

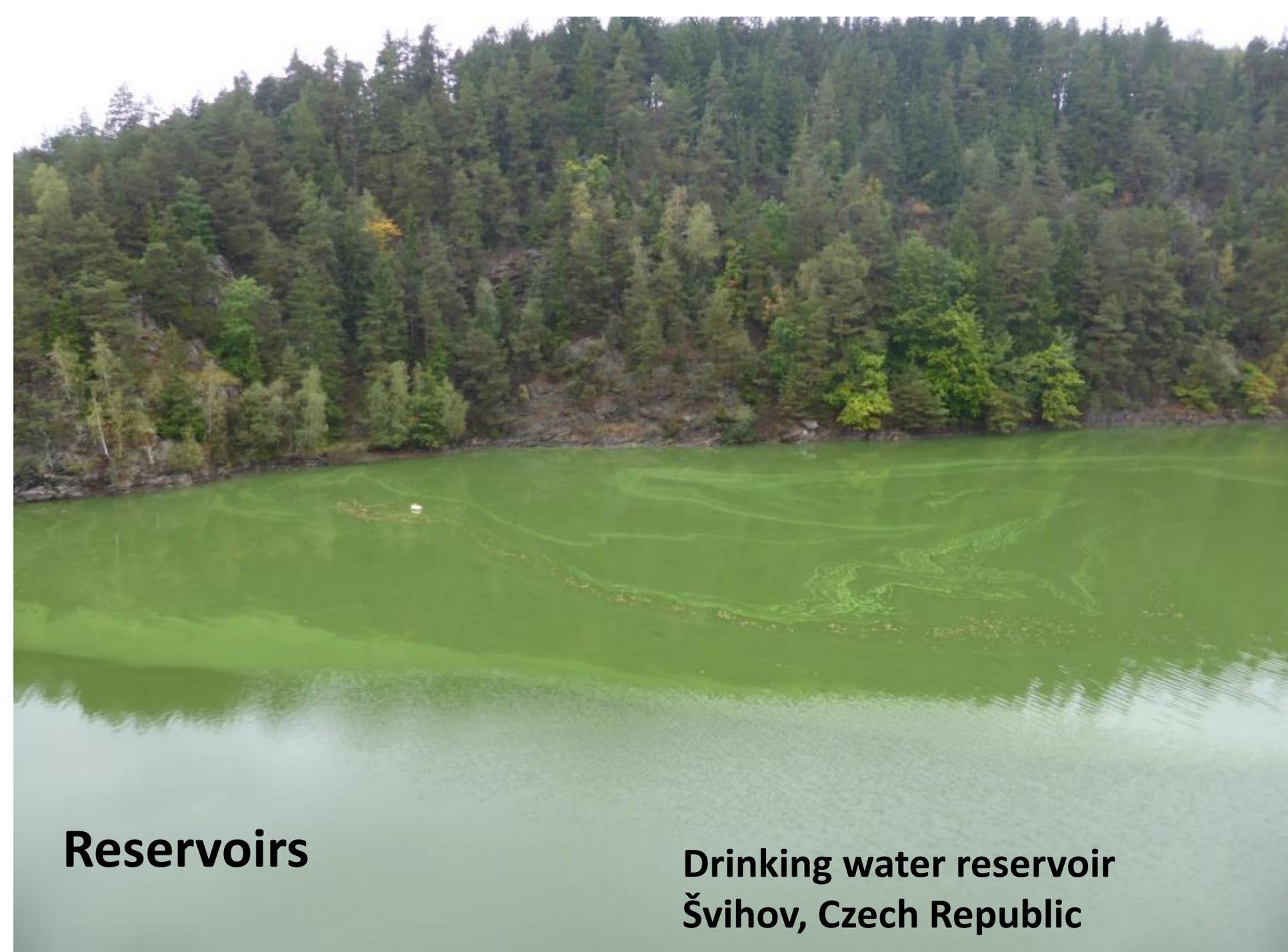
The image shows a wide, flat area covered with tall, green and yellowish-brown grasses, characteristic of a wetland or meadow. In the background, there is a dense forest of tall, thin trees, possibly pines or spruces, under a cloudy sky. The overall scene is a natural, rural landscape.

**The use of free water surface constructed wetlands to
remove nutrients from agricultural drainage**

Jan Vymazal
Czech University of Life Sciences Prague

Nutrients in agricultural drainage trigger eutrophication of streams





Reservoirs

**Drinking water reservoir
Švihov, Czech Republic**

and coastal areas

Kuressaare, Saaremaa, Estonia



The ability of natural wetlands to retain nitrogen from freshwaters was recognized and has been reported since the 1970s (Mitsch et al., 1979; Richardson, 1990).

