Managing Buffers to Meet Water Quality Goals

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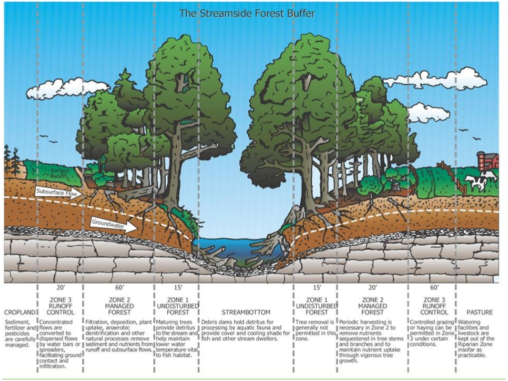


Outcomes

- Define Buffer and Buffer Goals
- Summarize Mechanistic Considerations for Buffer Success
  - Sediments
  - Temperature
  - Pesticides
  - Nitrogen
  - Phosphorous
  - Salts
  - Pathogens
  - Metals
- Develop an Appropriate Design with Effective Functions
- Long-term Effectiveness

Define Buffers

Defining Buffers

Ecotones Ecologist might describe transitions between two types of communities

Hedgerow British traditions to break up landscape with living fence lines that have habitat value (by selection?).

Field Margin / Fence line Farm view and edge of field cultural practices.

Vegetative Buffers Strips Best Management Practice for Water Quality (NRCS/Clean Water Act)

Riparian Buffers / Forests from a wetland or stream/lake perspective

Others

Names/Types of Buffers

- Vegetative Barriers
- Field Borders
- Filter Strips
- Vegetative Buffer Strips
- Riparian Forest Buffers
- Wind Buffers

Water Quality Stressors

- Sediments
- Stream Temperature
- Sub-soil Applied Pesticides (fumigants, chemigation)
- Aerially Applied Pesticides (fungicides versus insecticides)
- Nitrogen (Total and Dissolved)
- Phosphorous (Total and Dissolved)
- Salts
- Pathogens
- Metals

Defining Buffer Goals

Goals proscribe design in terms of **structure and function** and evaluation of success.

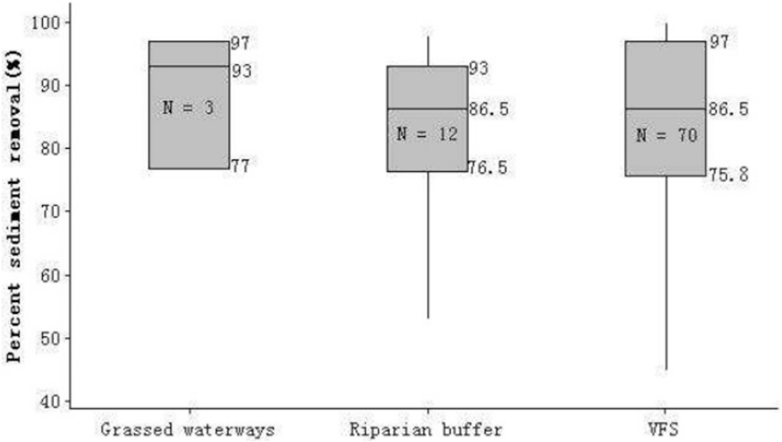
For example, distinctions should be made between:

- Storm versus Irrigation Runoff
- Surface and Subsurface Flow
- Concentrated versus Diffuse Flows
- Eolian versus Water Transport

Defining Water Quality Goals

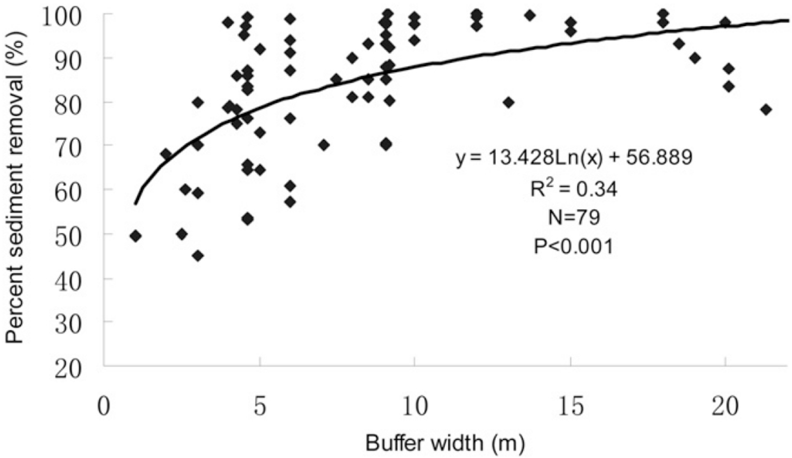
- Regulatory – Water Quality
- Regulatory – Habitat
- Ecological – Community composition
- Ecological – Ecosystem functions
- Ecological – Conservation
- Agroecological – Beneficial Insects
- Agroecological – Dust Control

