REMM: Riparian Ecosystem Management Model

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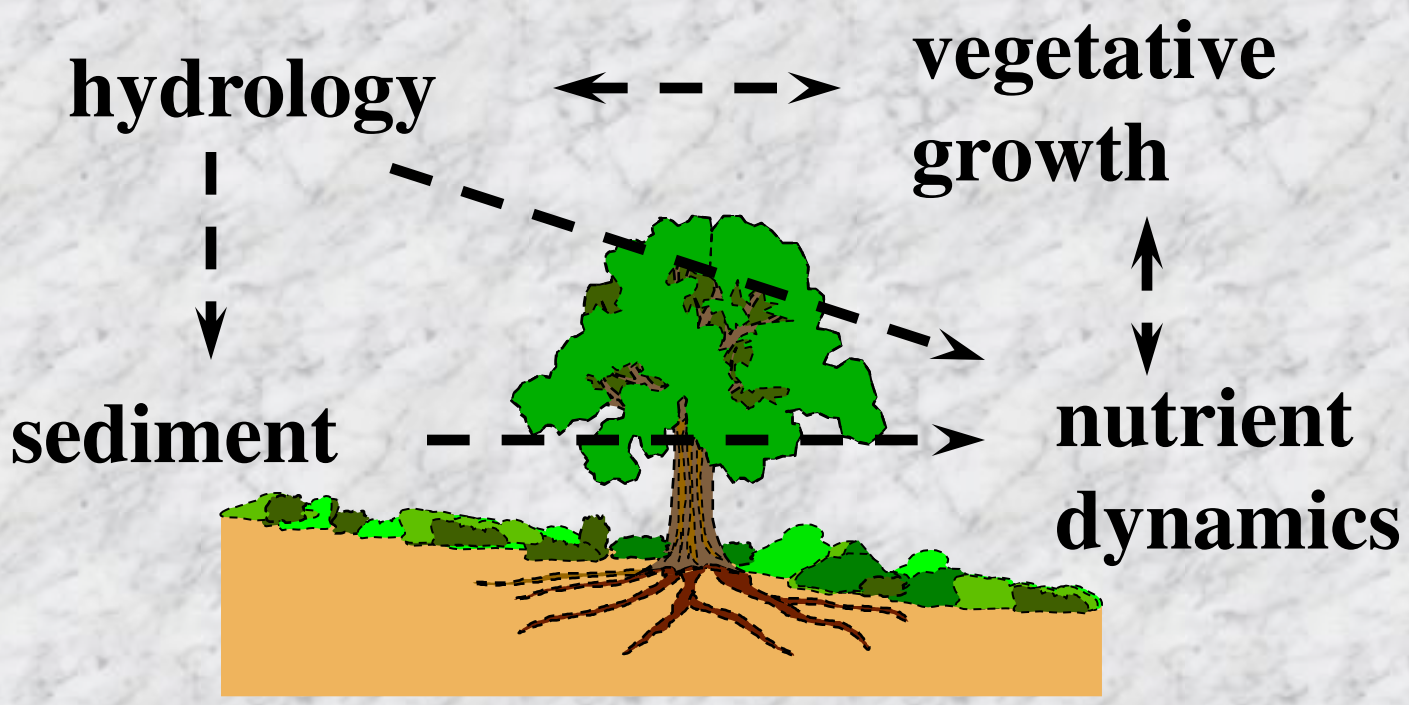
University of Georgia
California State University – Chico
USDA-Natural Resources Conservation Service