The major processes responsible for **nitrogen** removal in wetlands are:

- denitrification
- plant uptake (subsequent harvest)
- sedimentation and sediment accretion
- volatilization

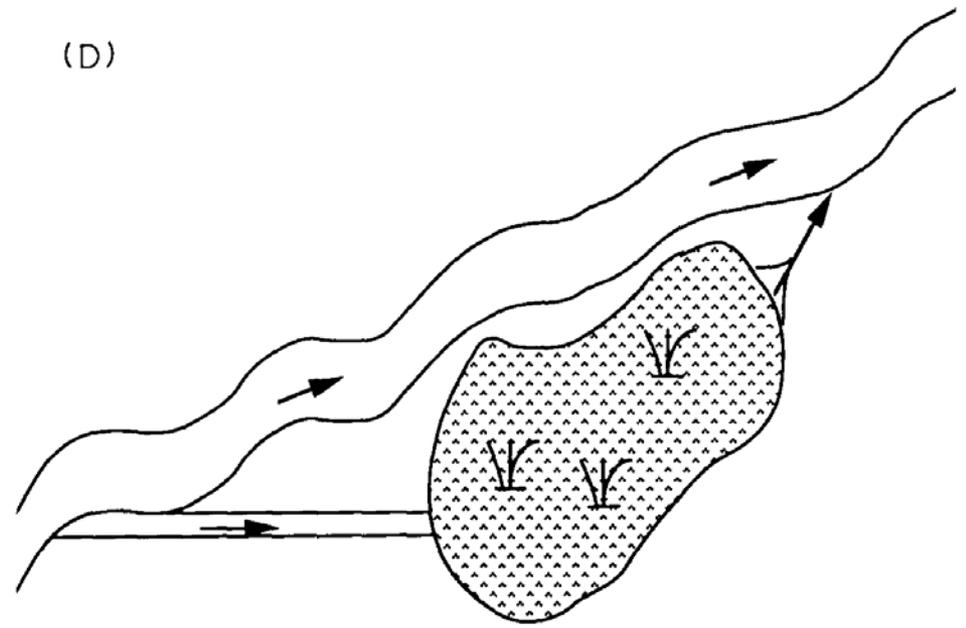
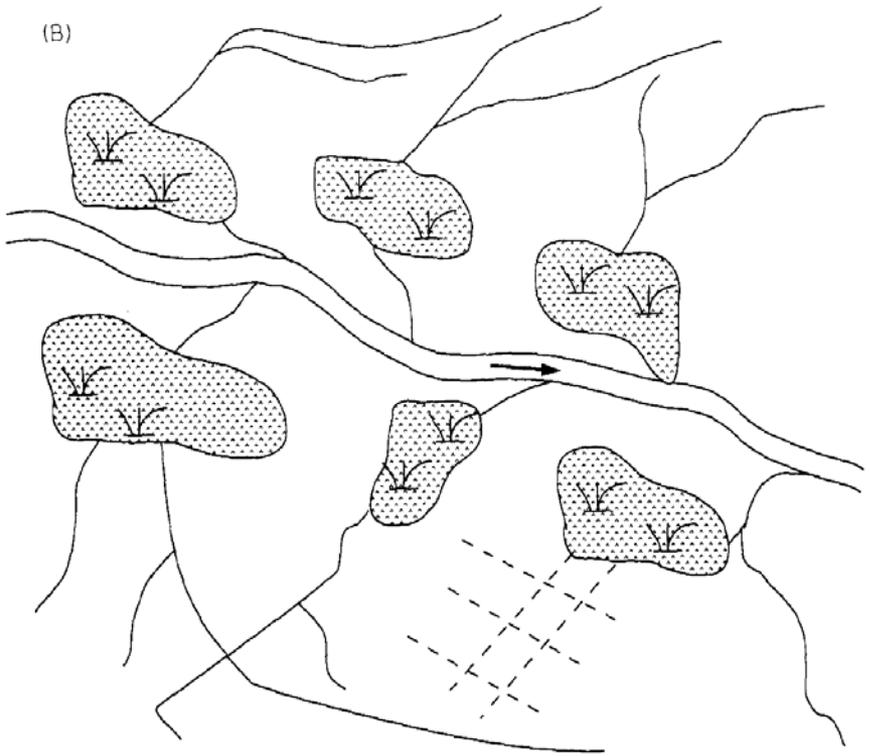
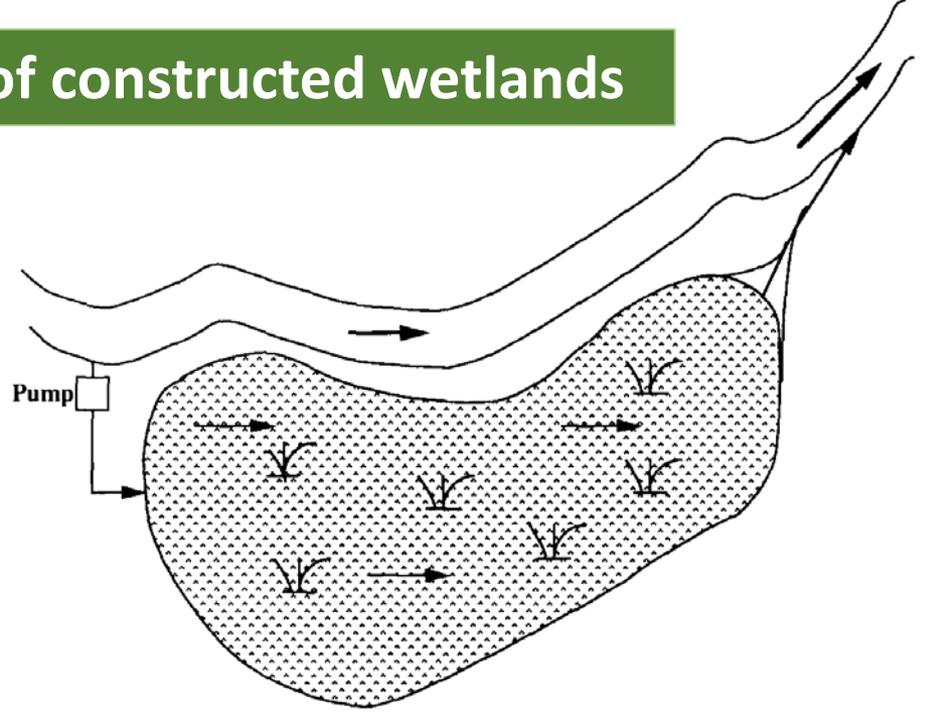
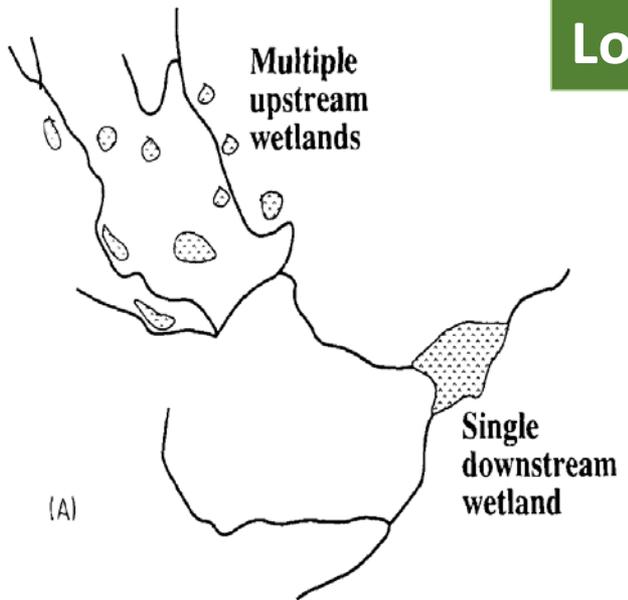
The major processes responsible for **phosphorus** removal in wetlands are:

