
Bioretention Basins:
Design, Construction & Maintenance, Oh My!
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BARR
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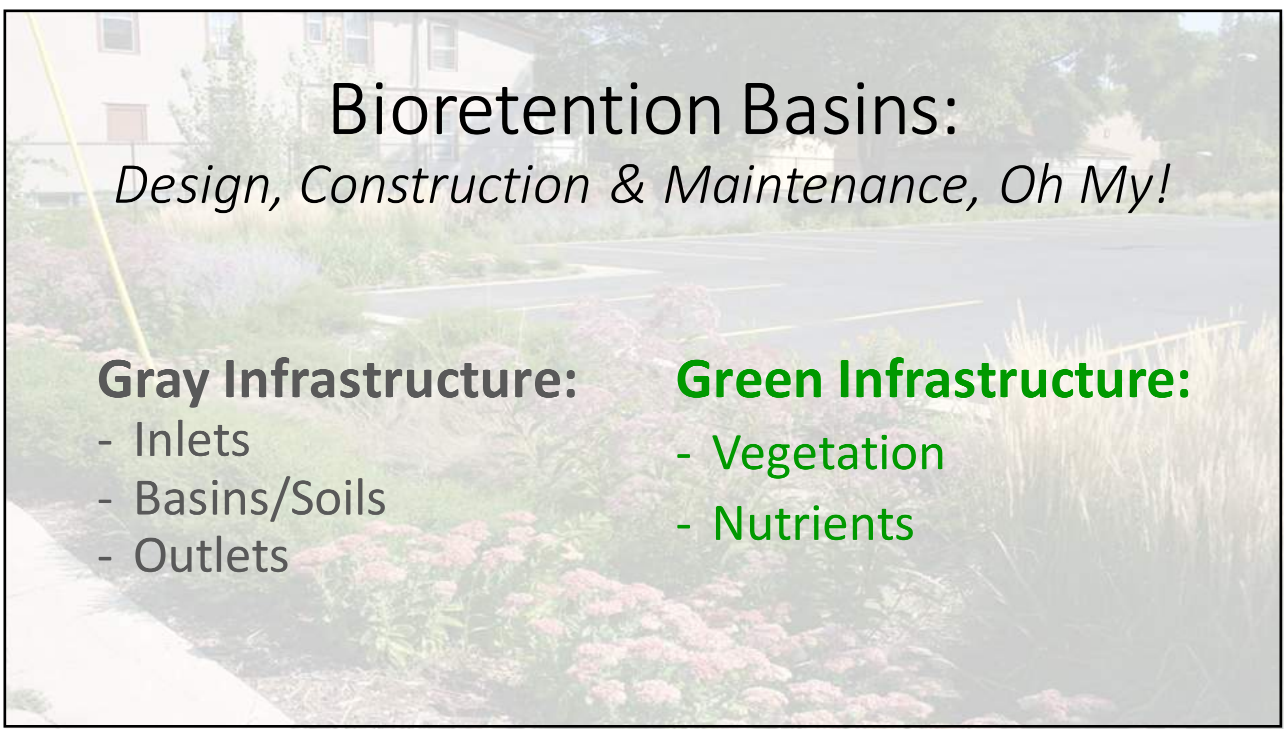
EAGAN


Bioretention Basins:
Design, Construction & Maintenance, Oh My!
Gray Infrastructure:
- Inlets
- Basins/Soils
- Outlets
Green Infrastructure:
- Vegetation
- Nutrients

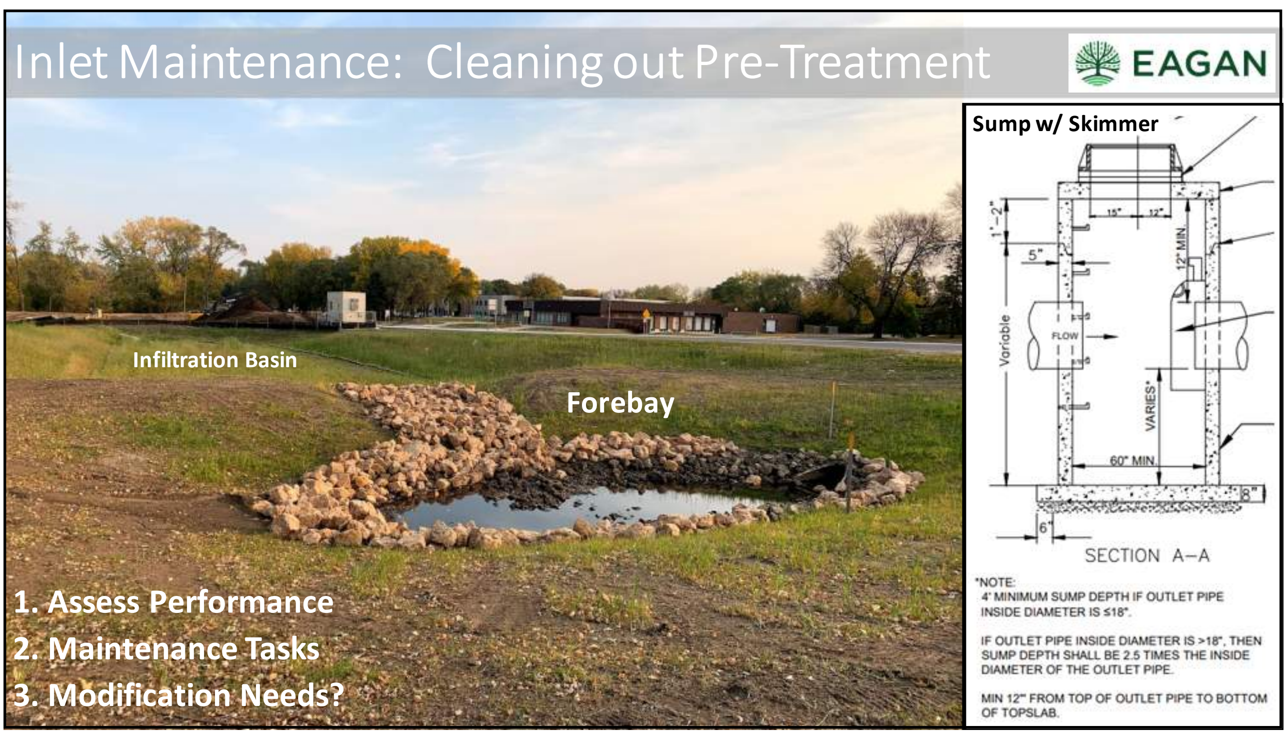

Bioretention: Gray Infrastructure Maintenance (& Inspections)
Challenges & Lessons Learned
EAGAN
Outlet
Basin
Inlet
& Pre-Treatment
1. Assess Performance
2. Maintenance Tasks
3. Modification Needs?


Inlet Maintenance: Inlet Erosion from Inflow
EAGAN
1. Assess Performance
2. Maintenance Tasks
3. Modification Needs?


Inlet Maintenance: Pre-Treatment?
EAGAN
12"
Rain Guardian Turret
1. Assess Performance
2. Maintenance Tasks
3. Modification Needs?


Inlet Maintenance: Cleaning out Pre-Treatment
EAGAN
1. Assess Performance
2. Maintenance Tasks
3. Modification Needs?


Inlet Maintenance: Cleaning out Pre-Treatment
EAGAN
1. Assess Performance
2. Maintenance Tasks
3. Modification Needs?
Luggage scale for weighing sediment removed


Inlet Maintenance: Cleaning out Pre-Treatment
EAGAN
Infiltration Basin
Forebay
1. Assess Performance
2. Maintenance Tasks
3. Modification Needs?
Sump w/ Skimmer
FLOW
Variable
VARIES*
12" MIN.
60" MIN
SECTION A–A
*NOTE:
4' MINIMUM SUMP DEPTH IF OUTLET PIPE INSIDE DIAMETER IS ≤18".
IF OUTLET PIPE INSIDE DIAMETER IS >18", THEN SUMP DEPTH SHALL BE 2.5 TIMES THE INSIDE DIAMETER OF THE OUTLET PIPE.
MIN 12" FROM TOP OF OUTLET PIPE TO BOTTOM OF TOPSLAB.


Basin Maintenance: Slow Draw-down
EAGAN
1. Assess Performance
2. Maintenance Tasks
3. Modification Needs?


Basin Maintenance: Simplified Vegetation
EAGAN
50% Fox Sedge
50% Prairie Cordgrass
1. Assess Performance
2. Maintenance Tasks
3. Modification Needs?

Basin Maintenance: Inspecting Under-Drains

EAGAN

Looking for condition, plugging, pipe separation, gate valve, overall function

Outlet Maintenance

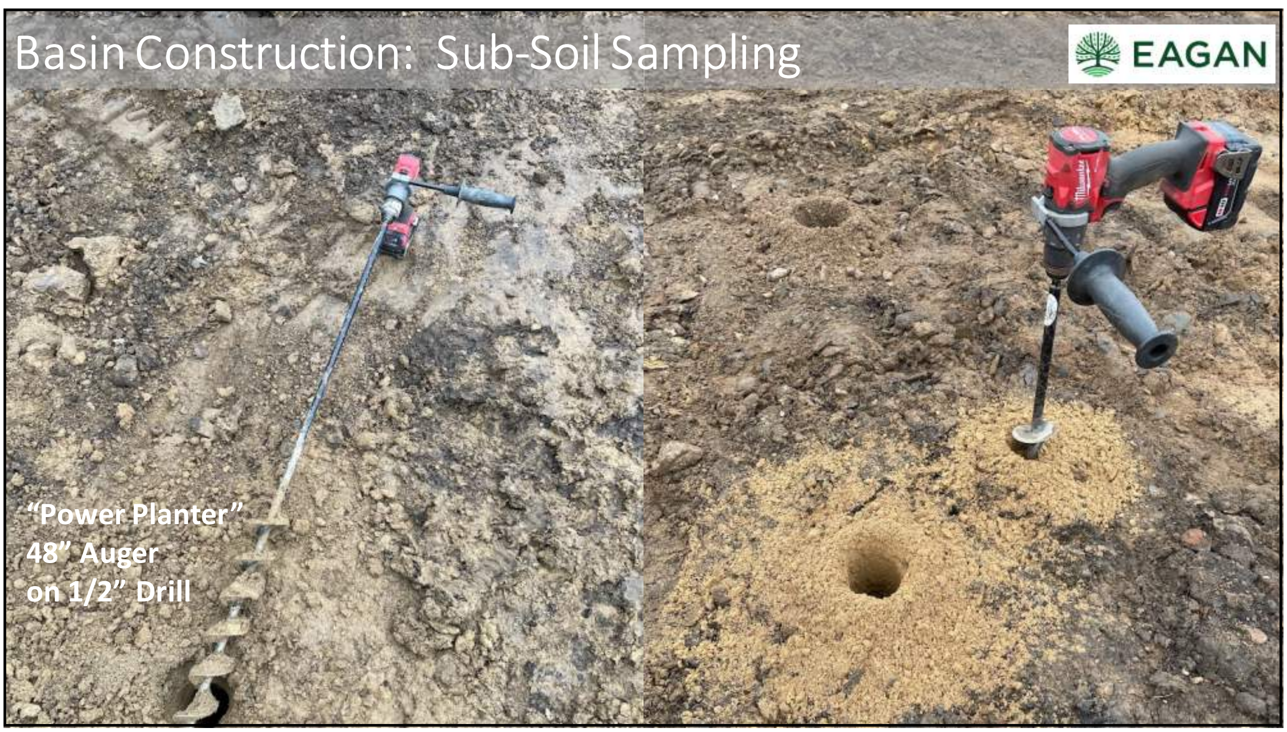
EAGAN

Checking Outlet Control Structures:

- Trash Rack(s) for debris plugging
- Sediment Deposition
- Valve Function
- Causes of issues?
- Repair options?

