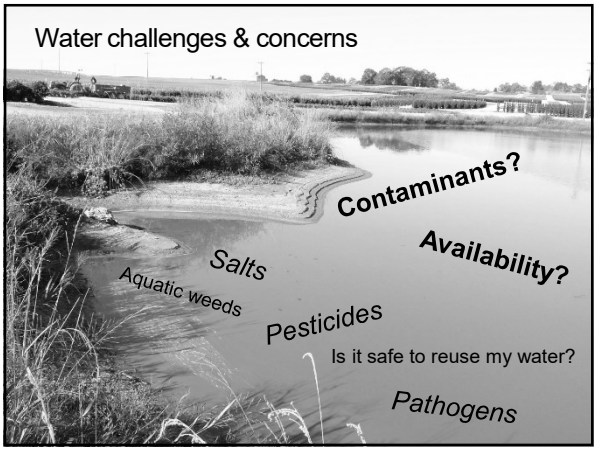
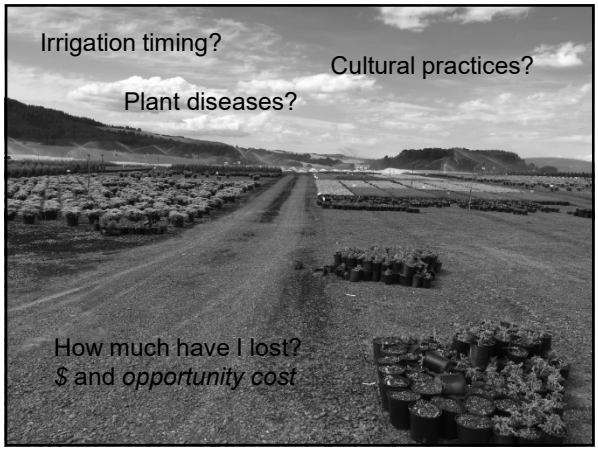
CLEAN WATER^3
REDUCE, REMEDIATE, RECYCLE

CLEAN WATER WITH PLANTS & WOOD CHIPS

Sarah A. White, Ph.D.

CLEMSON
PLANT AND ENVIRONMENTAL SCIENCES





Treatment technologies for runoff

- Filter strips
- Floating wetlands
- Wood chip bioreactors

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Treatment technologies: Plants

- Slows water
- Absorbs
  - nutrients
  - trace metals
  - other compounds
- Microbes
  - Habitat (surface area)
  - carbon source

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Filter strips

Bands of vegetation used between production areas & retention ponds

- Slow runoff
- Trap:
  - Sediment
  - Fertilizer
  - pesticides
  - (potentially) pathogens

Before they enter surface water

Image: Peter Rogers

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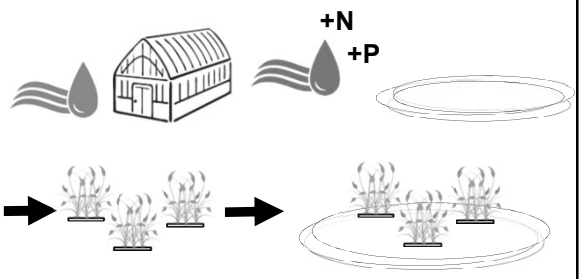
Floating Treatment Wetlands



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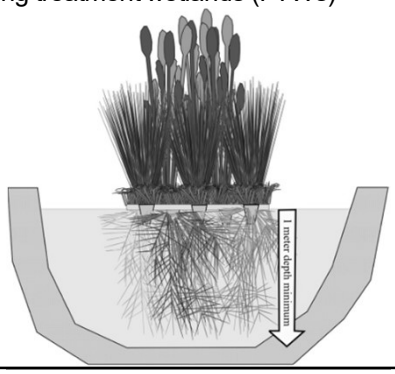
Floating treatment wetlands (FTWs)