Outline

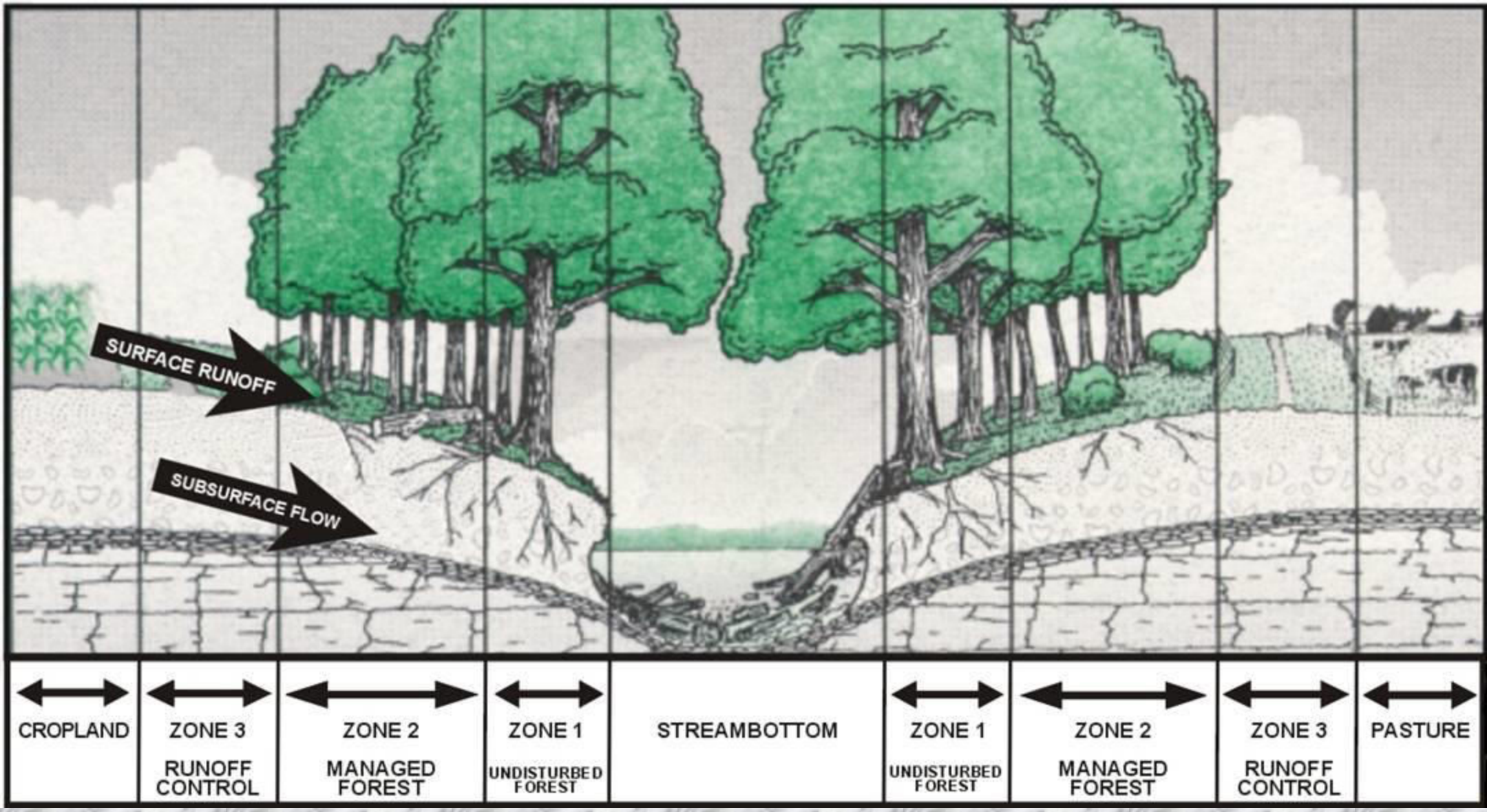
- Model Components
- Applications of REMM
- Integration with watershed models/other ongoing work

REMM: Components



- Adding pesticides

Three Zone Buffer System

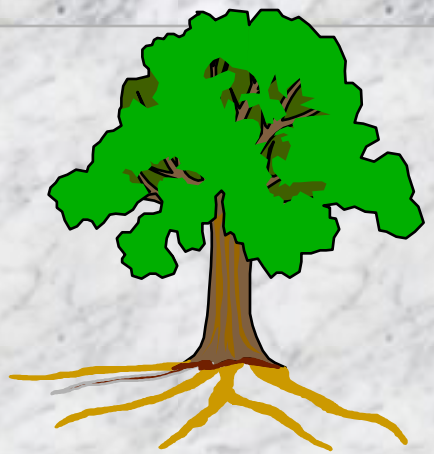


Riparian Ecosystem Management Model

- Quantify water quality benefits of multiple zone buffers and account for:
- Climate (either real or synthetic)
- Slope (variable among zones)
- Soils (hydrologic, nutrient, carbon)
- Vegetation (above and below)
- loadings from nonpoint source