In-House vs. Contracted Maintenance/Repair?


Bioretention: Gray Infrastructure Construction (& Inspections)
Challenges & Lessons Learned
EAGAN
1. Protections during construction
2. Inspections/verifications at critical stages
3. Modification Needs?


Basin Construction: Sub-Soil Sampling
EAGAN
"Power Planter"
48" Auger
on 1/2" Drill

Basin Construction: Infiltration Testing

Basin Construction: Infiltration Testing

MPD Infiltrometer
Upstream Technologies

ASTM Standard D8152
for calculating Field Hydraulic Conductivity (Ksat)


Basin Construction: Sub-Soil Decompaction
EAGAN


Basin Construction: Protecting Filter Media
EAGAN

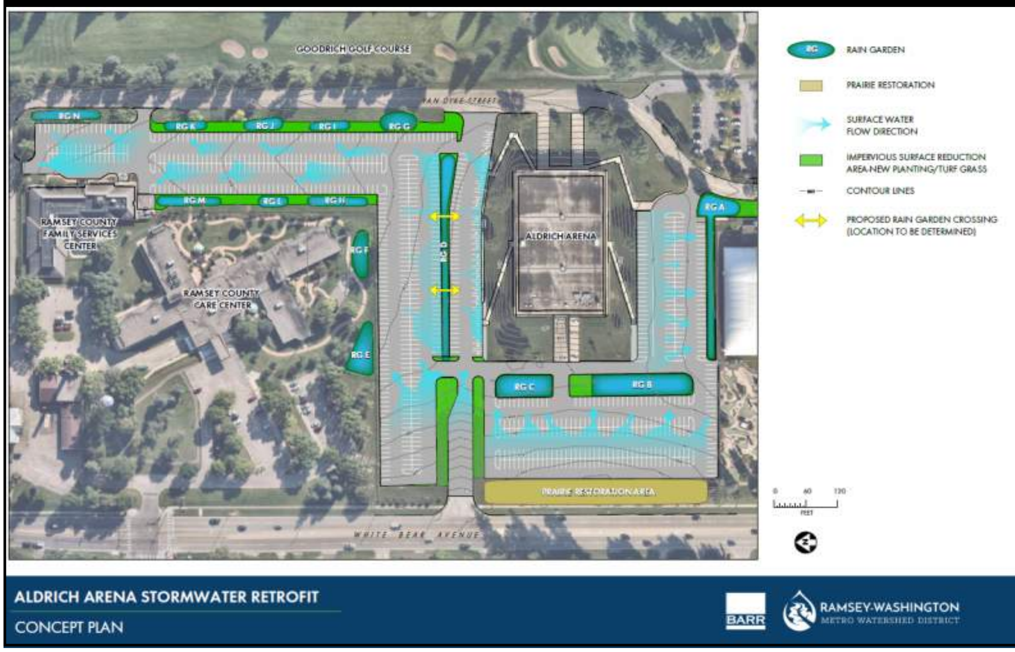

Basin Construction: Protecting Filter Media – oops!
EAGAN


Basin Construction: Protecting Filter Media
EAGAN


Basin Construction: Side-Slope Decompaction
EAGAN

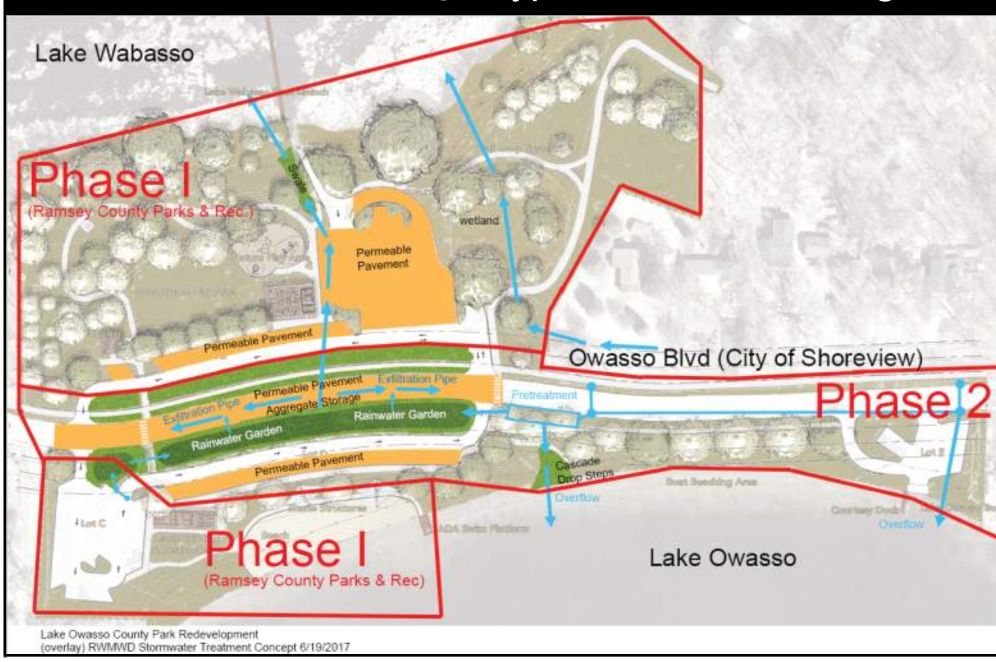

Bioretention Basin Design: How can design decisions reduce risk of maintenance problems or basin failure & extend design life?
Matt Metzger
Senior Civil Engineer
BARR

Bioretention Basin Design: typical feature arrangement



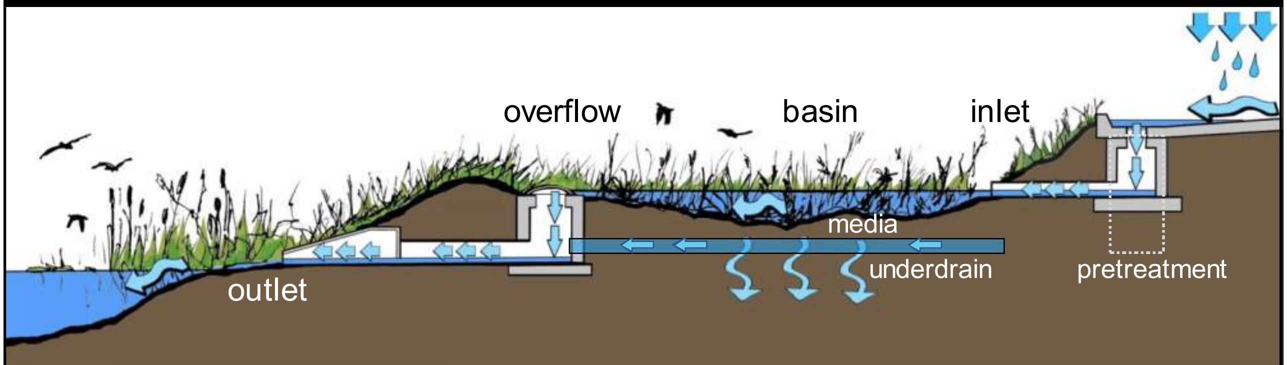
distributed
bioretention
basins

Bioretention Basin Design: typical feature arrangement

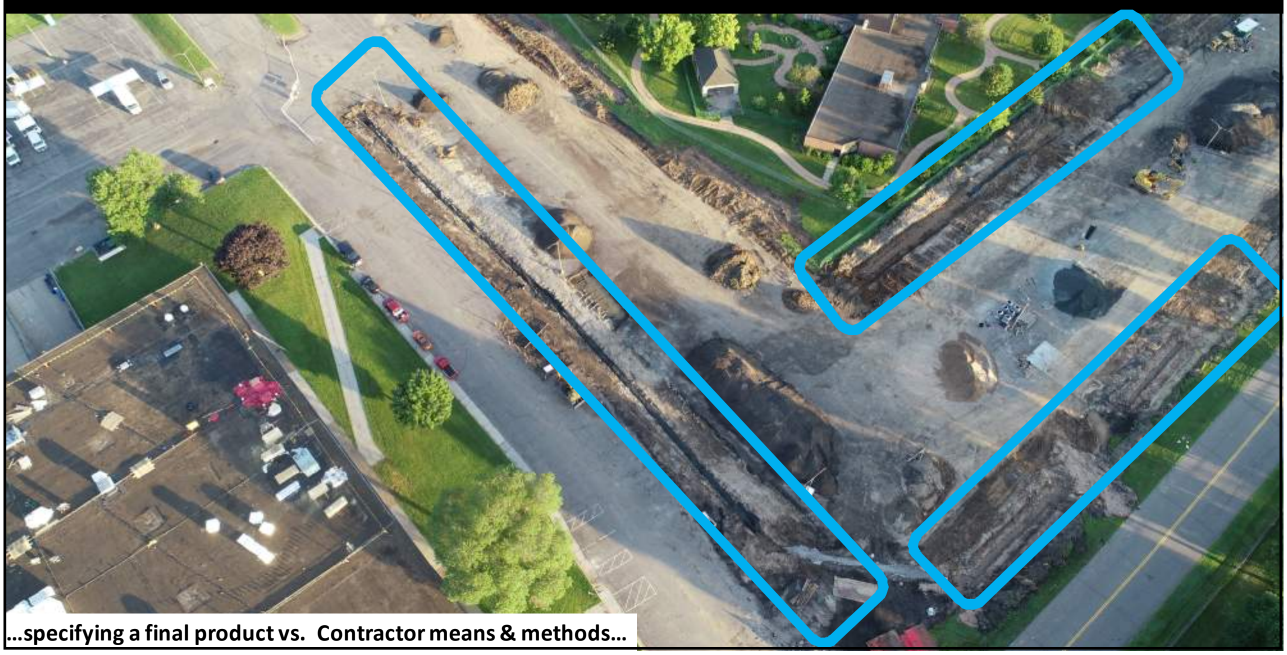


district
bioretention
basins
(centralized)