Trapping Sediments



Liu et al. 2008.

Sediments and Buffer Width



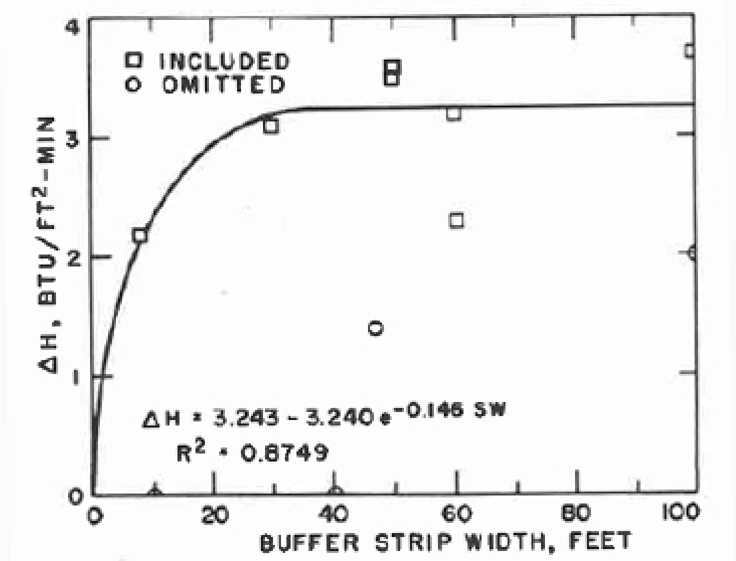
Liu et al. 2008.

Sediments and Buffer Width

Mechanisms of Trapping Sediments

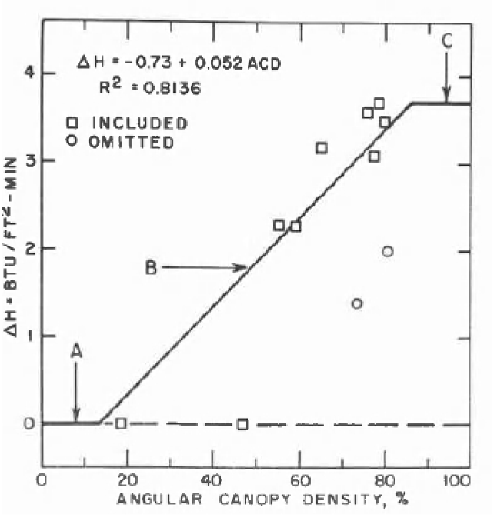
- Deposition via infiltration (Soil porosity)
- Filtration (Vegetation roughness)

Moderating Stream Temperatures



Brazier and Brown. 1973.

Moderating Stream Temperatures



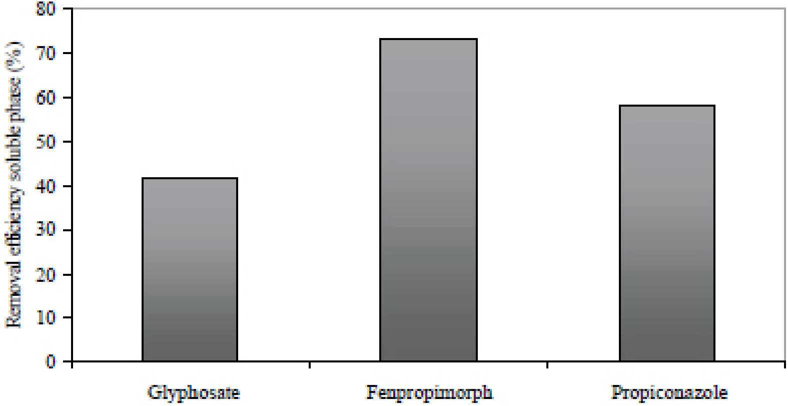
Brazier and Brown. 1973.