- sedimentation and sediment accretion
- plant uptake (subsequent harvest)
- sorption
- precipitation/co-precipitation (Al, Fe, Mg, Ca)

Constructed wetlands for treatment of diffuse pollution – design principles (Mitsch, 1992)

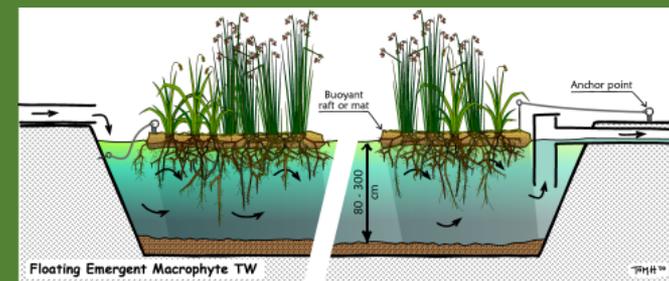
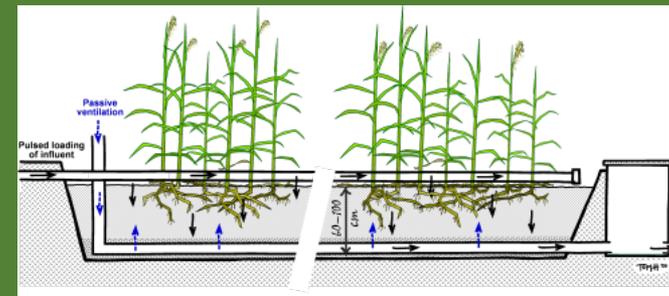
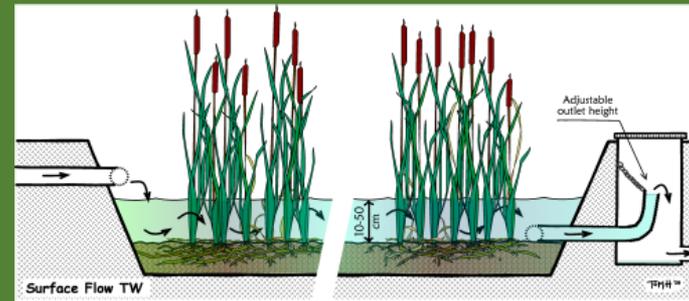
1. Minimum maintenance
2. Use of natural energy
3. Design the system with the landscape, not against it
4. Design with multiple objectives
5. Design the system as ecotone
6. Give the system time to develop
7. Design the system for function, not for form
8. Do not over-engineer the system (with rectangular basins, rigid structures and regular morphology)