Algae & duckweed control

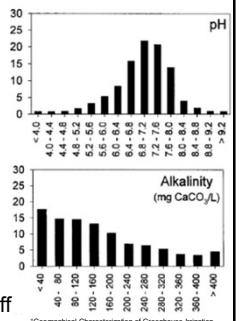
Alkalinity, pH & nutrient management

Alkalinity & Acidity

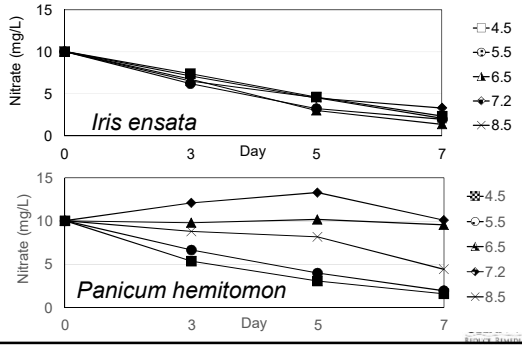
Greenhouse irrigation water ranges across US and Canada
- pH: 3.3 to 10.4
- alkalinity: 2 to 575 mg·L^{-1} $CaCO_3$

Assume runoff from irrigation maintains similar water quality measures

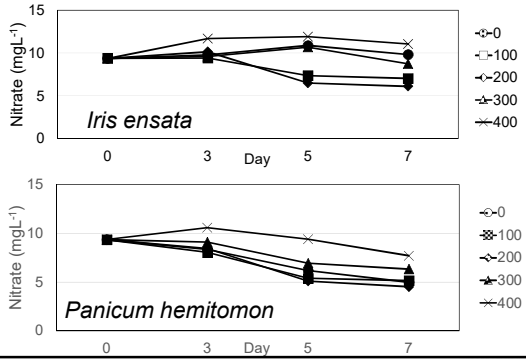
Do ranges in alkalinity & pH of runoff affect bioremediation efficacy?

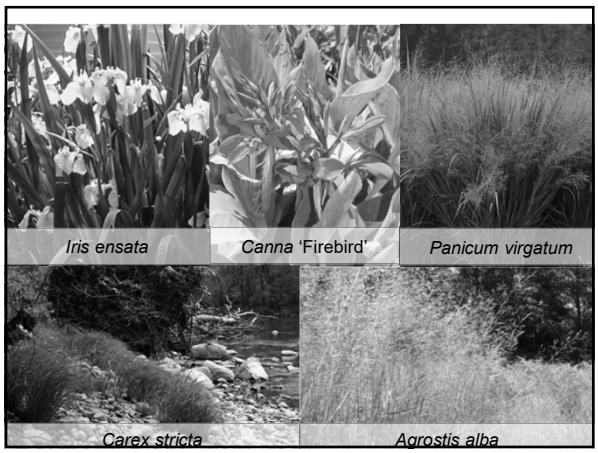


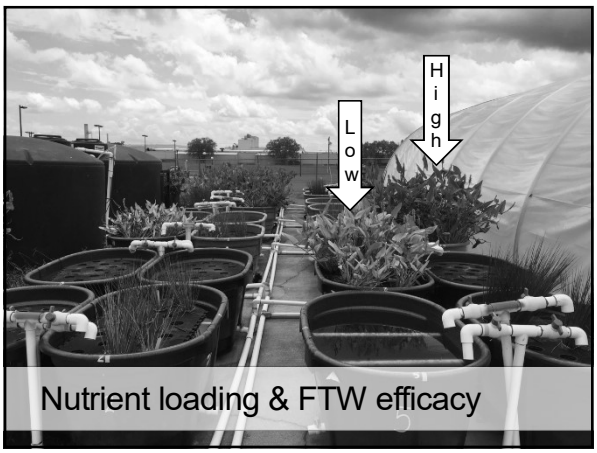
Acidity (pH)

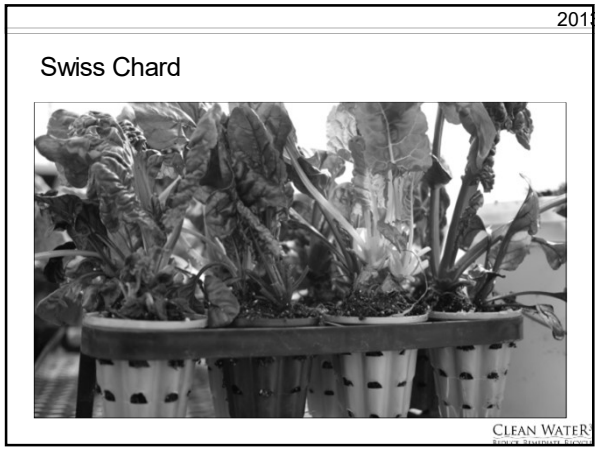


Alkalinity ($CaCO_3$ mg/L)