Soil Fumigants and Chemigation

Vadose Zone Transport of soil fumigants.

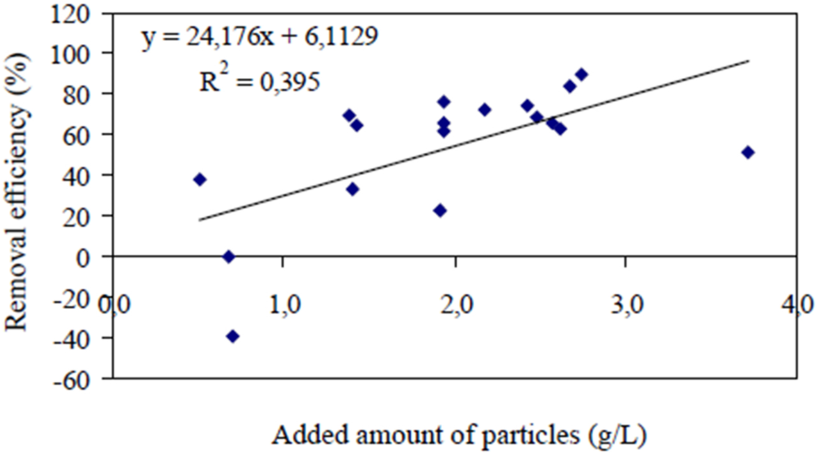
- Limited buffer capacity for buffers to function to improve water quality
- Strict rules defined by public health concerns.

Surface Runoff and Removal Rates (5 meter buffer)



Syversen and Bechmann. 2004.

Surface Runoff and Particles



Syversen and Bechmann. 2004.

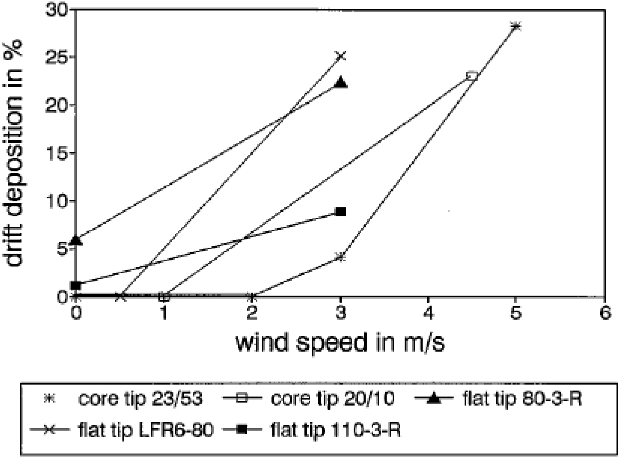
Pesticide Drift

	Normal	3-m buffer	6-m buffer
Ditch bank			
23/53 core spray tip	4.10	0.08	0
20/10 core spray tip[b]	23.96	0.03	0
LFR6-80° flat tip	25.12	0	0
80°-3-R flat tip	22.39	0.02	0.02
110°-6-R flat tip	8.79	0.01	0
Ditch			
23/53 core spray tip	0.98	0.02	0
20/10 core spray tip[b]	0.56	0.03	0
LFR6-80° flat tip	0.83	0	0
80°-3-R flat tip	2.19	0.07	0
110°-6-R flat tip	0.76	0	0

[a]Sprayed area = 100% drift deposition.
[b]Tested with wind speed of 4.5 m/s.

de Snoo, et al. 1998.

