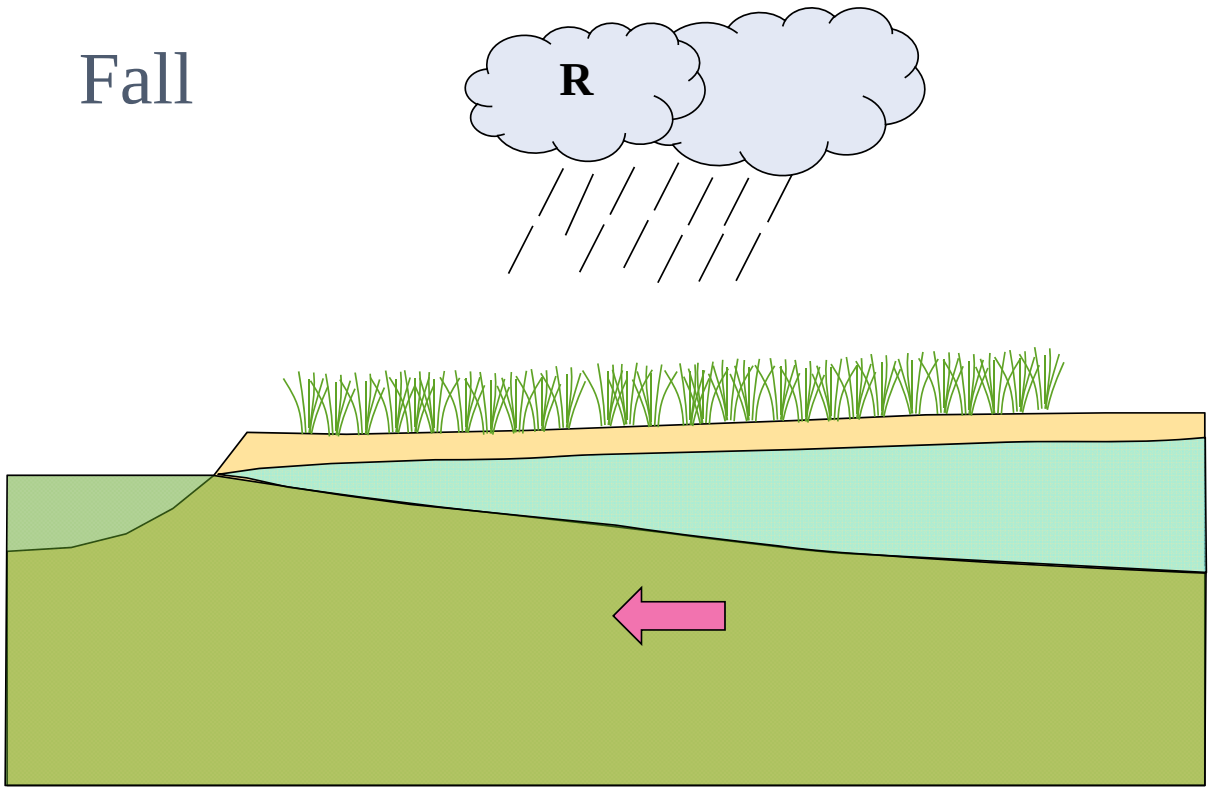

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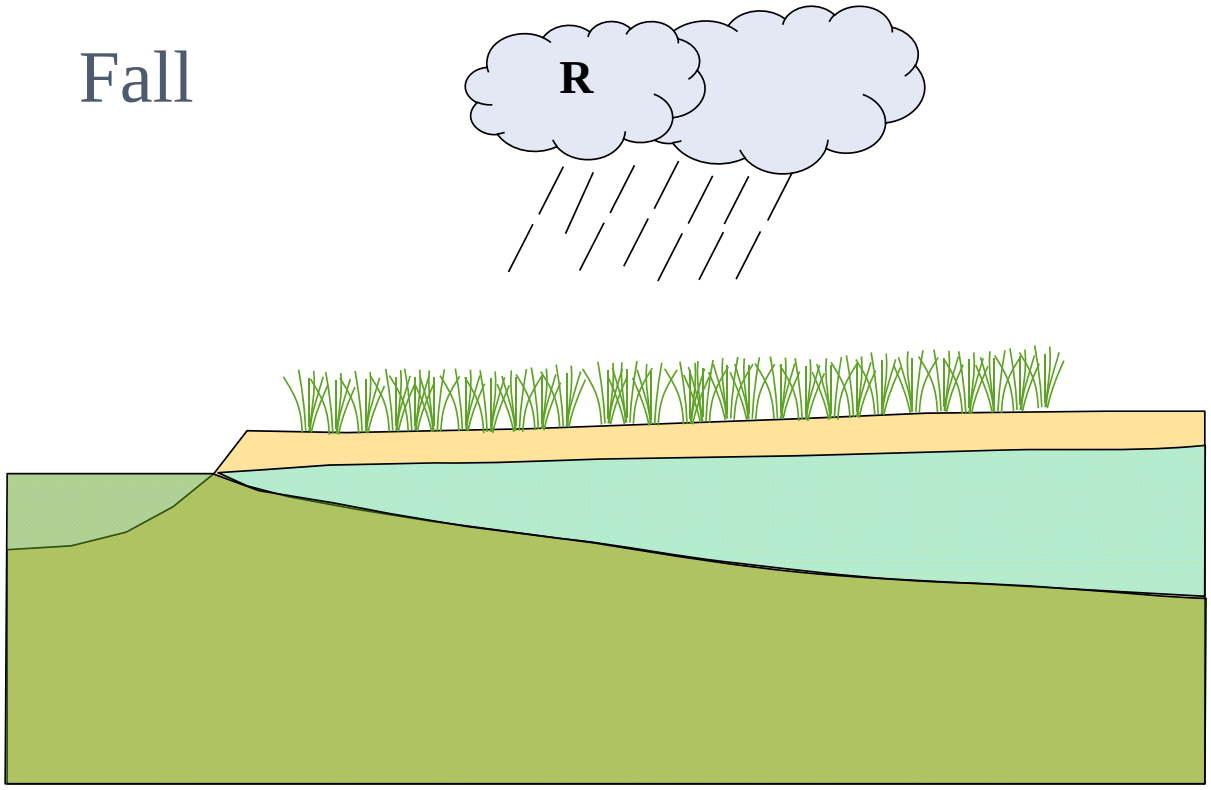