Bioretention Basin Design: typical feature arrangement



Bioretention Basin Design: Specify Feature Construction Phasing

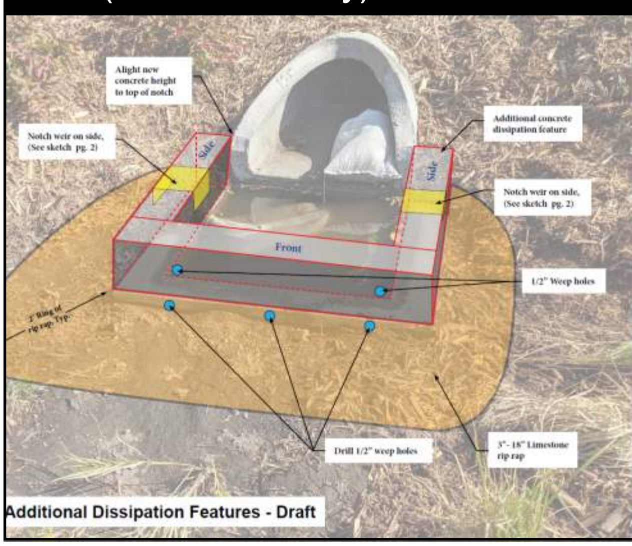


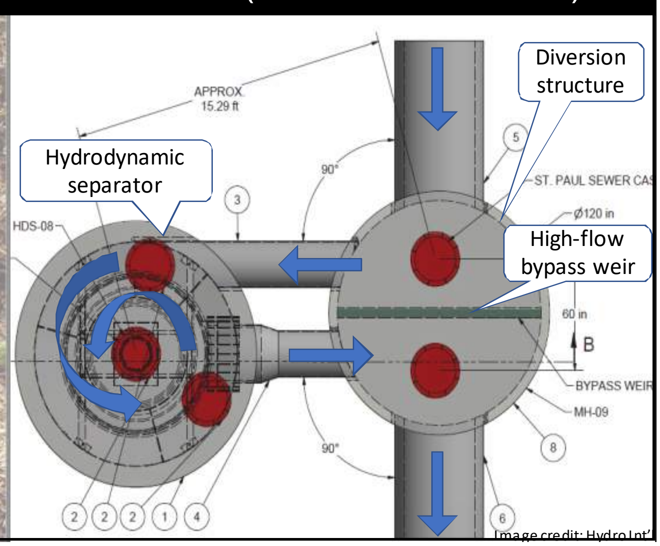
…specifying a final product vs. Contractor means & methods…

Bioretention Basin Design: Specify Feature Construction Phasing

Bioretention Basin Design: Pretreatment Design

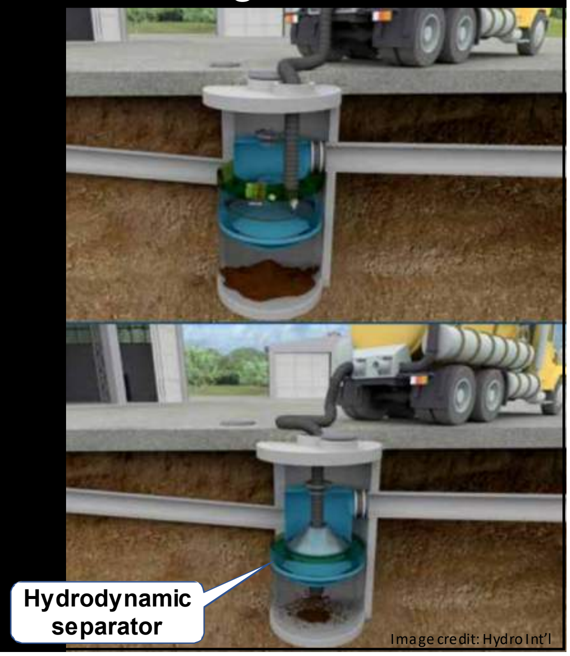
Small Subwatershed (often less risky) ⟷ Large Subwatershed (more sediment risk)





Bioretention Basin Design: Pretreatment Design

Hydrodynamic Separator Considerations



Bioretention Basin Design: Inlet Design

Small Subwatershed (often less risky) ←-----→ Large Subwatershed (more sediment & erosion risk)

University of Minnesota Duluth – Duluth, MN

Macalester College - St. Paul, MN

Bioretention Basin Design: Flow Routing & Temp. Bypass Design

Off-line
(often less risky)

In-line
(often more risky)

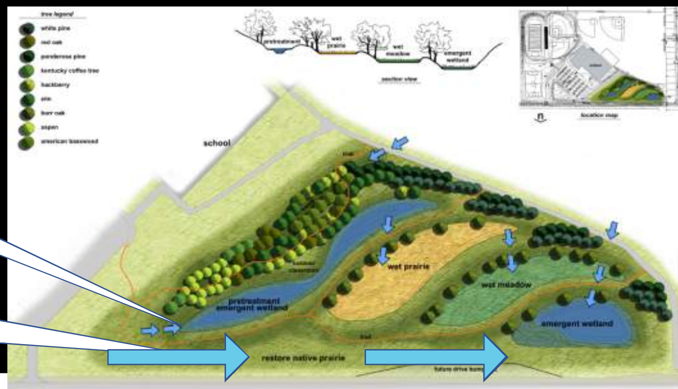
Bioretention Basin Design: Flow Routing & Temp. Bypass Design

Align inlets/outlets for temporary bypass piping

Bioretention Basin Design: Flow Routing & Temp. Bypass Design

Flow splitter:

Both temp. bypass and high flows use existing ditch



Steele County Highway Department & Medford School, MN

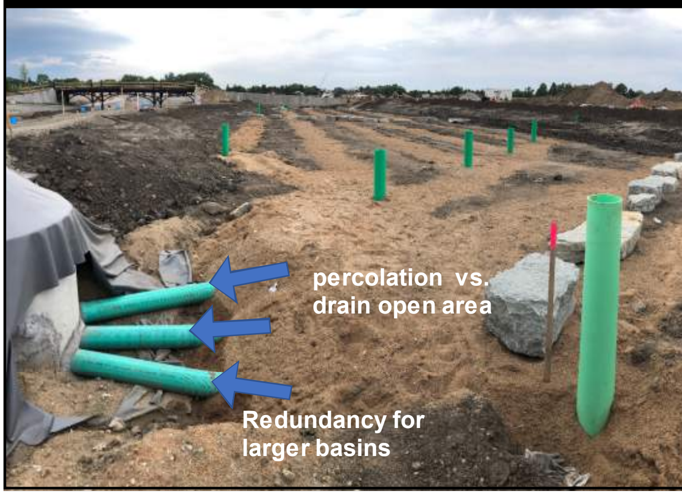
Bioretention Basin Design: Underdrain & Outlet Design

Specify swept fittings to ease cleanout

Temp. cleanout risers help avoid damage during work

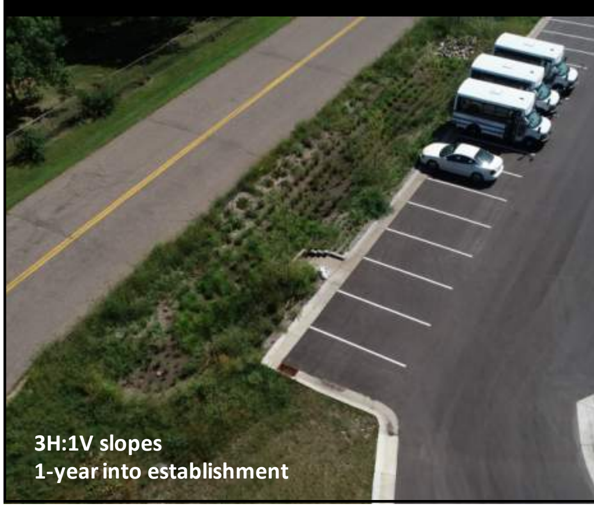
Bioretention Basin Design: Underdrain & Outlet Design

Multiple Outlets (often less risky) ⟷ One Outlet (often more risky)



Bioretention Basin Design: Basin Grading, Soils, Media Design

Shallower Storage (6”-18”), Flatter Slopes (4H:1) (often less risky) ⟷ Deeper Storage (24”+), Steeper Slopes (2H:1) (often more risky)



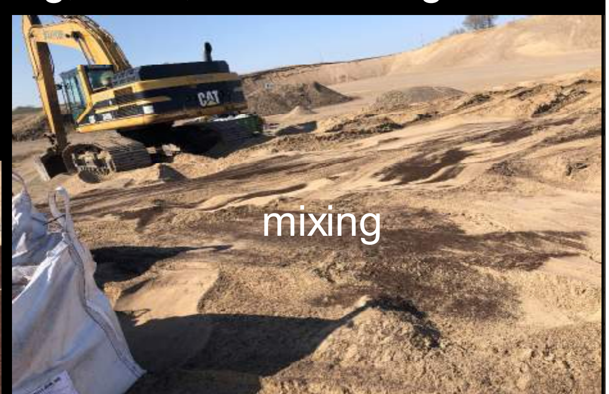
Bioretention Basin Design: Basin Grading, Soils, Media Design

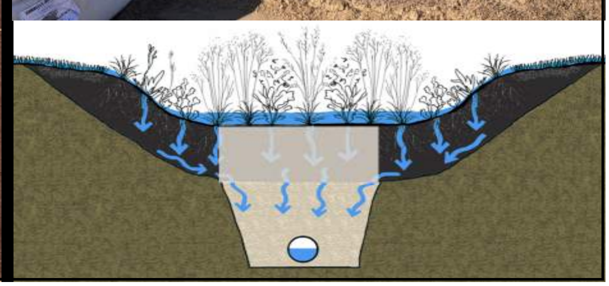
Specify construction sediment removal

Temporary crowning sand trench *can* work

Bioretention Basin Design: Basin Grading, Soils, Media Design

Specify mixing and testing of enhanced media in the





Bioretention Basin Design: Basin Grading, Soils, Media Design

Loosen underlying soils

Specify no rubber tired vehicles in basin (soil work

Bioretention Basin Design: Basin Grading, Soils, Media Design

Large basins – specify only tracked low-ground pressure equipment, and soil loosening as they work outward

Design decisions can reduce risk of maintenance problems or basin failure & extend design life.