REMM: Vegetation Types

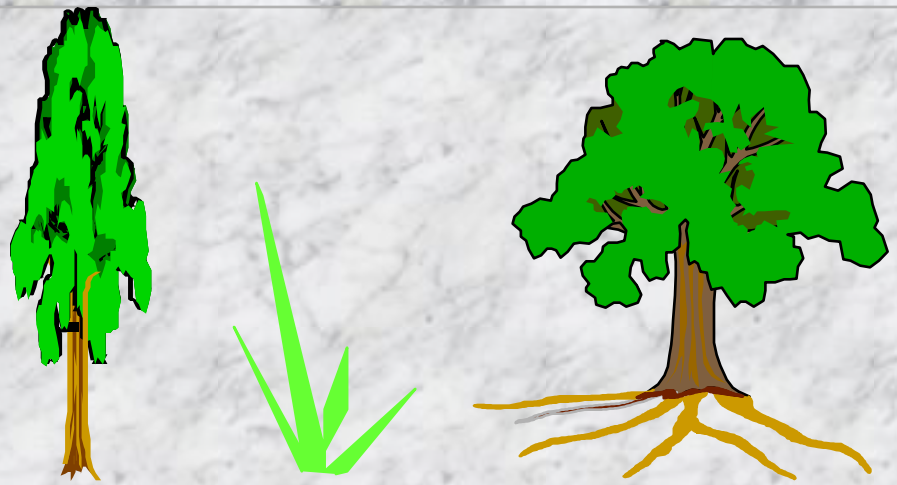
coniferous trees



deciduous trees

herbaceous perennials/
annuals

REMM: Vegetation