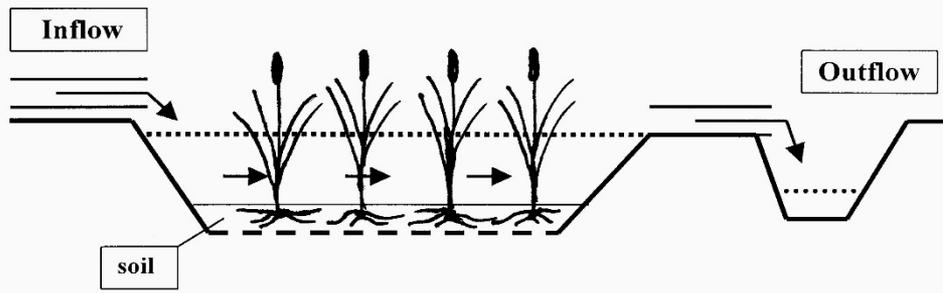
Location of constructed wetlands



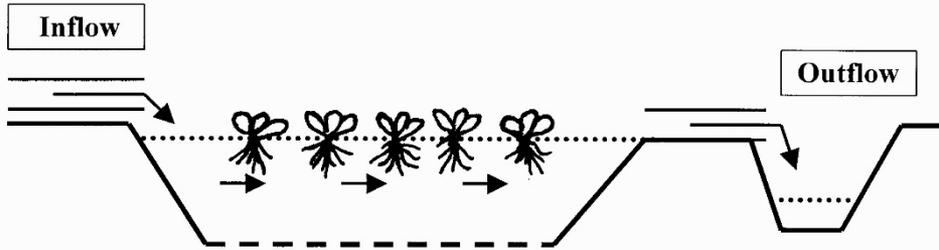
Types of Constructed Wetlands

- Surface Flow Wetlands
- Horizontal Subsurface Flow
- Vertical Flow
- Floating Treatment Wetlands