…because a longer design life accrues more benefits!

Basins, Vegetation, and Nitrogen

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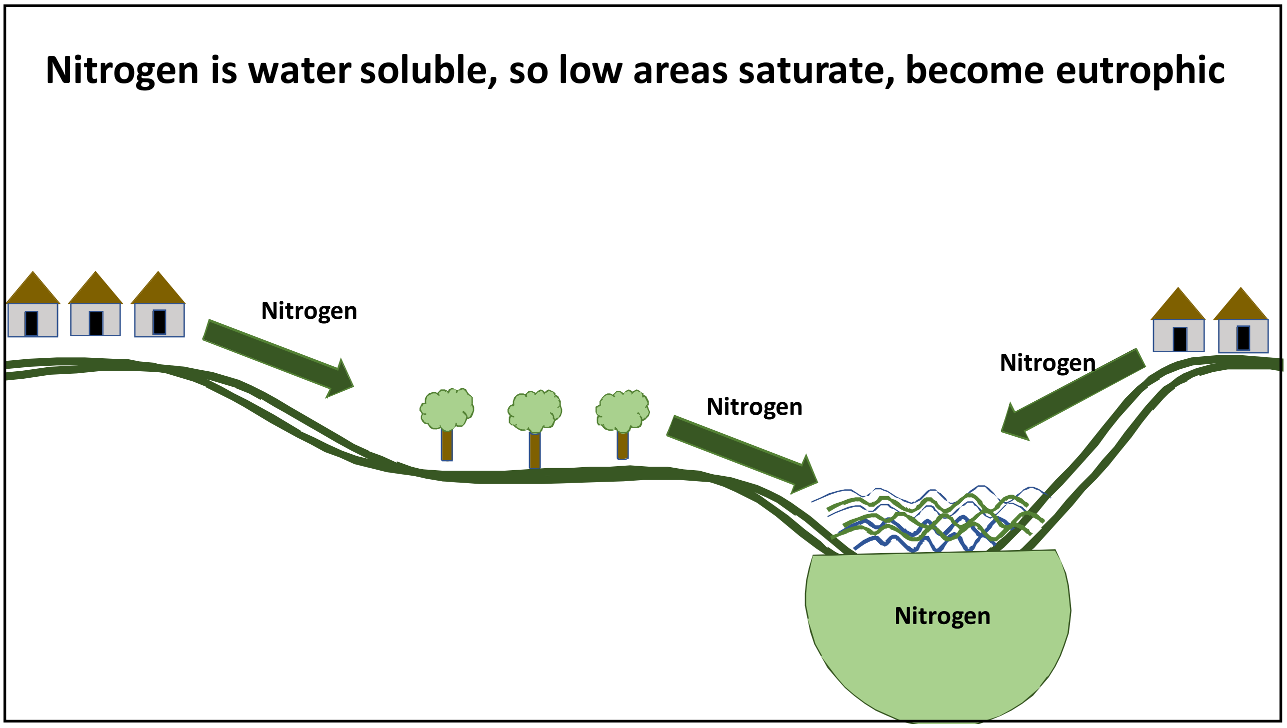
Stantec

Final Check-Off: Vegetation

Constraints Over Vegetation Configuration

1. **Shade**
- **Trees**

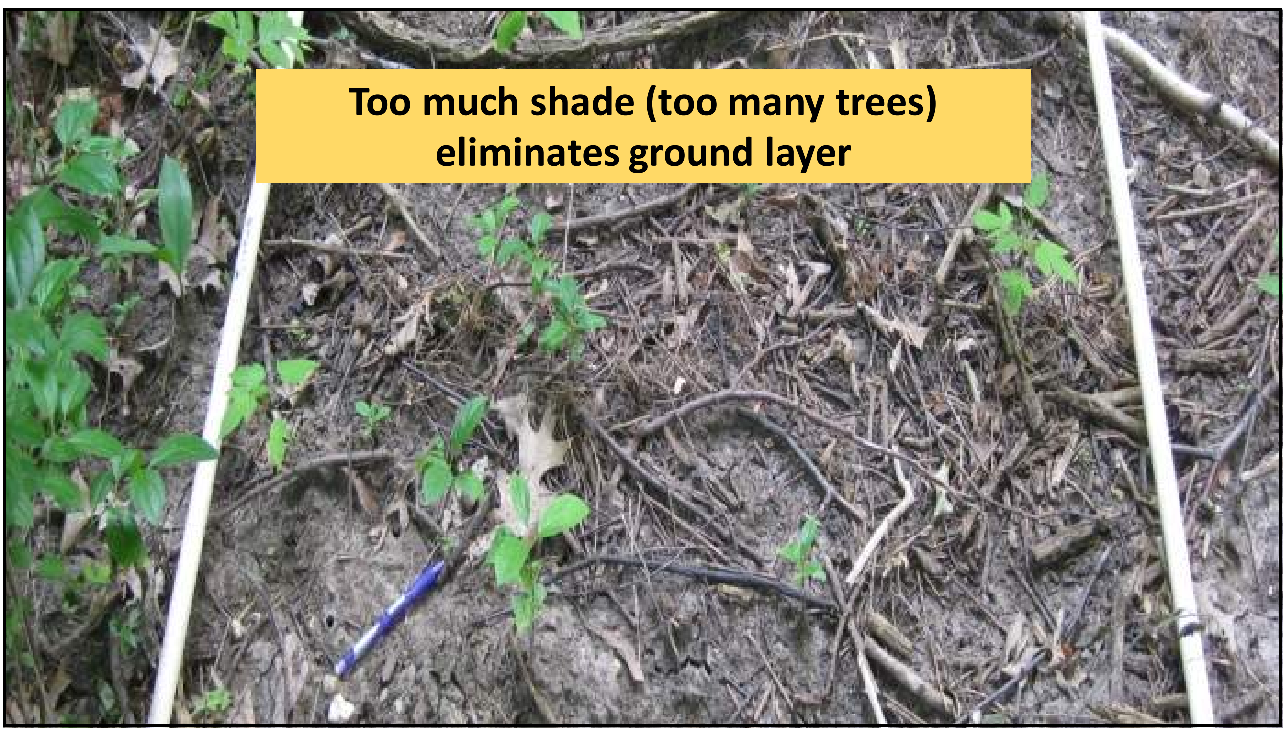
2. **Nitrogen (N)**
- **Lawn fertilizer**
- **Mower discharge**
- **Lawn wastes**
- **Nitrophilic plants (N lovers and reinforce > N)**
- **Adjacent to high fossil fuel burning**

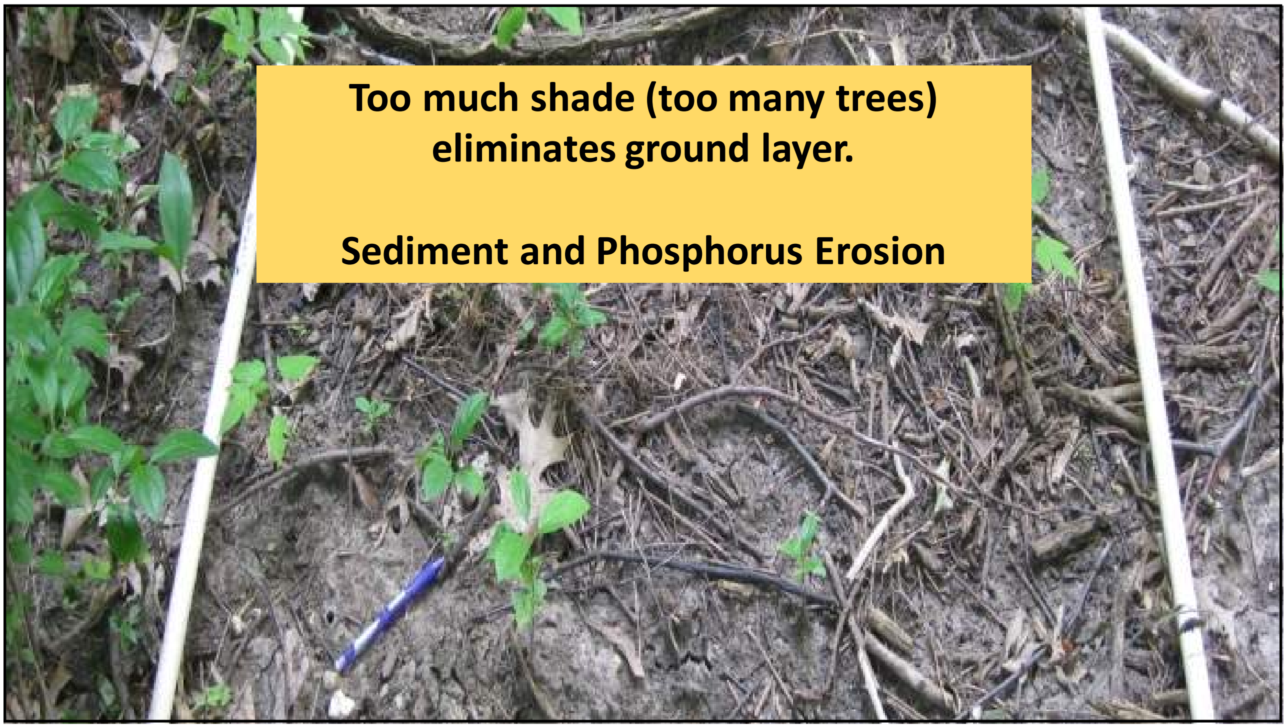

Nitrogen is water soluble, so low areas saturate, become eutrophic
Nitrogen
Nitrogen
Nitrogen
Nitrogen