Iris ensata
Canna 'Firebird'
Panicum virgatum
Carex stricta
Agrostis alba


High
Low
Nutrient loading & FTW efficacy


2013
Swiss Chard
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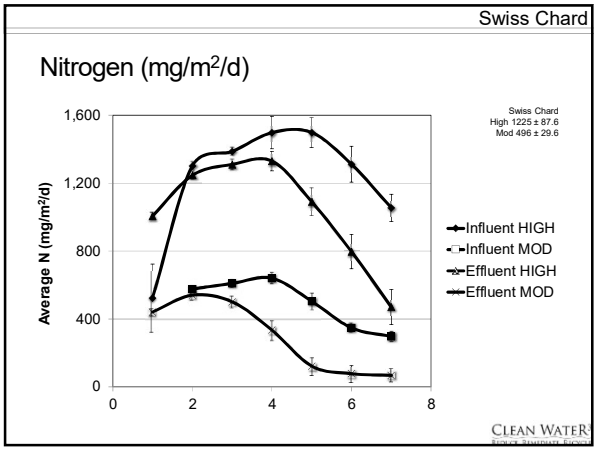
Swiss Chard
Nitrogen (mg/m2/d)
Swiss Chard
High 1225 ± 87.6
Mod 496 ± 29.6
Average N (mg/m2/d)
1,600
1,200
800
400
0
0
2
4
6
8
Influent HIGH
Influent MOD
Effluent HIGH
Effluent MOD
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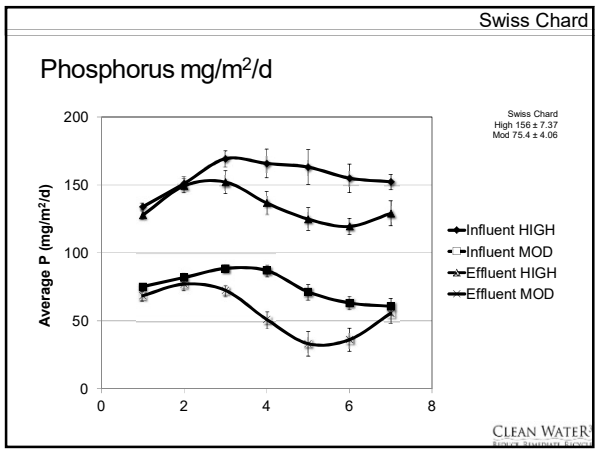
Swiss Chard
Phosphorus mg/m2/d
Swiss Chard
High 156 ± 7.37
Mod 75.4 ± 4.06
Average P (mg/m2/d)
200
150
100
50
0
0
2
4
6
8
Influent HIGH
Influent MOD
Effluent HIGH
Effluent MOD
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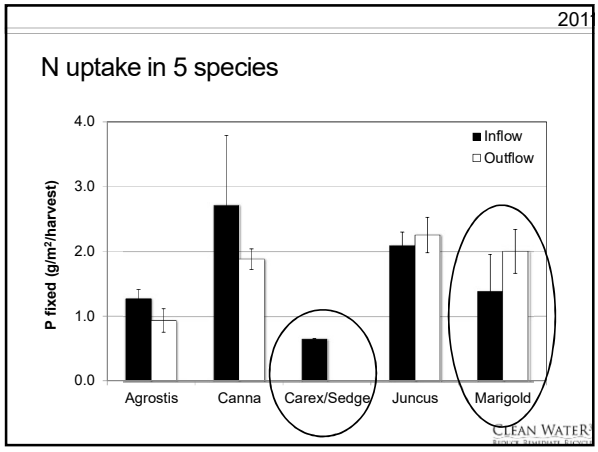
Maintenance of FTWs: weeds & harvest