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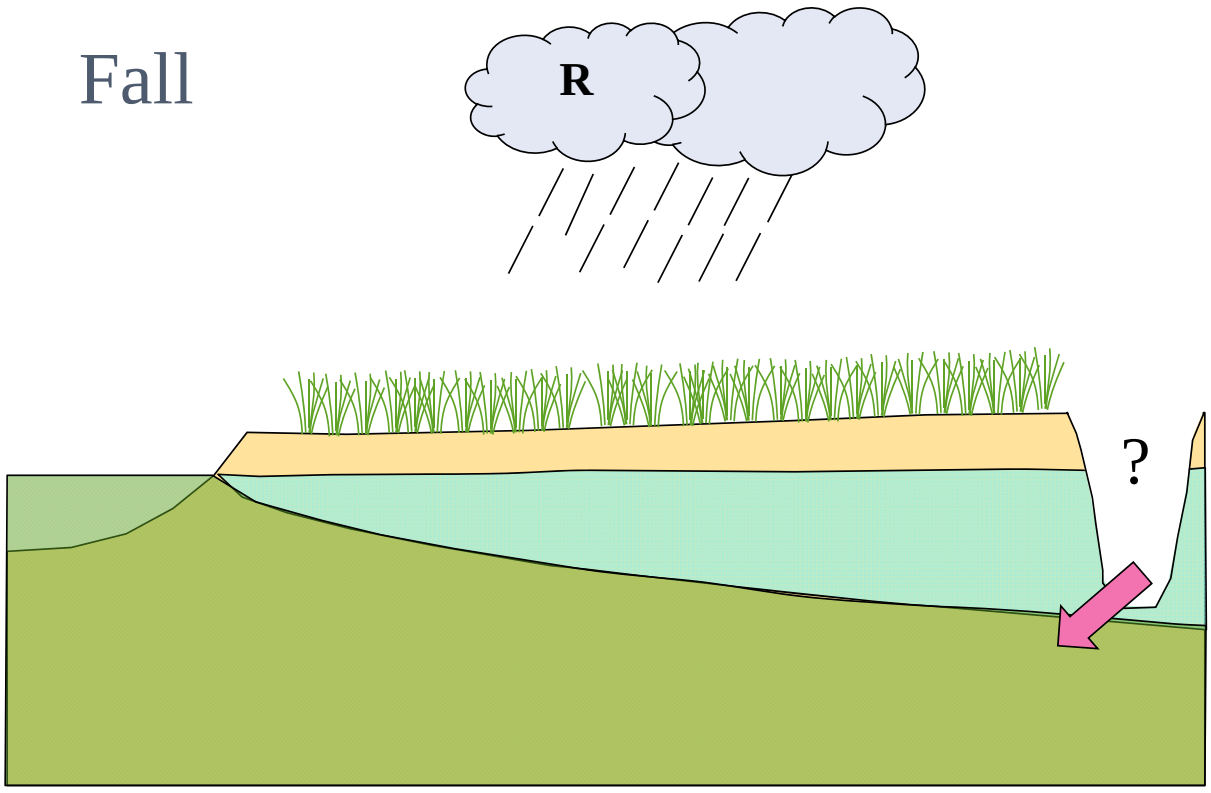