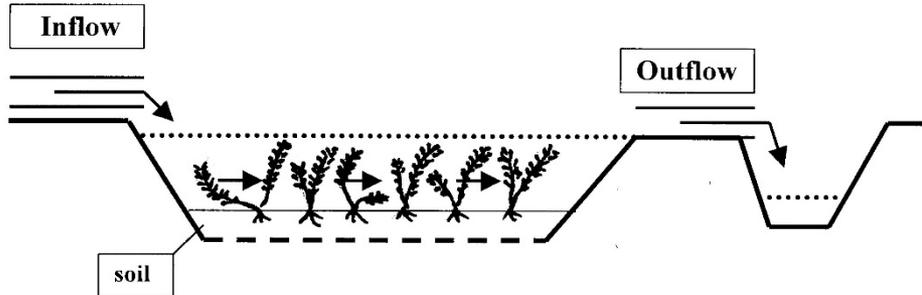




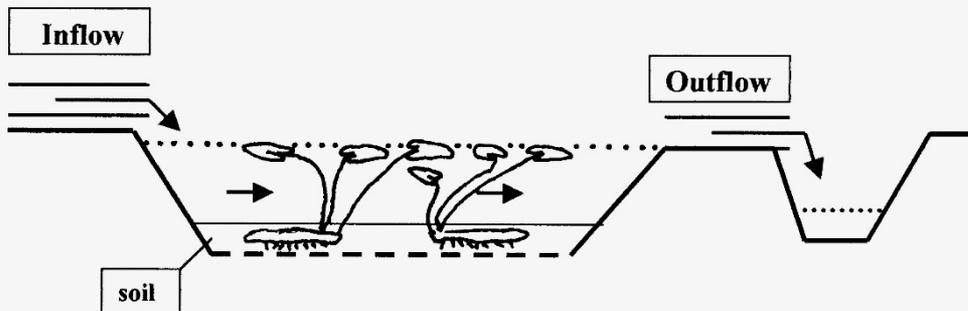
Emergent species



Free floating species

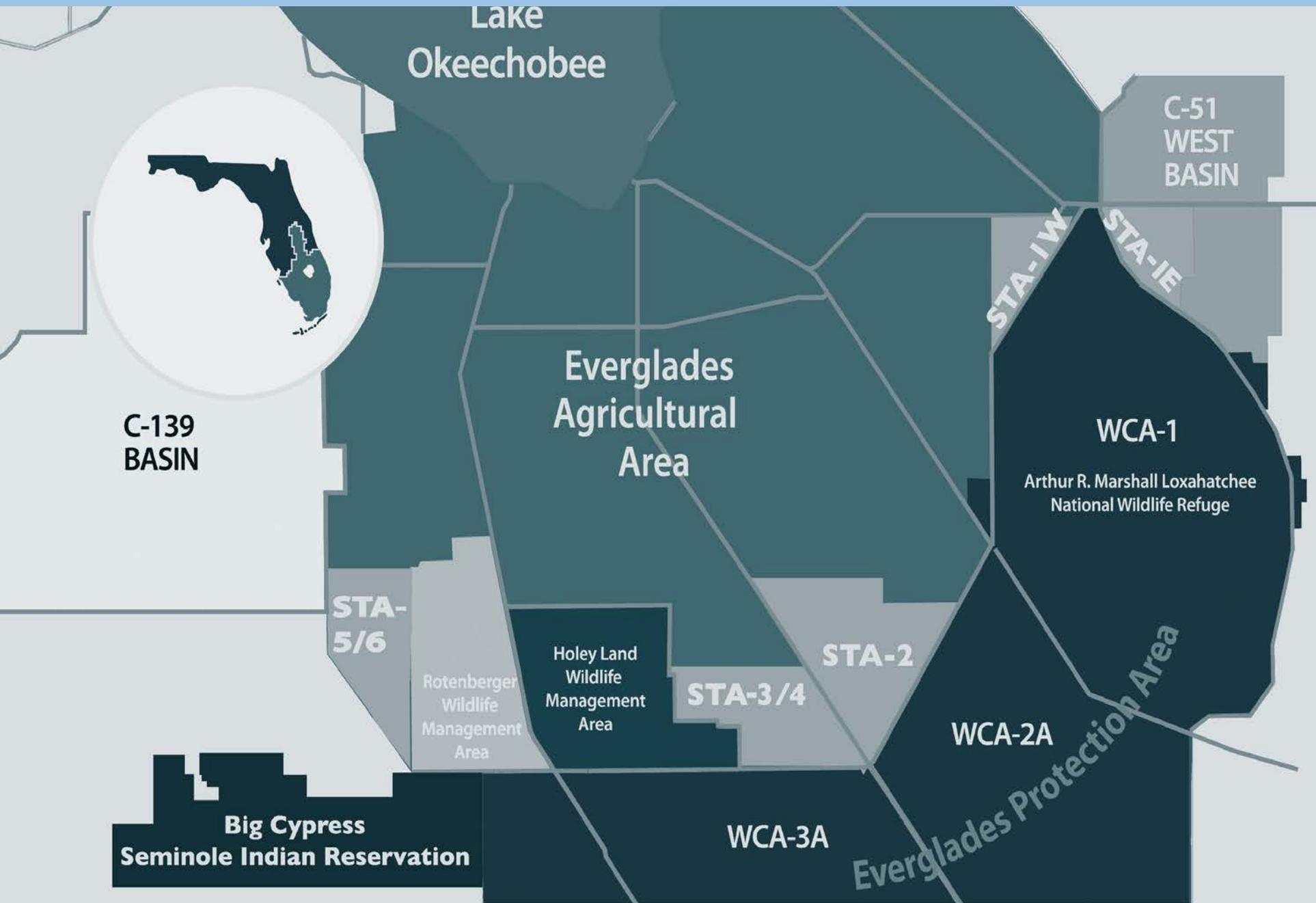


Submerged species



Floating-leaved species

Stormwater treatment Areas, Florida, USA, 26 000 ha



Everglades Agricultural Area, Florida, USA





Florida Everglades Stormwater Treatment Area



Najas guadalupensis

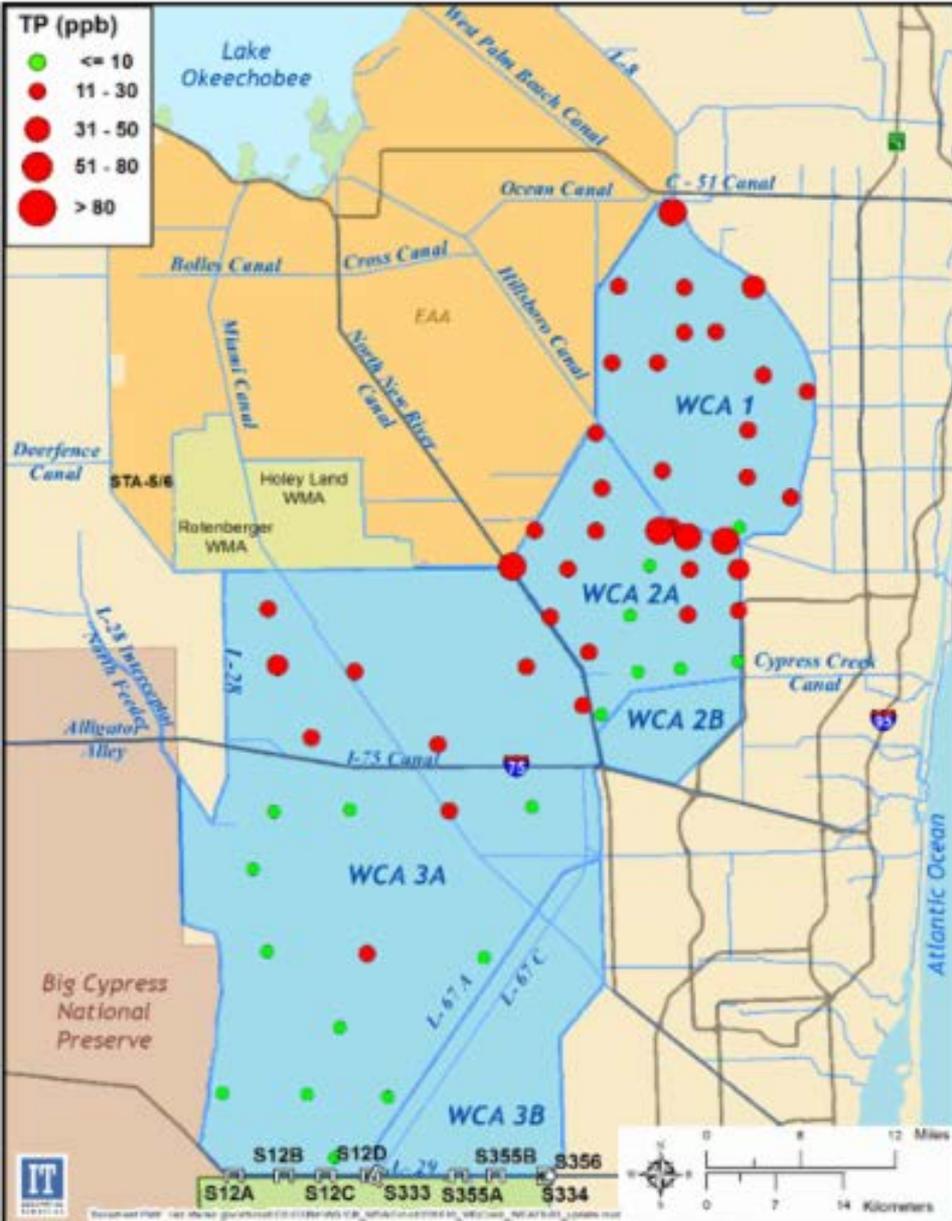