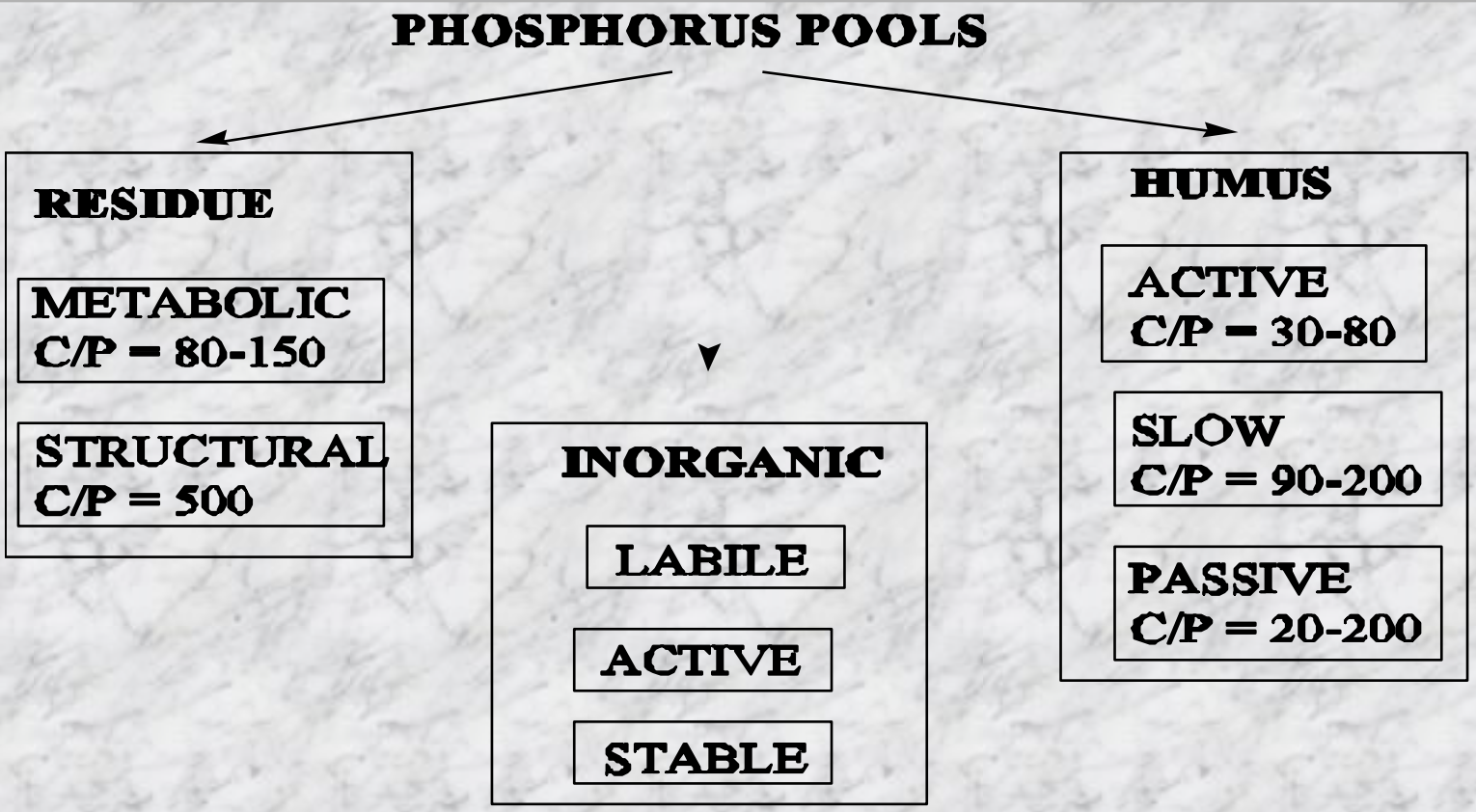


Upper canopy/lower canopy

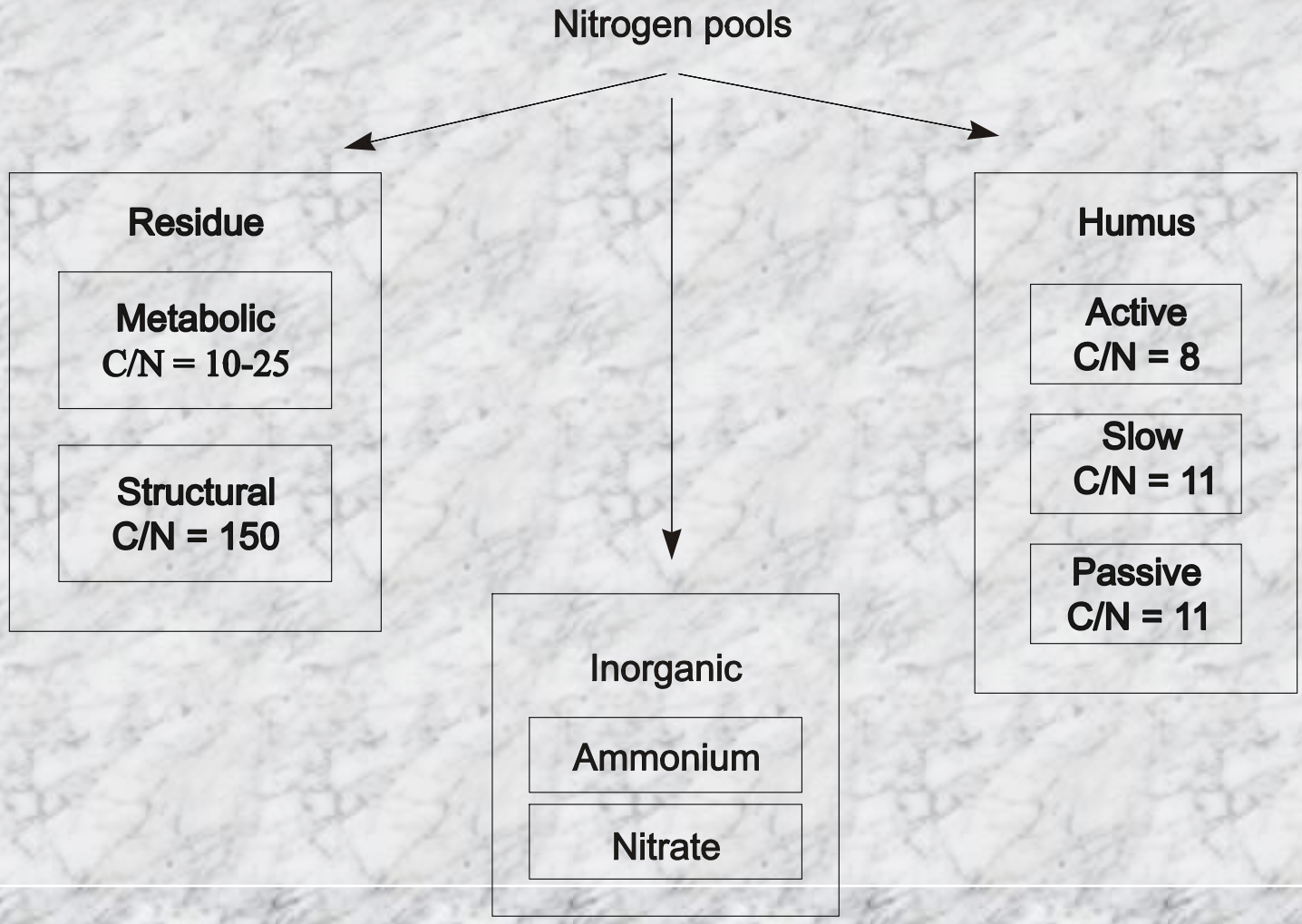
Multiple vegetation types in both canopies based on percent cover