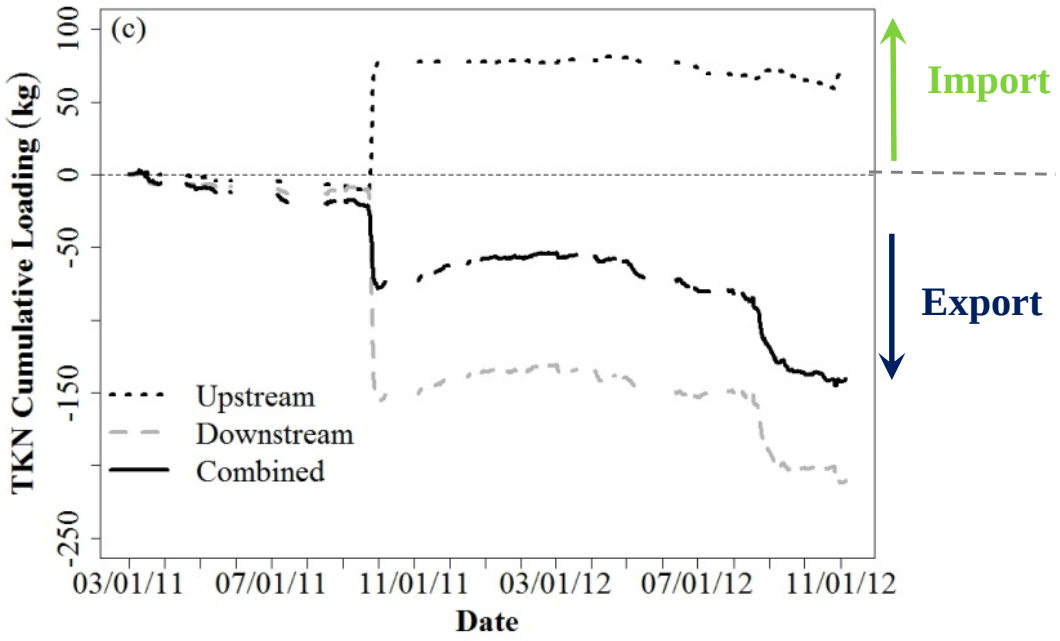
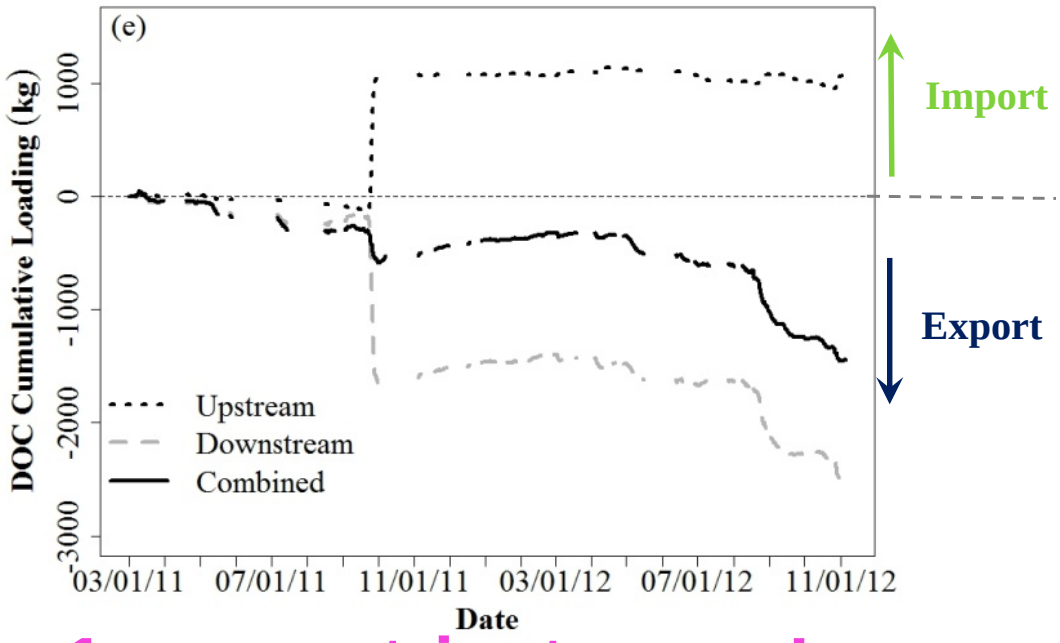