Ceratophyllum demersum



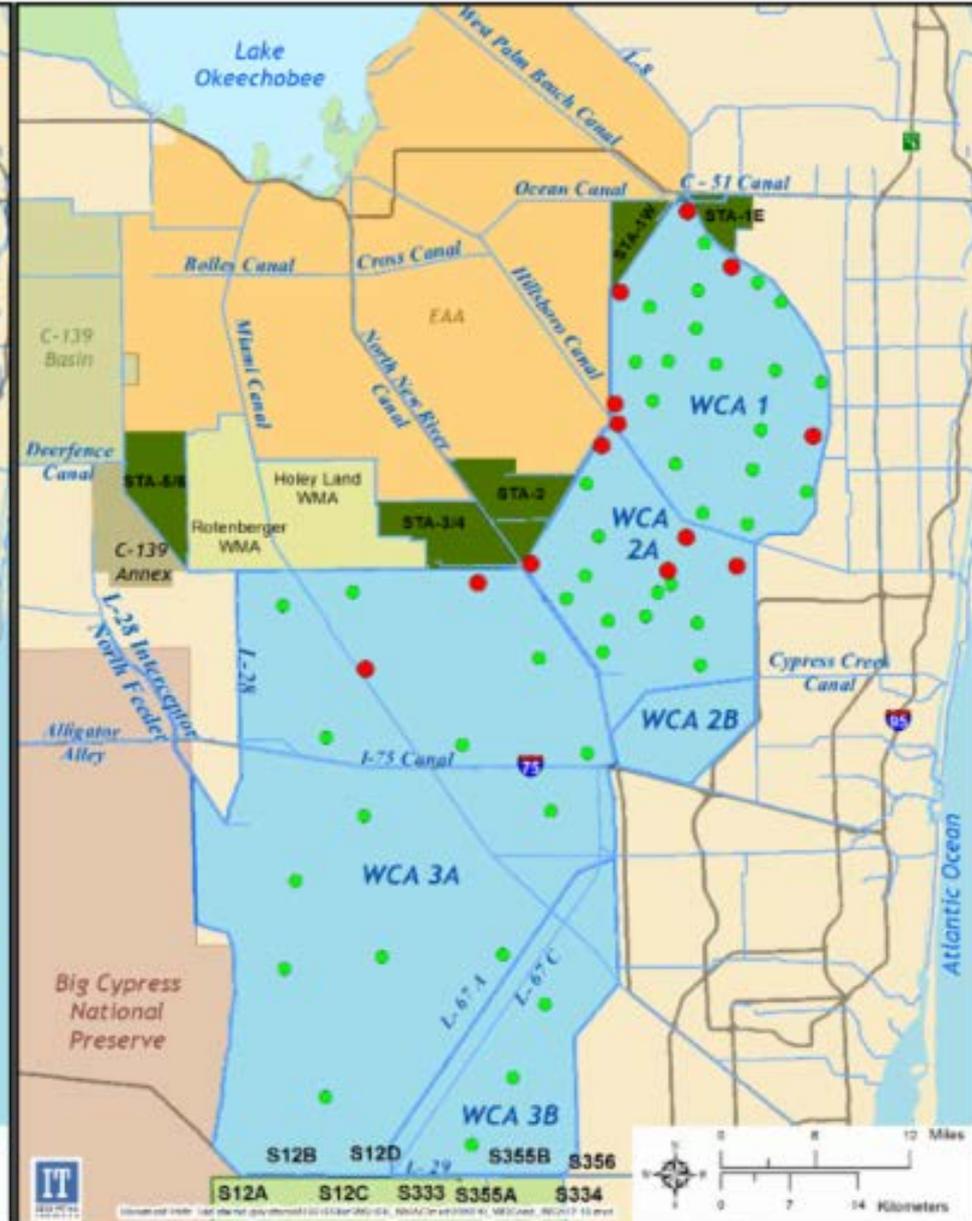
1979-1983

Phosphorus Concentrations



2012-2016

Phosphorus Concentrations



Genarp, Skåne, Sweden: Phosphorus retention 140 kg P/ha yr



Foto Pia Kynkäänniemi

Near Padova, Italy



Laluzza, Spain





**CW for pasture drainage runoff (40 ha),
Lake Okaro, New Zealand**

Lake Okaro, New Zealand, treatment of pasture drainage