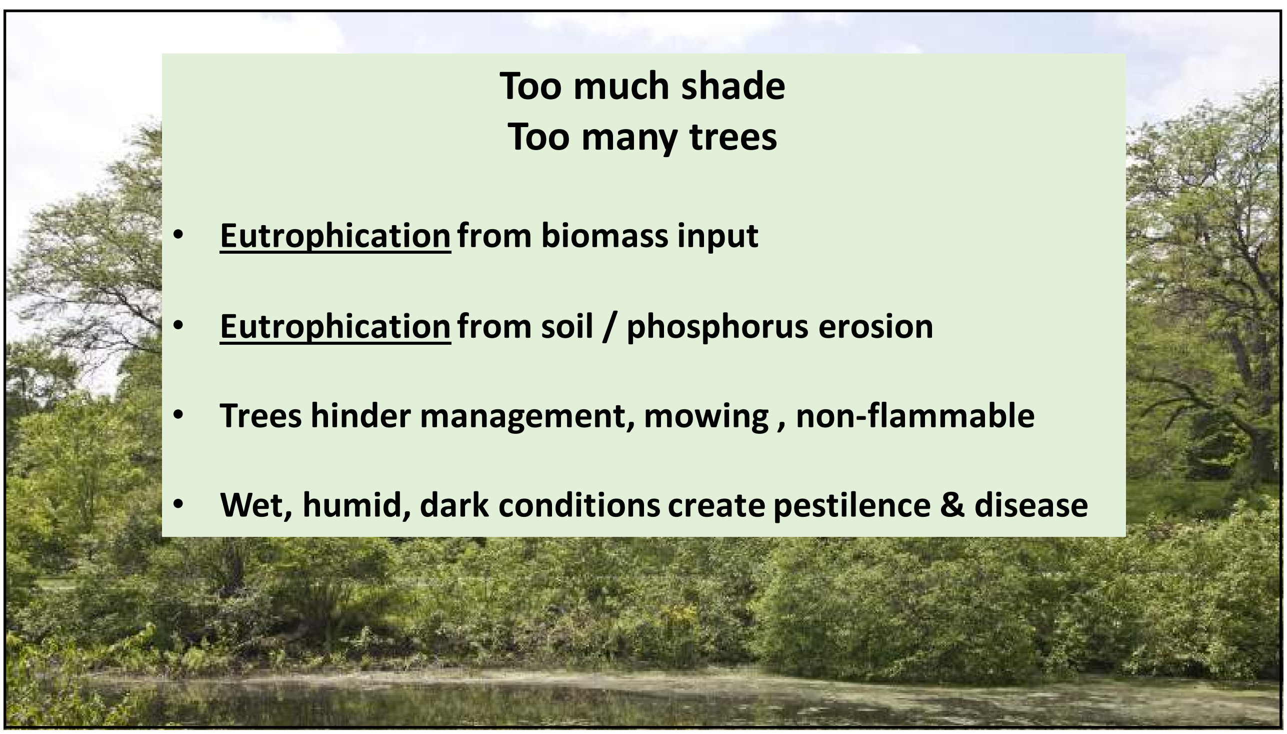

Too Much Shade
Too Many Trees

Too Many Trees

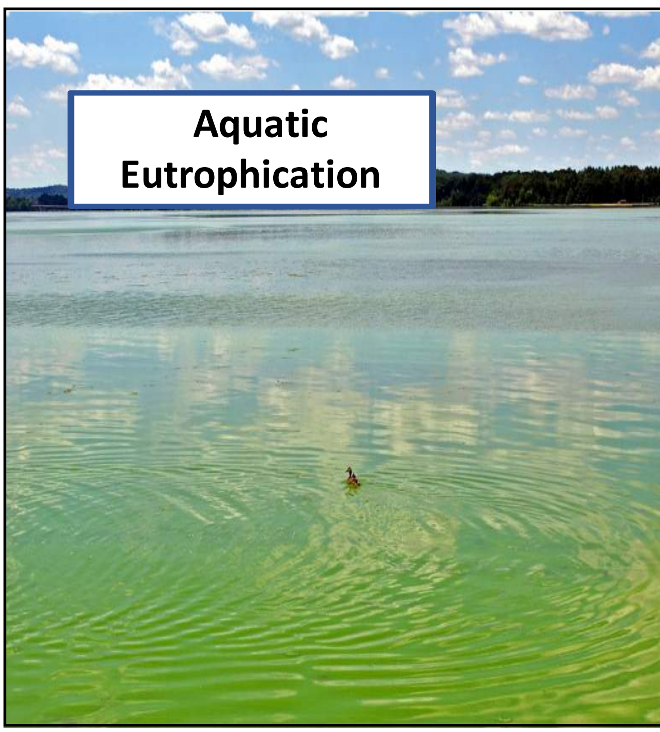
Biomass input = nitrogen input




Too much shade (too many trees)
eliminates ground layer.
Sediment and Phosphorus Erosion


Too much shade
Too many trees
• Eutrophication from biomass input
• Eutrophication from soil / phosphorus erosion
• Trees hinder management, mowing , non-flammable
• Wet, humid, dark conditions create pestilence & disease

Too Much Nitrogen



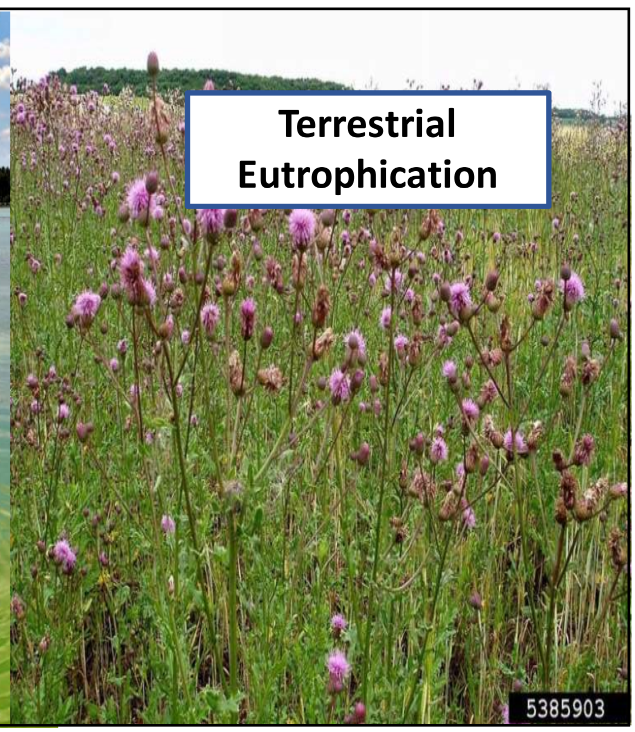


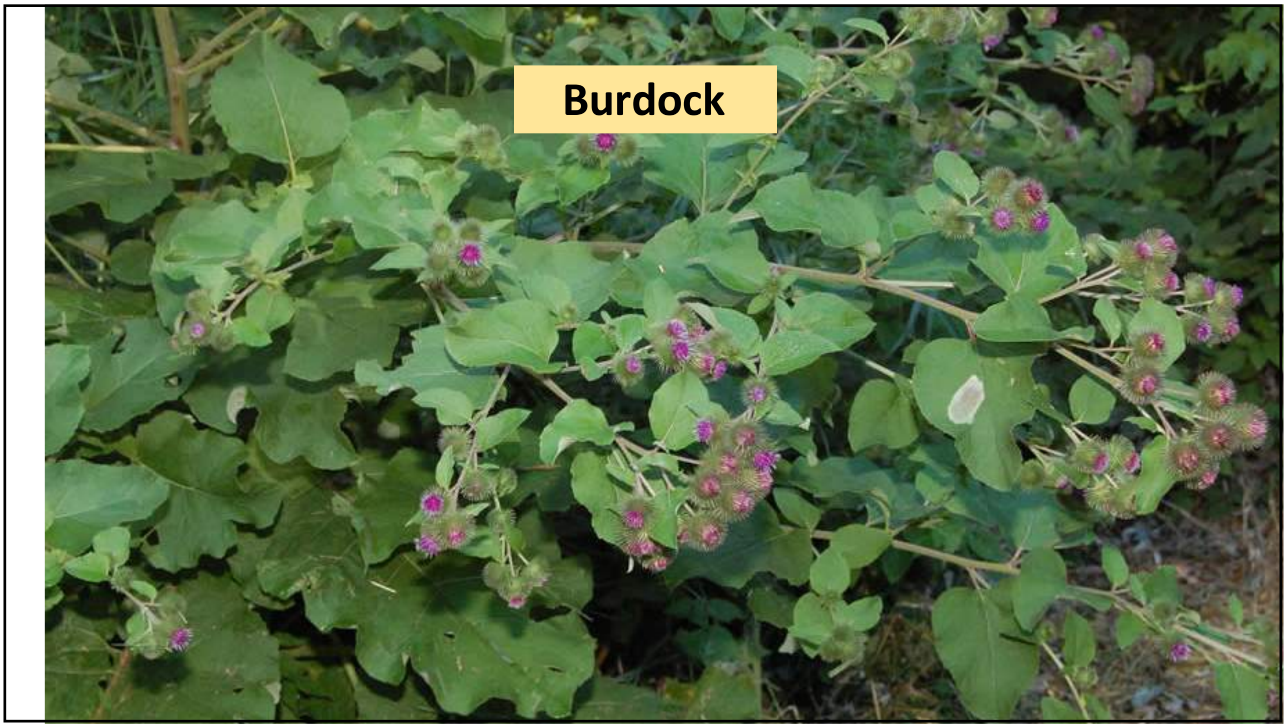
Table XXI-1

Prevalent species of weed communities of southern moist, nitrogen-rich soils

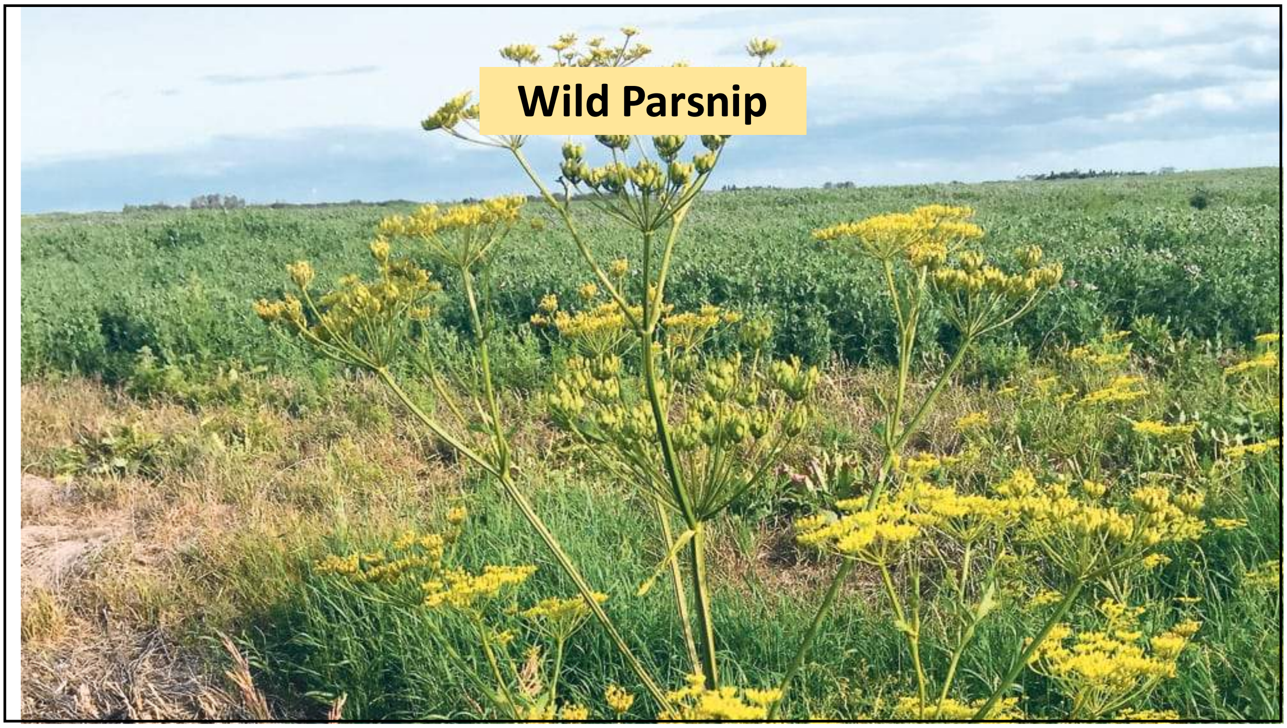
Species	*Pres.*	*Species*	*Pres.*
Agropyron repens	80%	Melilotus albus	47%
Amaranthus retroflexus*	68	Nepeta cataria*	53
Ambrosia artemisiifolia	87	Panicum capillare*	60
A. trifida*	60	Phleum pratense	67
Anthemis cotula*	47	Plantago major*	87
Arctium minus*	73	Poa pratensis	47
Asclepias syriaca	60	Polygonum aviculare	40
Bromus inermis*	40	P. convolvulus	47
Chenopodium album	87	P. pensylvanicum*	47
Cirsium arvense	60	Rumex crispus*	80
C. vulgare	47	Setaria lutescens	40
Digitaria sanguinalis*	40	Solanum dulcamara	40
Echinochloa crusgalli*	67	Taraxacum officinale	73
Lactuca scariola	73	Trifolium repens	40
Leonurus cardiaca*	60	Urtica dioica*	60
Lychnis alba	53	Verbascum thapsus	40
Malva neglecta*	53		