TKN balance: net export

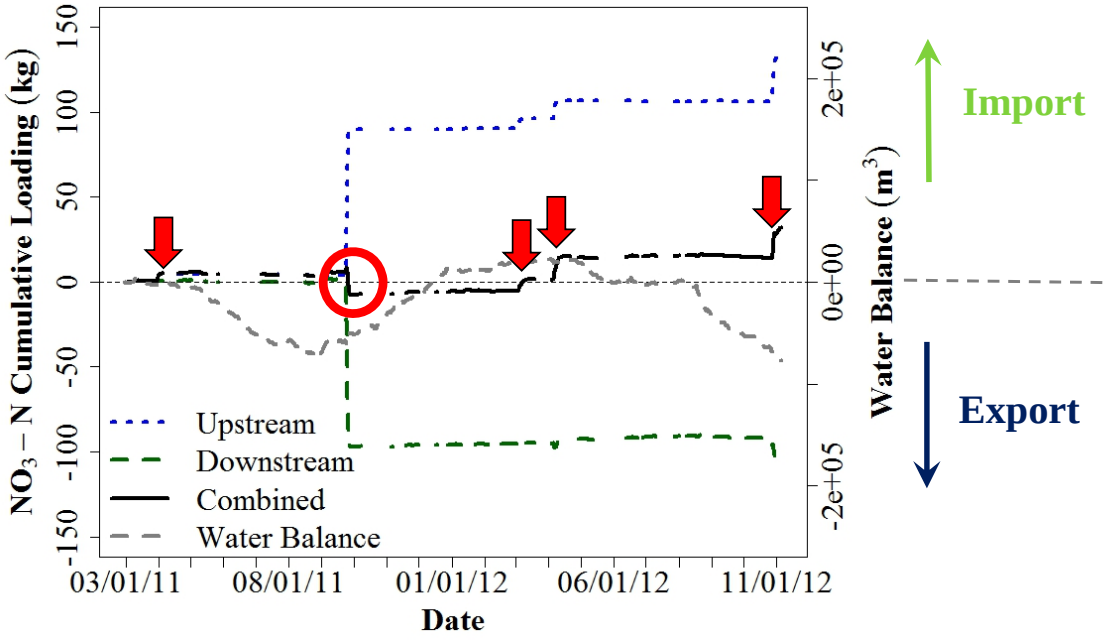


DOC balance: net export



1-way nutrient pump!

Nitrate Mass Balance



Mass Balance Summary

Parameter	Input Mass (kg)	Output Mass (kg)	Mass Balance (kg)	Percent Retention
NO_3-N	**470**	**430**	**40**	**9%**
TKN	1,290	1,410	-120	-9%
TN	1,760	1,840	-80	-5%
DOC	18,000	19,400	-1,400	-8%
PO_4-P	57	59	-2	-4%
TP	117	125	-8	-7%
TSS	48,000	51,000	-3,000	-6%

Conclusion

- Long-term 15-min data: essential to make meaningful conclusions
- Nitrate retention values mid-way between stream and non-tidal wetlands
- Marsh: 2-way water pump, 1-way nutrient pump
- Nutrient outwelling confirmed?

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Questions?

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