Pesticide Drift and Windspeed



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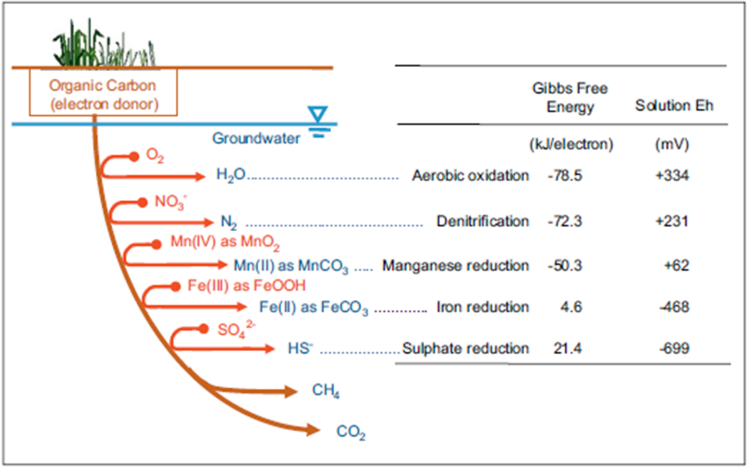
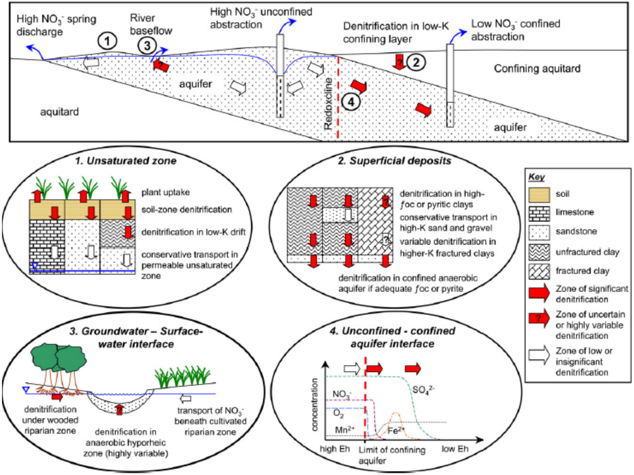
Nitrogen Biogeochemistry and Groundwater



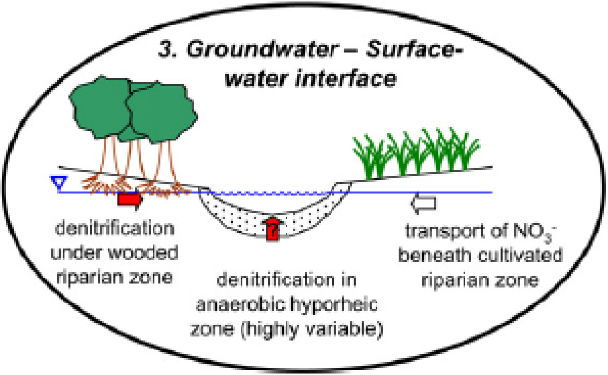
Rivett et al. 2008.

Nitrogen Biogeochemistry and Groundwater



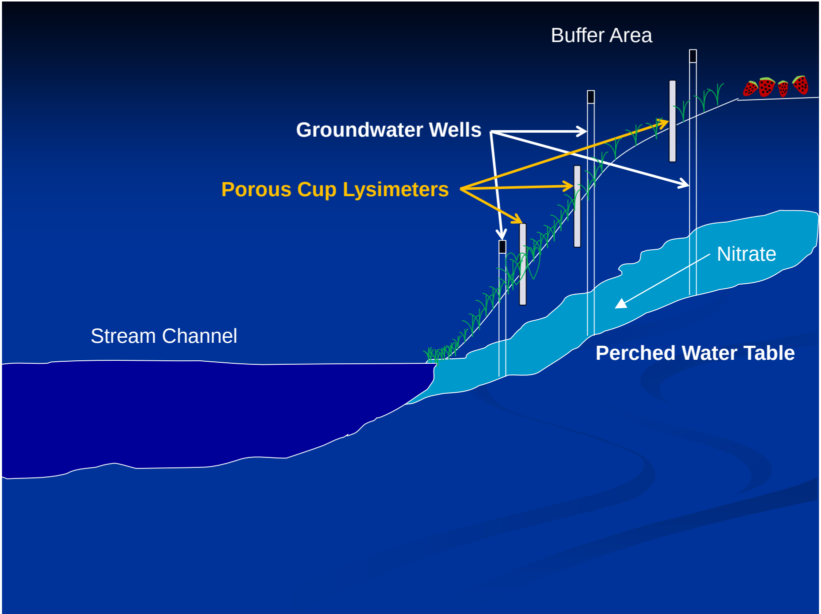
Rivett et al. 2008.