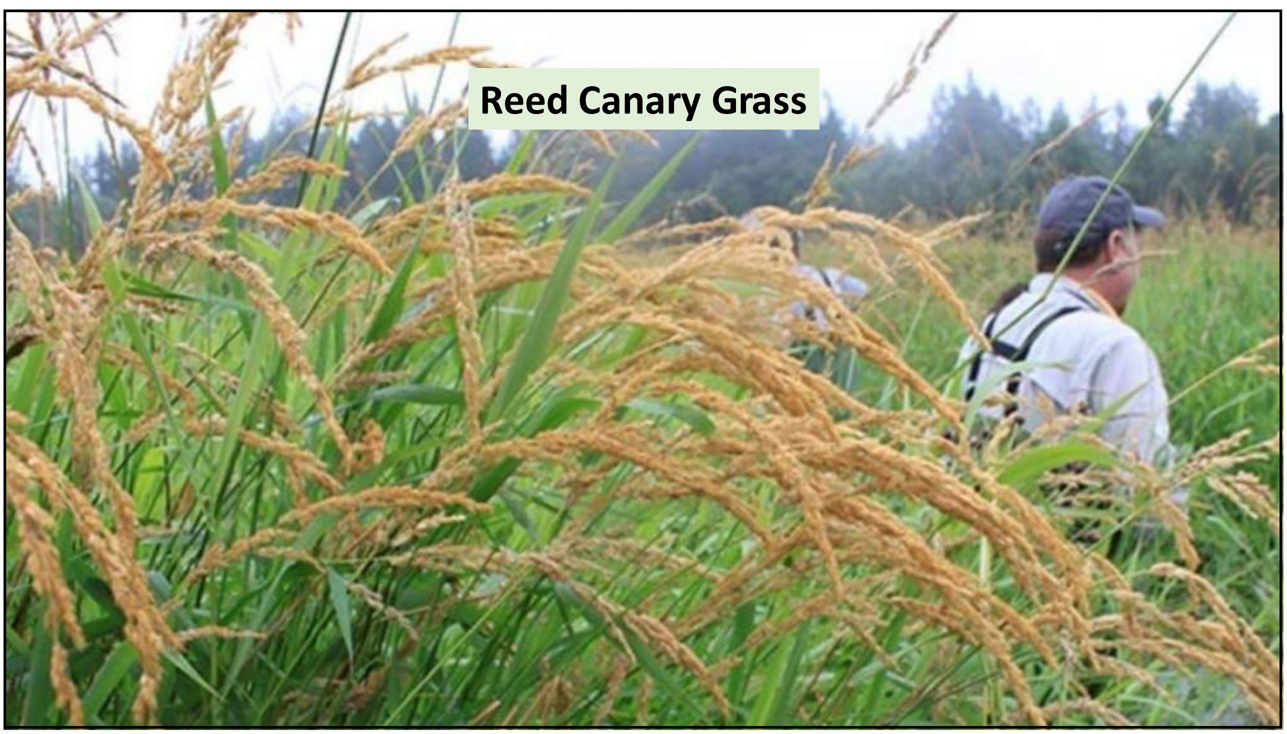
* Species are also modal, since their presence values are higher here than in any