Any/all vegetation can be in each zone

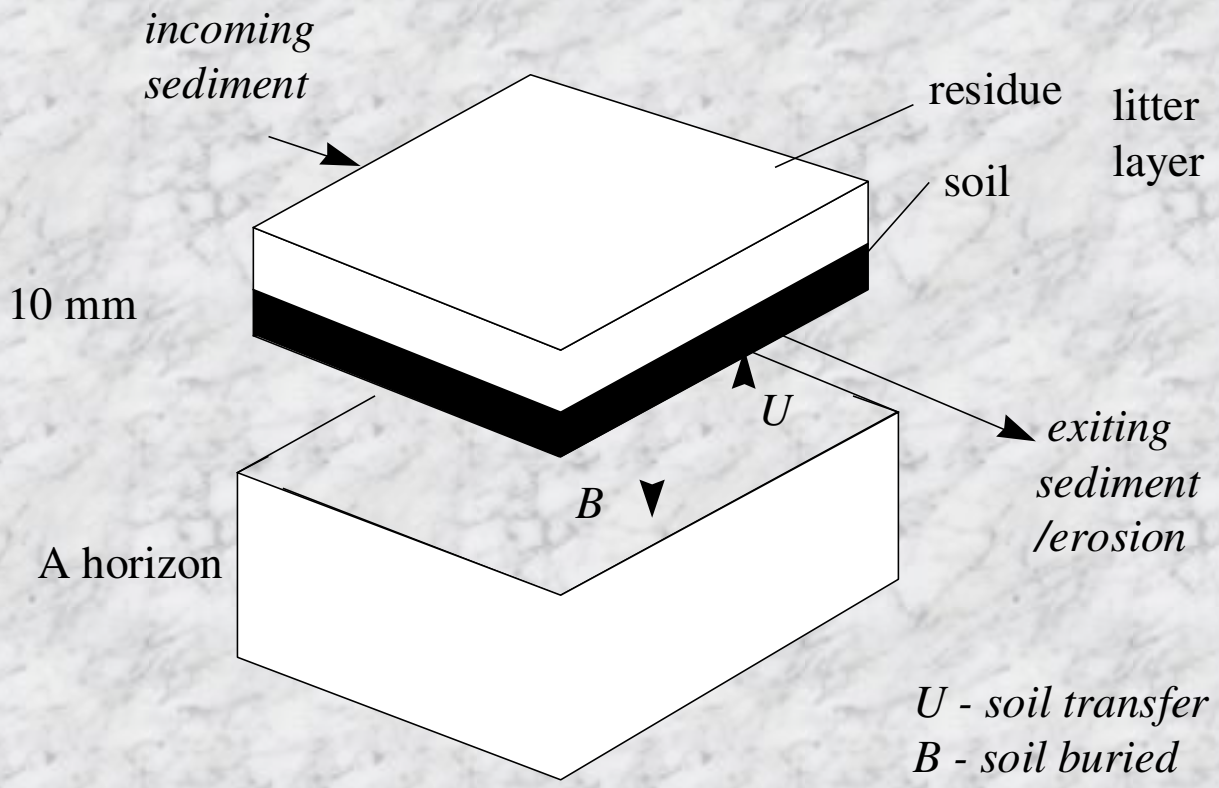
Phosphorus Pools in Soil and Litter



Nitrogen Pools in Soil and Litter



Litter and Soil Interactions in REMM



REMM: Input Required

- Upland inputs – daily surface runoff and subsurface flow, associated sediment and chemistry
- Daily Weather Data
- Site Description
- Soil Characteristics
- Erosion Factors
- Vegetation Characteristics

REMM: Documentation

- Coded in C++, primarily by R.G. Williams
- Executable version available for download
- Editing tools to build data sets available for download
- Text of users guide available online
- Graphical user interface developed by L. S. Altier at Cal State.