Biogeochemistry

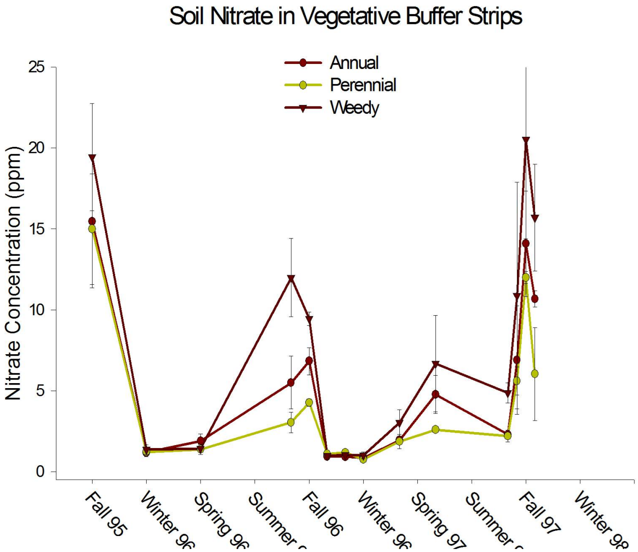


Rivett et al. 2008.

Vegetative Buffer Strips–Evaluation

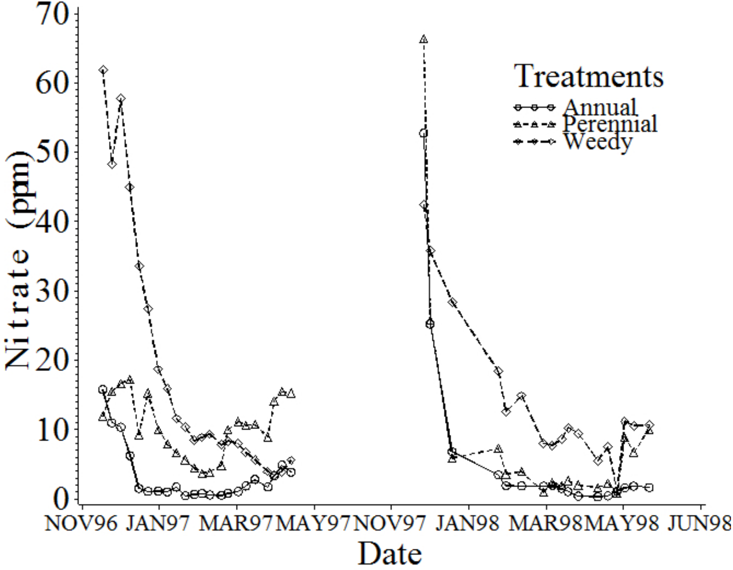


Vegetative Buffer Strips—Soil N



Los Huertos, unpub.

Vegetative Buffer Strips—Soil Water N



Los Huertos, unpub.

Vegetative Buffer Strips and Mediterranean-type Climate

- Season dry season limits redox conditions
- Seasonal flux of nitrate before appropriate redox conditions set in
- Reducing conditions are limited to narrow upland-wetland interfaces.

Phosphorous

- Generally sediment bound
- Complex sediment-water chemistry
- Phosphatase activity provides new insight into P dynamics.

Phosphorous Biogeochemistry in VBSs

VBS establishment can

- Enhance rates of soil P cycling (e.g. phosphatase enzyme activity, microbial diversity, and biomass P)
- Increase soil P solubility (e.g. inorganic P solubility indices, and dissolved organic P)
- Increase potential P leaching to surface waters

Possible Mechanism: VBS may increase plant-microbial system diversity, which can access previous immobilized soil P from past fertilization or trapped sediment P.