Bog Burn, New Zealand, drainage from an experimental pasture



Inflow: 1062 kg N/ha yr

Outflow: 221 kg N/ha yr

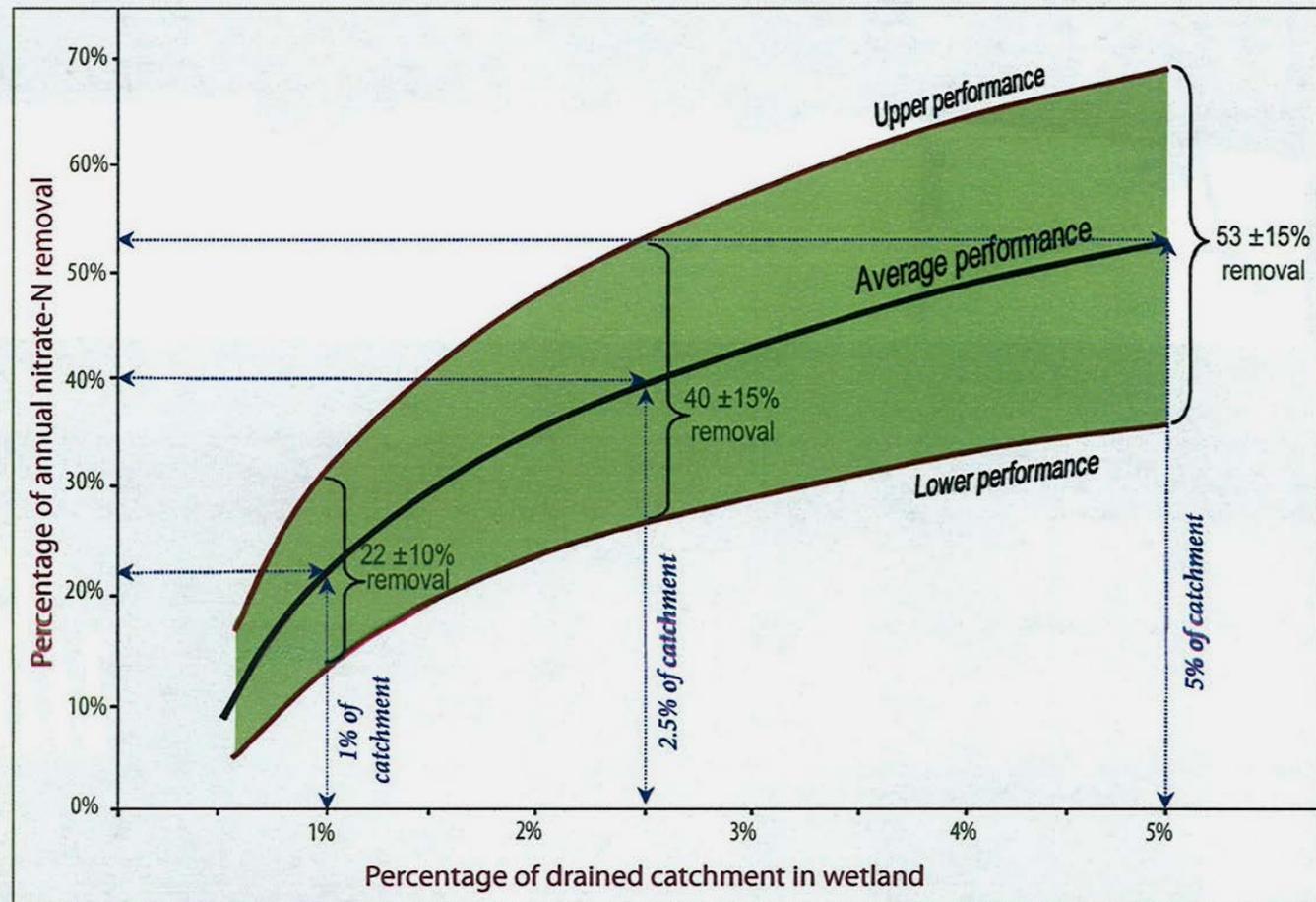
Retention: 841 kg N/ha yr (79%)

Relationship between nitrate removal and wetland/watershed ratio

New Zealand Guidelines: Constructed wetland treatment of tile drainage (2010)

<http://www.niwa.co.nz/our-science/freshwater/tools/tile-drain-wetland-guidelines>