REMM: Documentation

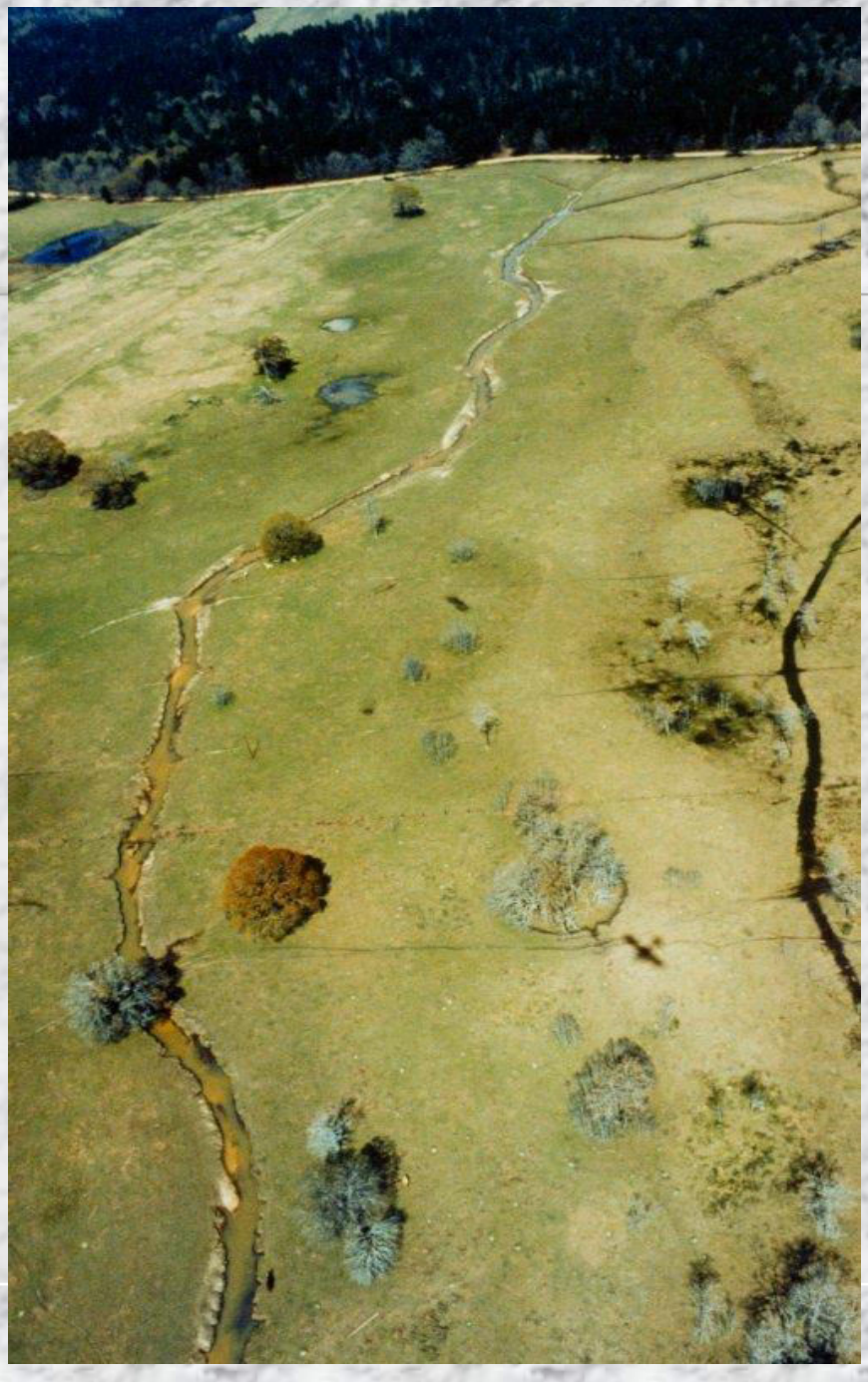
- Published as USDA Conservation Research Report No. 46 in 2002. We have copies!!
- General article on REMM structure with some sensitivity analysis in JSWC
- REMM tested (validation) in two articles in Trans. ASAE
- Applications of REMM for coastal plain systems published in JAWRA and Trans. ASAE

Uses for REMM

- Predict load reductions for buffer scenarios
- Predict outputs to streams for different nonpoint source loadings
- Predict changes in pollutant transport processes