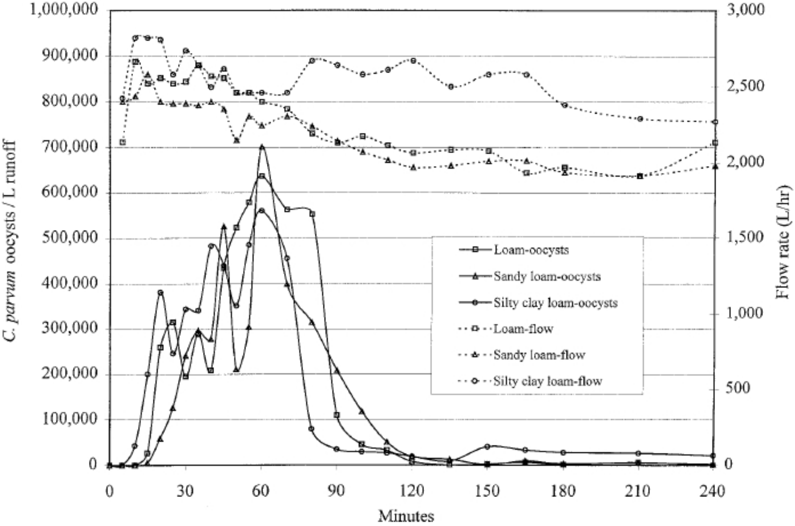
Stutter, et al. 1999.

Salts

Ground water basin salt management may be one of the most challenging long-term issues to face agriculture in California.

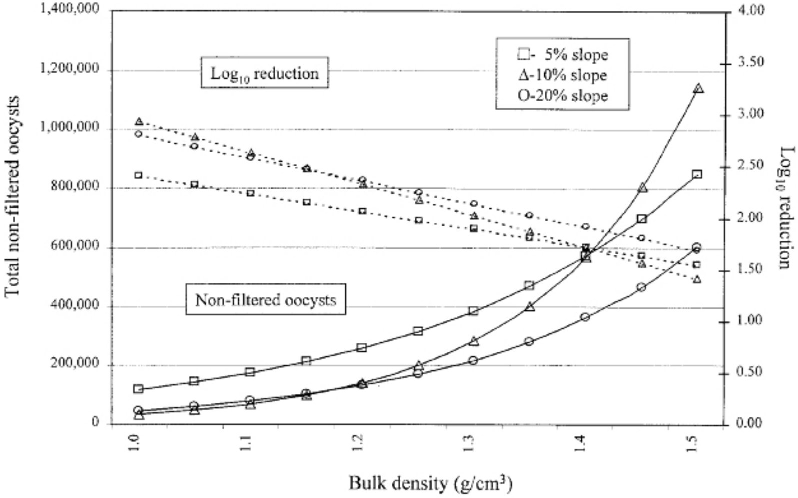
- No buffer have been tested for salt mitigation
- No “known” mechanisms for salt removal
- Salt losses from farms are necessary and mitigation of salts may be considered a “low priority”

Pathogens



Atwill, et al. 2002.

Modeled Pathogen Removal: Slope and Texture



Atwill, et al. 2002.

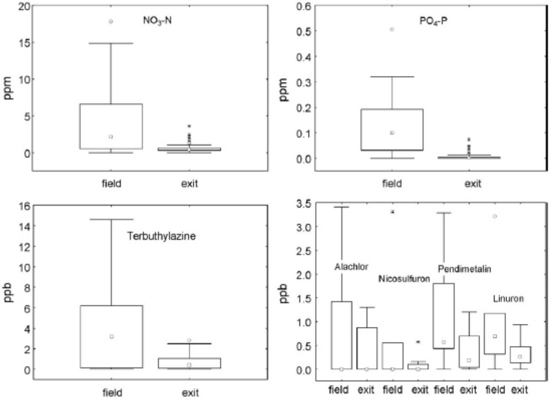
Metals: Particle Size and Density

Metals are often associated with fine particles (often over 50% ¡250 m).

- Particles $<$250 μm usually have the highest metal content
- Loads are often associated with particles $<$125 μm
- Particles $<$125 μm may have lower densities
- Particles $<$250 μm are generally poorly trapped by vegetation

Zanders. 2005.

Multi-Parameter Benefits: Too good to be true?