N uptake in 5 species
P fixed (g/m2/harvest)
4.0
3.0
2.0
1.0
0.0
Inflow
Outflow
Agrostis
Canna
Carex/Sedge
Juncus
Marigold
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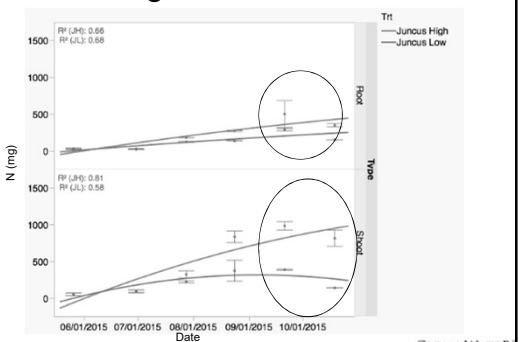
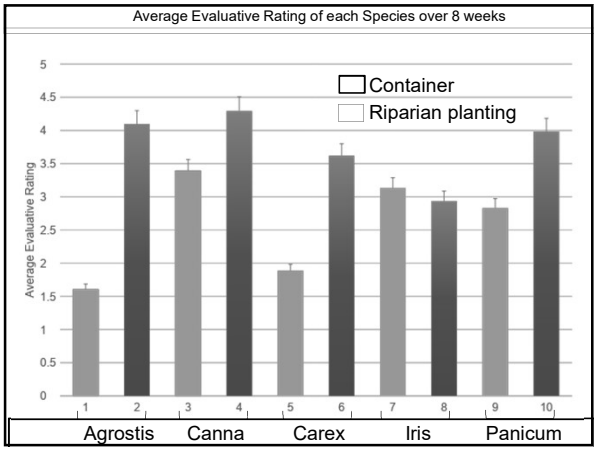
Harvest timing



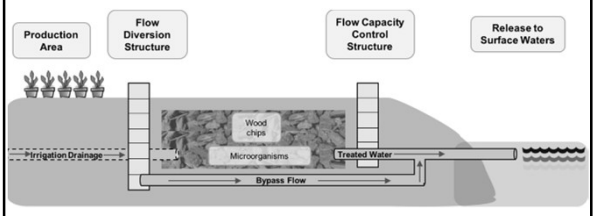
End-uses of harvested material

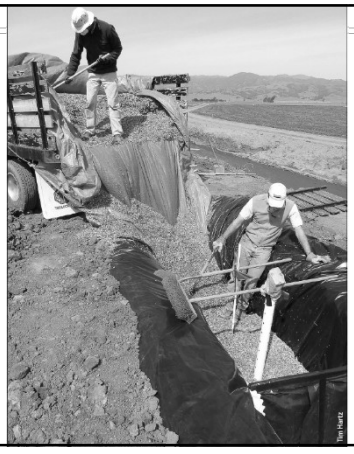


Treatment Technology: Wood chip bioreactors (Carbon wall)

- Subsurface trenches - filled with wood chips (¼ to 1")
- Water flows through trench
- Wood chips - substrate for bacteria that reduce nitrate to N gas via denitrification

Wood-chip bioreactors





Why bioreactors?

- Require no modification of current practices
- No land removed from production
- No decrease in drainage effectiveness
- Require little to no maintenance
- Last for up to 20 years
- Cost effective

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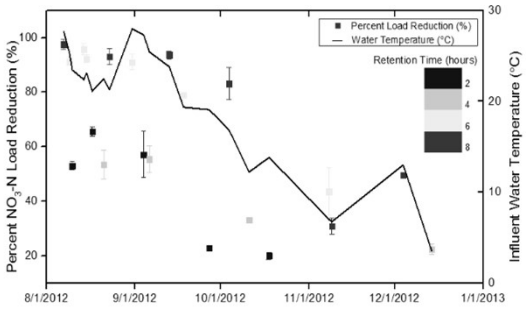
Nitrate-N removal & wood-chip bioreactors



Bell, N.L., Cooke, R.A.C., Olsen, T. David, M.B., Hudson, R. **2015**. Characterizing the Performance of Denitrifying Bioreactors during Simulated Subsurface Drainage Events. *Journal of Environmental Quality*. 44, 1647-1656.

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Pesticides & wood-chip bioreactors

Analyte	Bioreactor inlet (ppb)	Bioreactor outlet (ppb)	Report limit (ppb)	Chronic invertebrate benchmark (ppb)
Dinitroaniline: Oxyfluorfen	0.071	ND	0.05	13
Pyrethroids:				
Bifenthrin	0.0133	0.00434	0.001	0.0013
Permethrin-*cis*	0.00336	ND	0.002	0.0014
Imidacloprid	ND	ND	0.05	1.05

Sea Mist Farms Bioreactor

Wagner et al. 2018. Mitigation of pesticide runoff using woodchip bioreactors. California Department of Pesticide Regulation.

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Questions?

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THE TERRA CEIA FARMS

Beemats

HRI Horticultural Research Institute

FNRI Floriculture & Nursery Research Initiative

USDA NIFA United States Department of Agriculture National Institute of Food and Agriculture

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