Oxalis europaea (33), Pastinaca sativ (20), Portulaca oleracea (33), Setari


Burdock


Giant Ragweed


Wild Parsnip


Reed Canary Grass

Nitrogen Sources

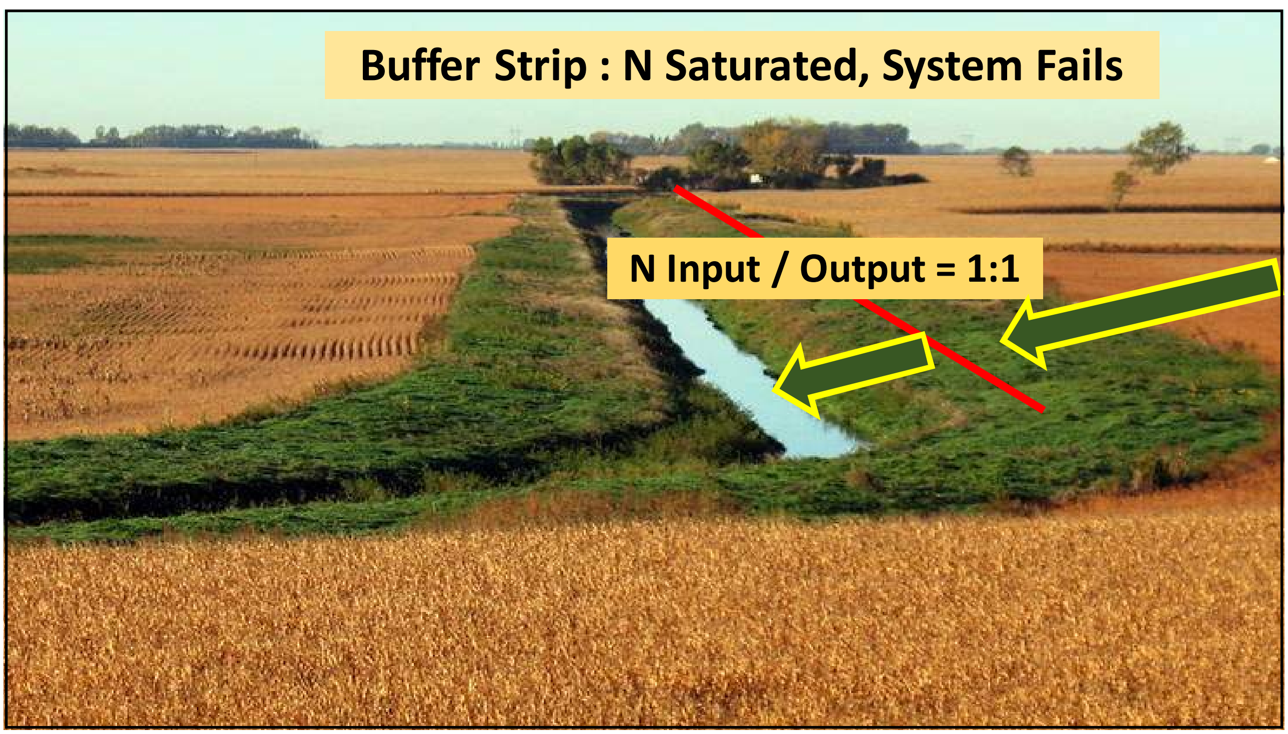

Nitrogen Lawn Fertilizer

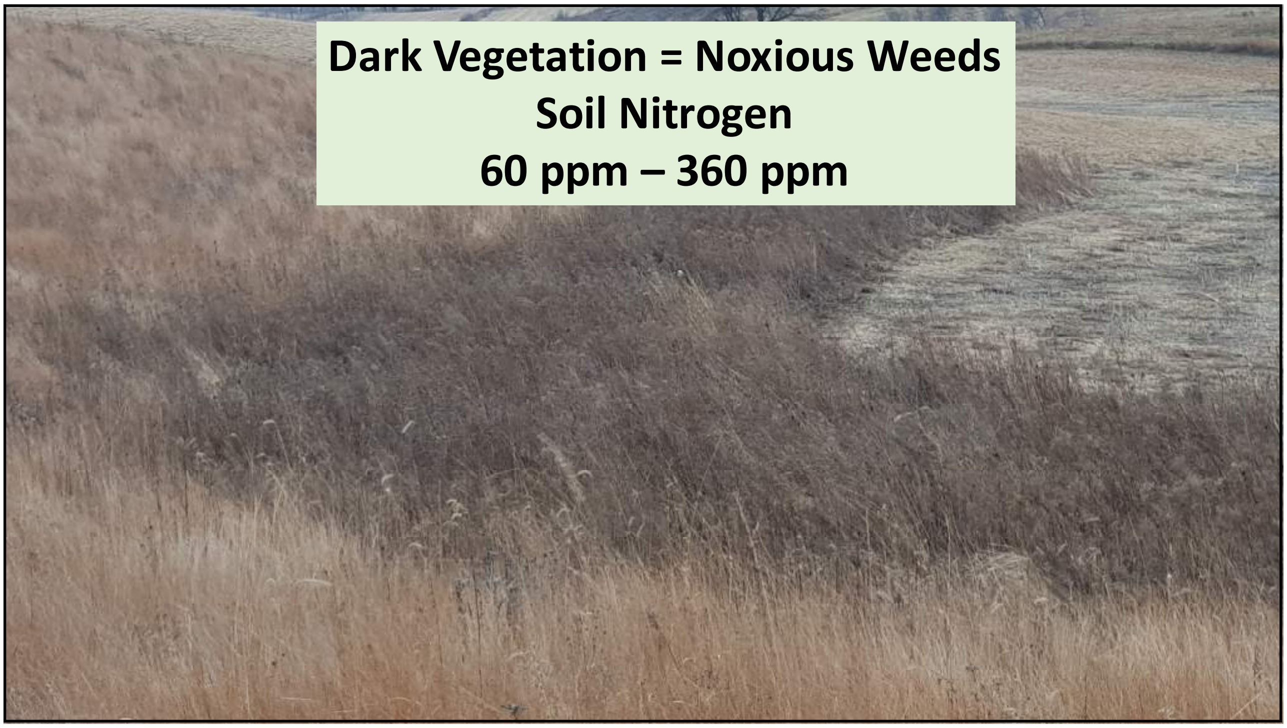

Nitrogen Lawn Fertilizer


Mow mowing
More weeds
More herbicide


Nitrogen is Water Soluble
Moves downward through soils


> Nitrogen = Landscape lowest Catena


Buffer Strip : N Saturated, System Fails
N Input / Output = 1:1


Dark Vegetation = Noxious Weeds
Soil Nitrogen
60 ppm – 360 ppm

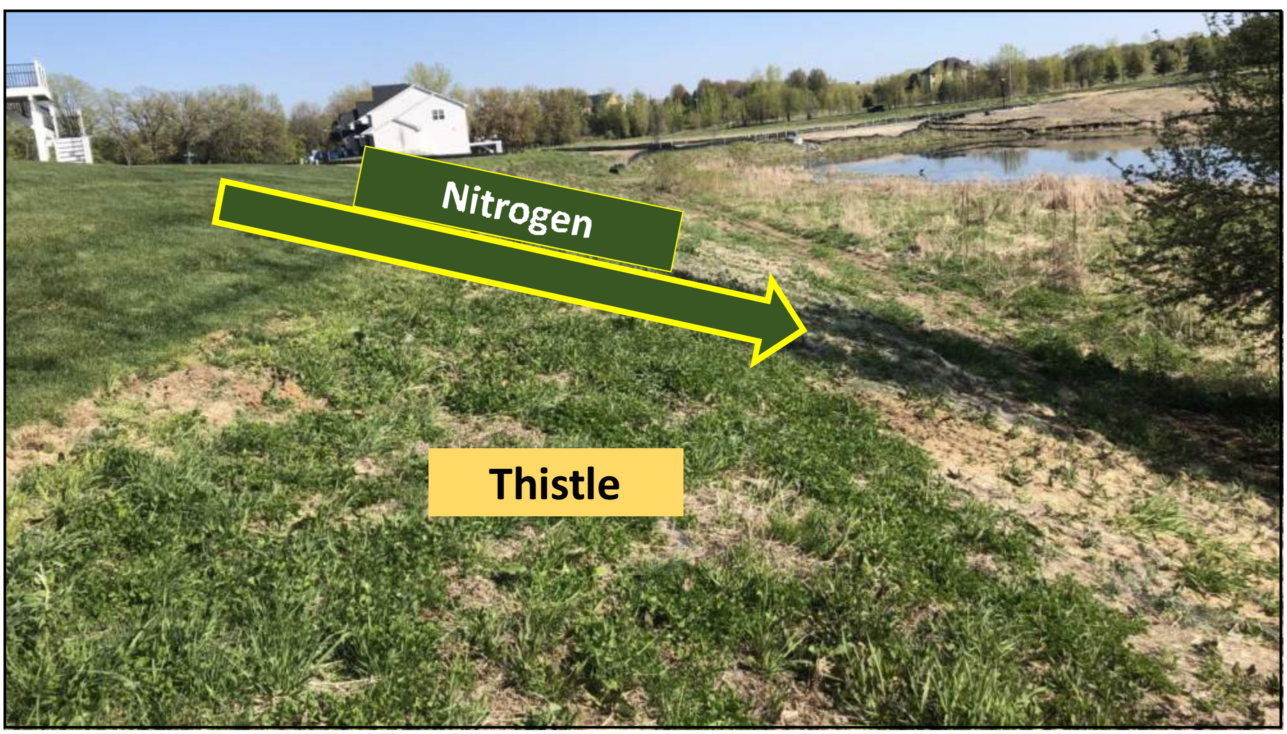

Year 5: From natives to weeds
KUBOTA
MX5200

Nitrogen Legacies

Bloomington, MN

Historic Farm
“Barnyard”

Canada Thistle


Nitrogen
Thistle


Pet Wastes


Mower Discharge Into Buffer

Mulch

Counter Intuitive / Positive Feedback

Decomposing

- **> Nitrogen**
- **> Weeds**

Response

- **Add more mulch**
- **> Nitrogen**
- **> Weeds**

Anthropocentric N contribution 3xs higher than natural fixation (Galloway *et al.* 2003)

Nitrogen Regulation


Fire: Nitrogen RedOx


Fire = carbon = < available nitrogen


Biomass Harvest
Mining Nitrogen
R 500


Communities Need Organic Recycling Centers

Plant appropriate nitrogen loving species
Non-aggressive, non-toxic, non-noxious

Kentucky Bluegrass

Native Strains ?