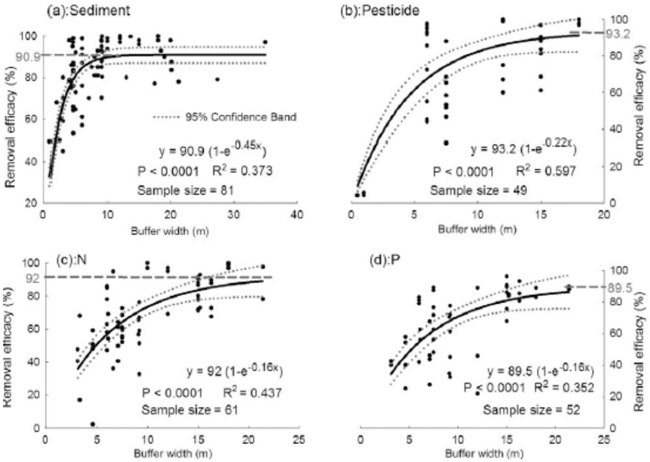
These studies generally ignore the mechanistic complexities that that might alter the interpretation.

Borin et al. 2010.

Designing with Mechanistic Considerations

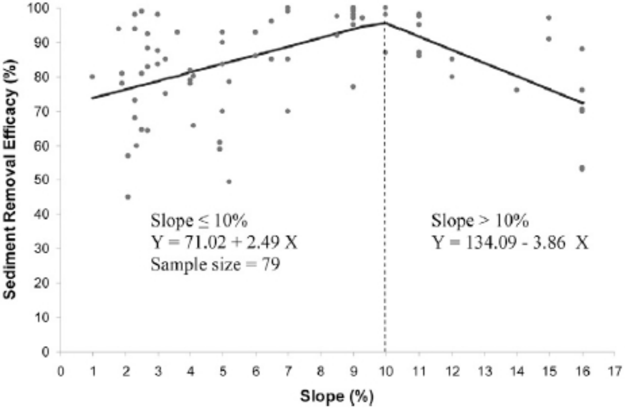
- “Space” between managed and “Un-”managed systems
- Stream shading
- Reduce Risk of Management Impacts on Non-management areas
- Filter Particles (via Hortonian overland-sheet flow processes, reduction in preferential flow in rills)
- Retain Water
- Increase Infiltration (via exfiltration in saturated variable source areas)
- Limit subsurface flow (subsurface instability, slumps, and landslides)
- Stream bank Stabilization

Design Criteria — Width



Zhang, et al. 2010.

Design Criteria — Slope



Zhang, et al. 2010.

Case Studies

- Evaluate Landscape Characteristics
- Determine if existing buffer structure and function
- Prioritize water quality goals
- List potential risks
  - Water quality impairments
  - Farm operation
  - Hydrological and geomorphological
  - others?
- Develop maintenance plan

Horticulture

- Horticulture is defined as that branch of agriculture concerned with **intensively cultivated plants** that are used by people for food, for medicinal purposes, and for aesthetic gratification.

Specialty Crop Production Constraints

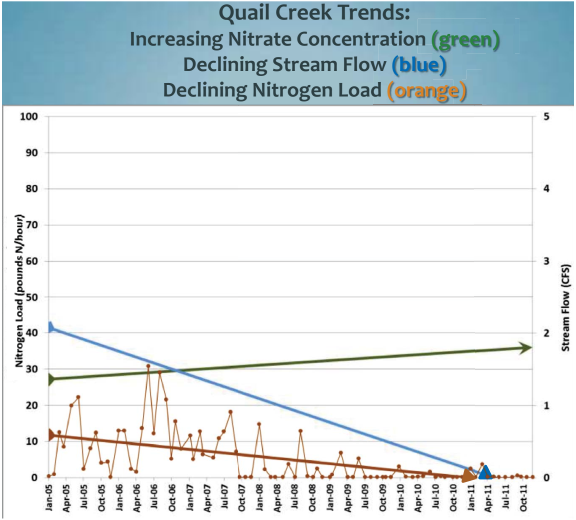
- High Value
- Cosmetic quality, shelf life, and supply/demand drives price
- Inputs are relatively low costs

Success Metrics

Determine *a priori* what can be used to determine success:

1. Optimize for *measurable* priority water quality constituents
2. Stakeholder capacity and interests
3. Reduced maintenance costs
4. Evaluate anticipated risks

Load Reduction versus Concentration Based



Maintenance and Long-term Effectiveness

- Concentrated flow
- Weed and insect pest management
- Stream management plan

Engaging the Industry – First Steps

- Know your stakeholders
- Capitalize on market-based incentives
- Promote industry engagement
- Performance measures are key
- Develop financial incentives

Conclusions, Reflections and Questions

Referernces

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