www.niwa.co.nz



41 FWS constructed wetlands (N removal)

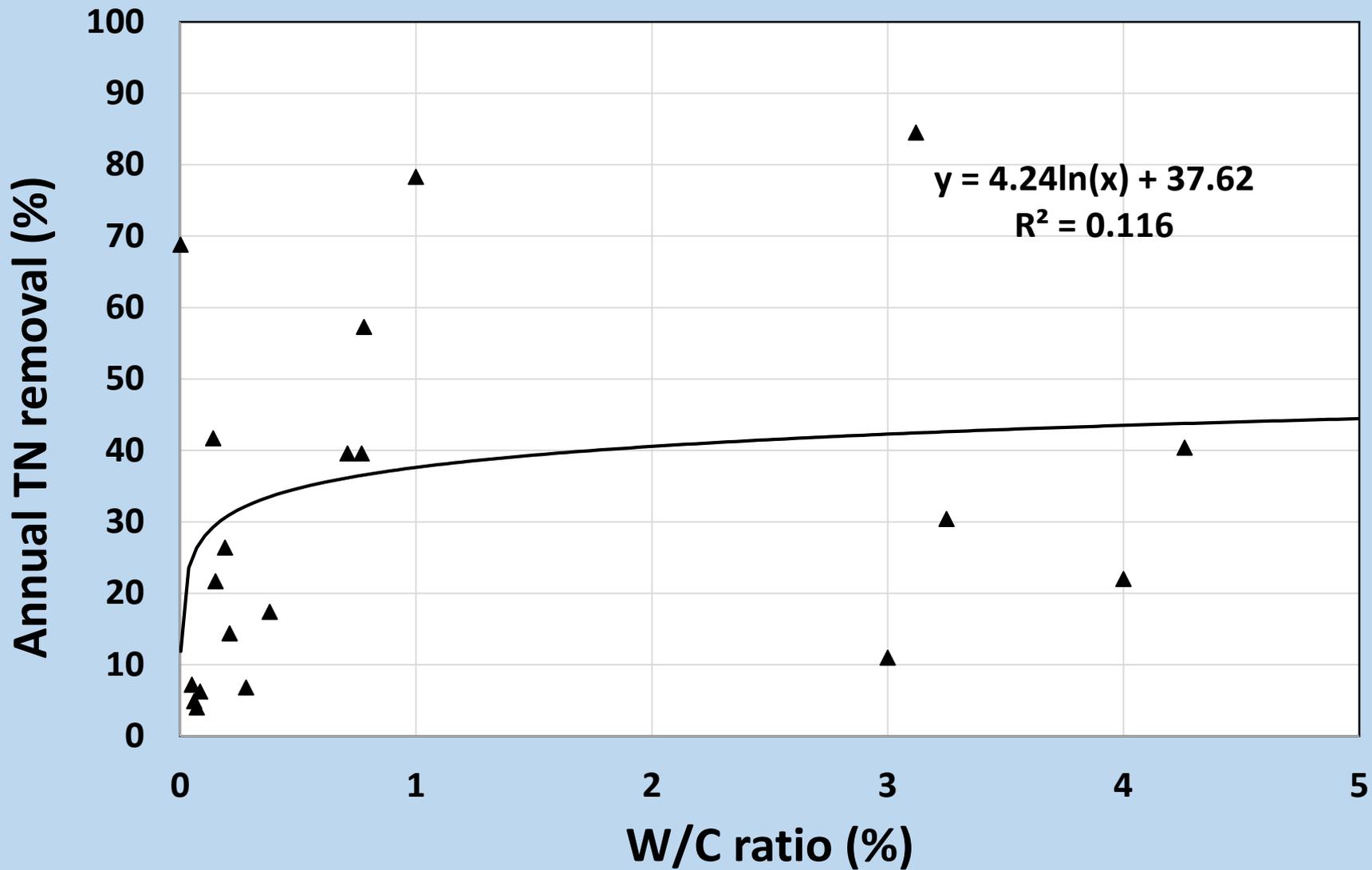
USA (14), Sweden (10), Norway (6), Finland (3), Korea (2), Australia (1), Taiwan (1), Italy (1), New Zealand (1), Denmark (1), Spain (1)

Wetland Area	0.026 – 150 ha	mean 60 ha	median 0.9 ha
Catchment Area	2.6 – 175 000 ha	mean 2219 ha	median 90 ha
W/C	0.0023 – 7.5%	mean 2.64%	median 0.71%
Inflow load	20 - 47 272 kg N ha ⁻¹ yr ⁻¹		
Removed load (kg N ha⁻¹ yr⁻¹)	11 - 13 026 kg	mean 1 374	median 426

27 FWS constructed wetlands (P removal)

USA (7), Sweden (5), Norway (5), Finland (4), Korea (2), Australia (1), Taiwan (1), China (1), Switzerland (1)

Wetland Area	0.036 – 150 ha	mean 9.1 ha	median 0.6 ha
Catchment Area	2.4 – 2 000 ha	mean 361 ha	median 90 ha
W/C	0.05 – 7.5%	mean 1.78%	median 0.53%
Inflow load	6 - 2 419 kg P ha ⁻¹ yr ⁻¹		
Removed load (kg P ha⁻¹ yr⁻¹)	1.8 - 1 160	mean 155	median 29



SR2

A Systematic Review

How effective are created or restored freshwater wetlands for nitrogen and phosphorus removal?

**Magnus Land
Wilhelm Granéli
Anders Grimvall
Carl Christian Hoffmann
William J. Mitsch
Karin S. Tonderski
Jos T.A. Verhoeven**

93 articles/ 203 wetlands, mostly Europe and North America

Nitrogen

Mean removal 1 810 kg N ha⁻¹ yr⁻¹

Median removal 930 kg N ha⁻¹ yr⁻¹

Median removal 37%

Phosphorus

Mean removal 130 kg P ha⁻¹ yr⁻¹

Median removal 12 kg P ha⁻¹ yr⁻¹

Median removal 46%

Case study from the Czech Republic



2016 removal
837 kg N ha⁻¹ yr⁻¹
45%

117 kg P ha⁻¹ yr⁻¹
37%



*Thank you for
your attention*