Creeping Bent Grass

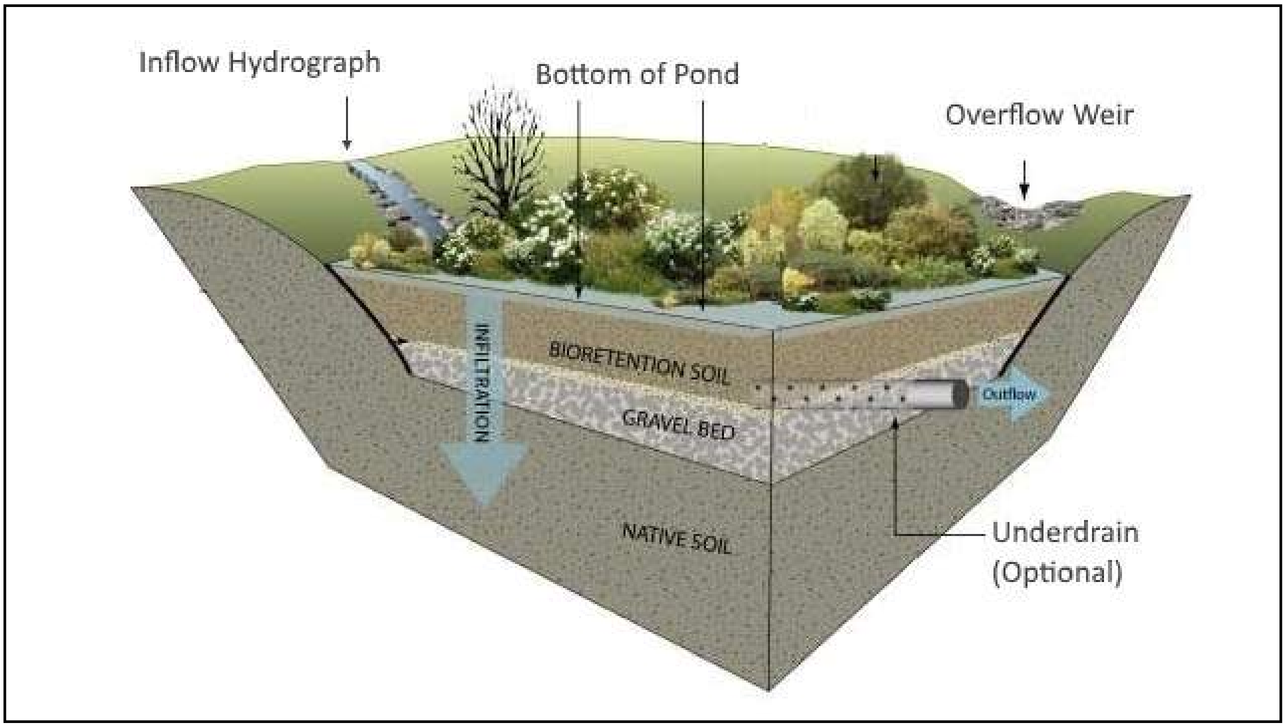
Native Strains

Smooth Brome

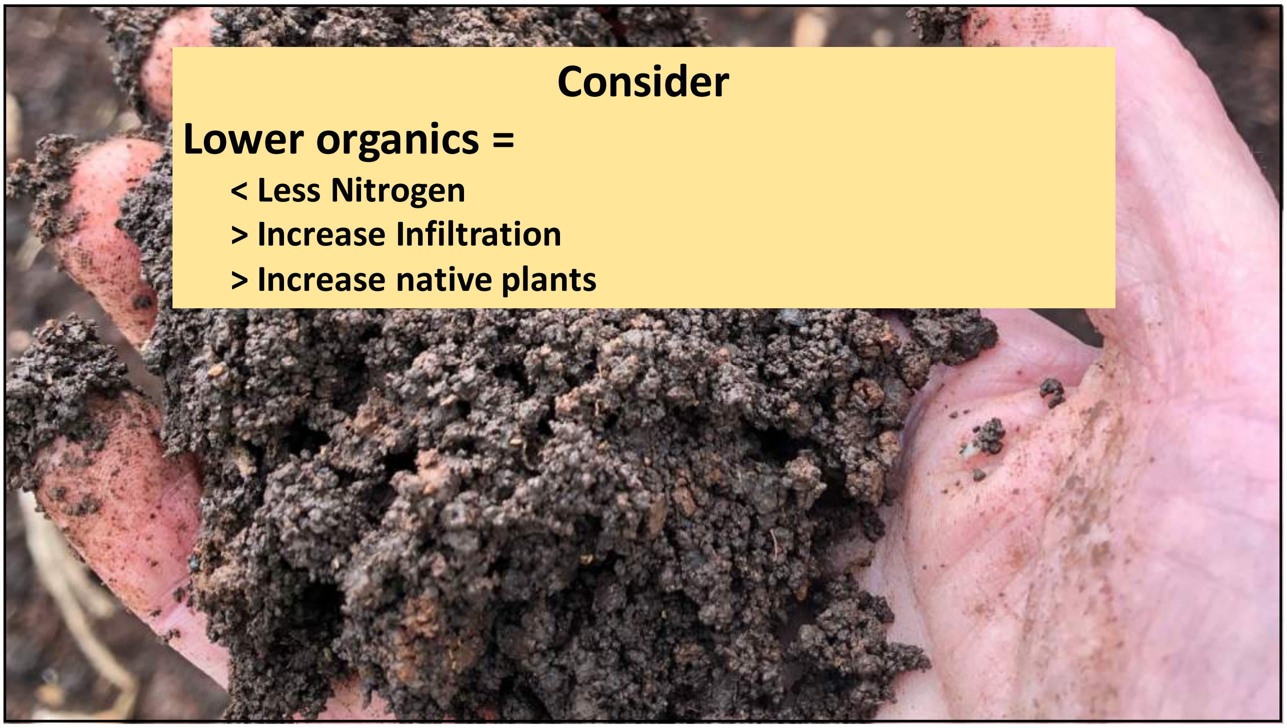
Cup Plant

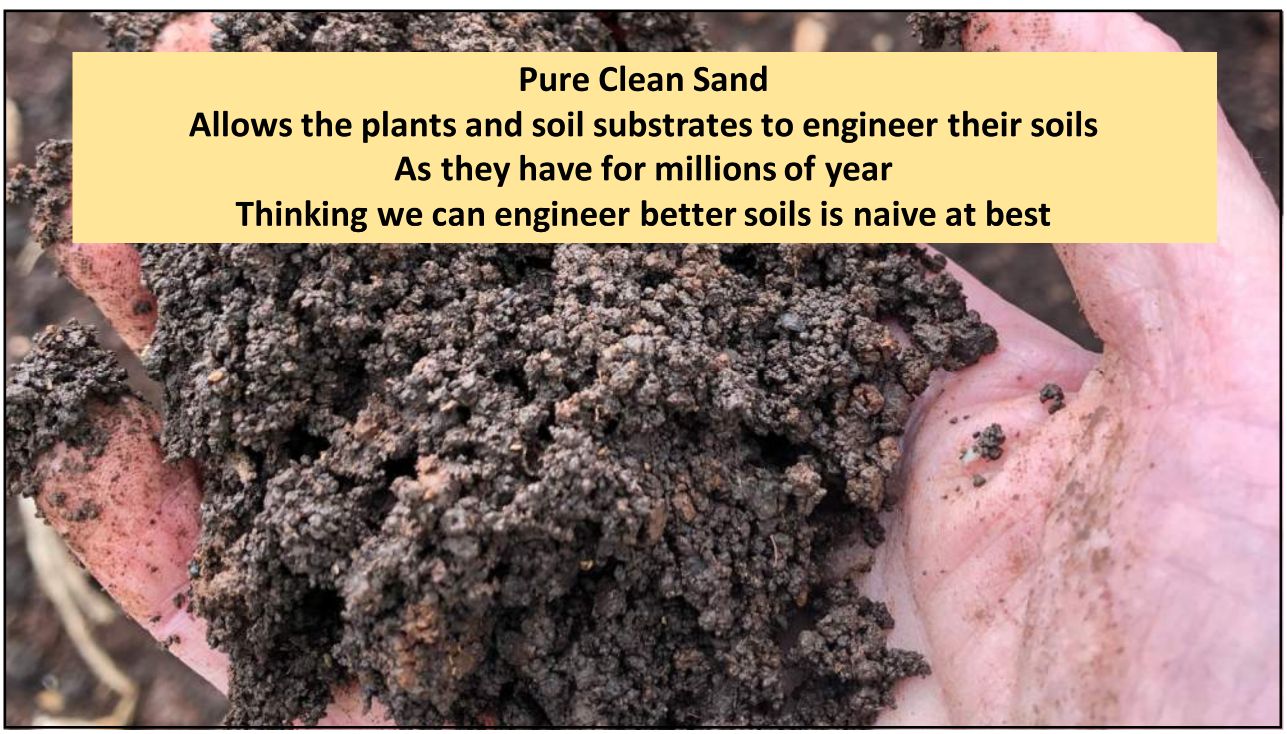
- **Native**
- **Nitrogen Loving**

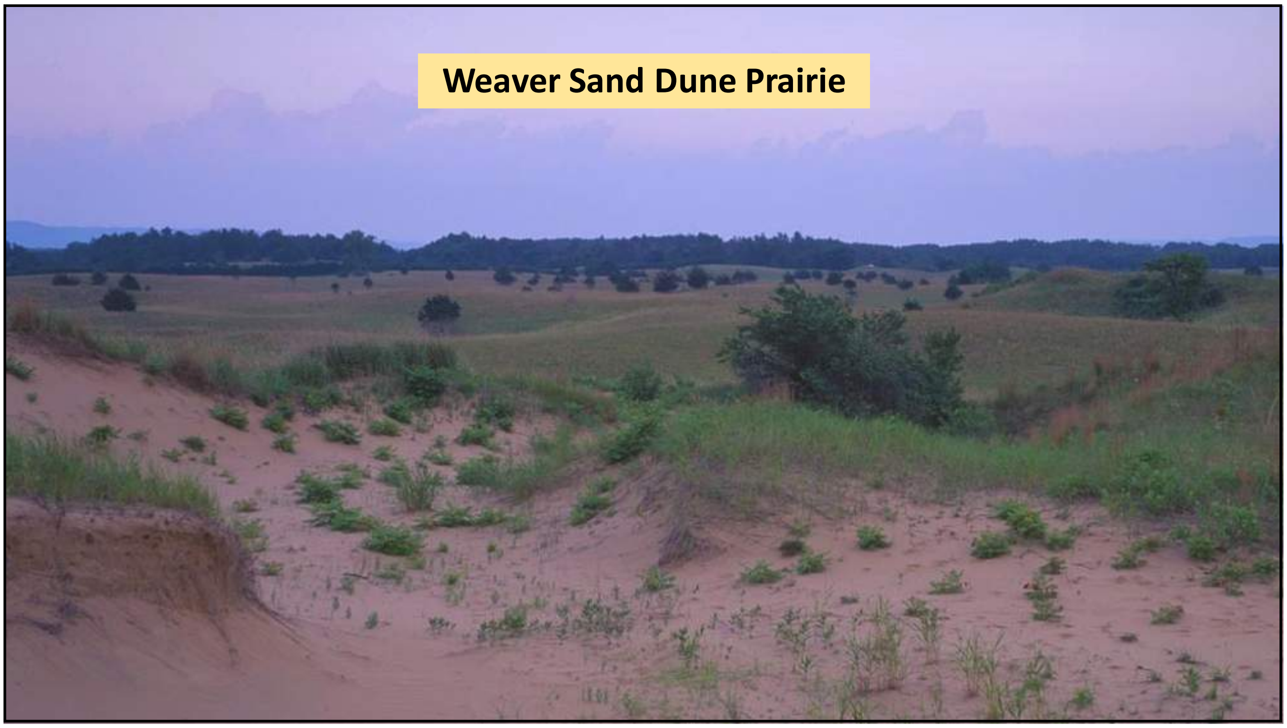
Design


Inflow Hydrograph
Bottom of Pond
Overflow Weir
INFILTRATION
BIORETENTION SOIL
Outflow
GRAVEL BED
NATIVE SOIL
Underdrain
(Optional)

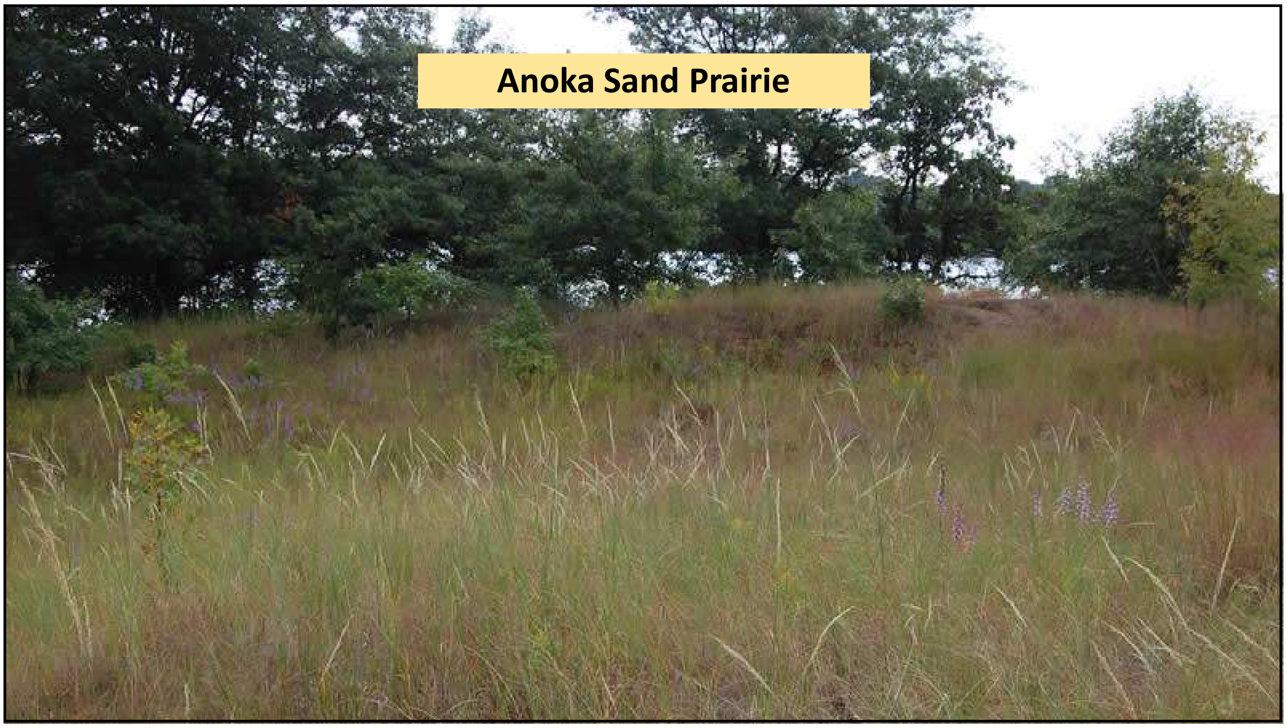

100% clean sand ?
95% clean sand ?


Consider
Lower organics =
< Less Nitrogen
> Increase Infiltration
> Increase native plants


Pure Clean Sand
Allows the plants and soil substrates to engineer their soils
As they have for millions of year
Thinking we can engineer better soils is naive at best


Weaver Sand Dune Prairie


Kankakee Sand Prairie


Anoka Sand Prairie


Wisconsin Sand Prairie


Nebraska Sand Hills Prairie


Nebraska Sand Hills Seasonal Wetland


This will fail


This will fail
Nitrogen
Mulch
Lawn fertilizer

Summary: Vegetation - **Context & Design impede long term establishment of quality native vegetation**

Nitrogen primary constraint over vegetation configuration

- **Too much N = noxious weeds**
- **N flows through water table**
- **N inputs, lawns, atmosphere, pet wastes, mower discharge, plants, compost, mulch and legacies**

Mitigate N

- **Regulate N use (fertilizers, waste dumping, mulch inputs, trees)**
- **Fire to redox N**
- **Haying to mine N**
- **Plant non-noxious Nitrophiles (e.g., Bluegrass, Bent Grass)**

Design

- **Limit organic mixing to < 5%**