Uses for REMM

- Compare buffers with different vegetation
- Predict changes in pollutant removal mechanisms
- Examine behavior of riparian systems as represented by REMM



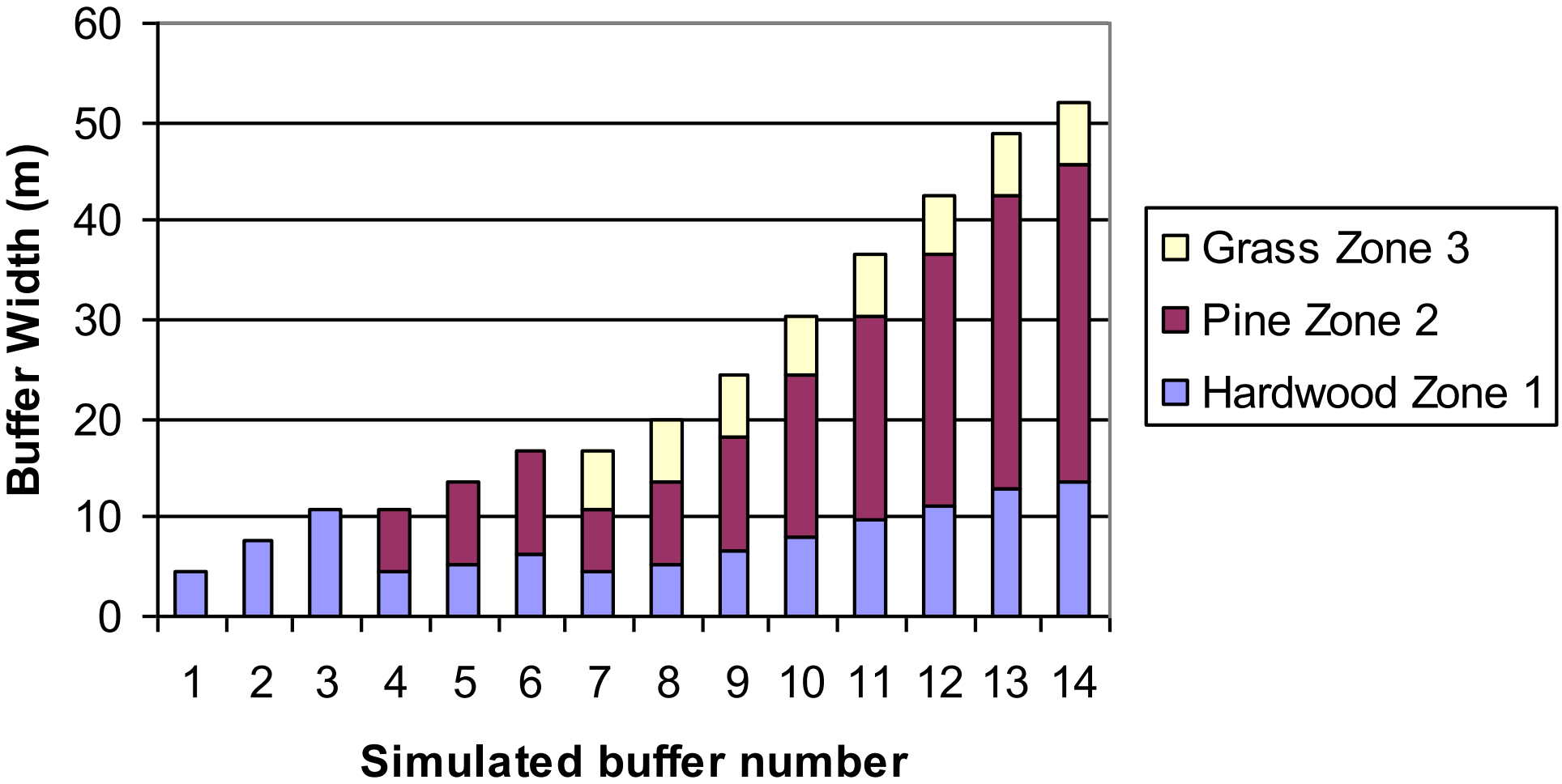
Example - Buffer Scenarios

- 14 buffers ranging from minimum Zone 1 buffer (5 m) to 52 m three zone buffer
- Simulated both conventional row crop loading (normal) and dairy lagoon effluent loading (high).

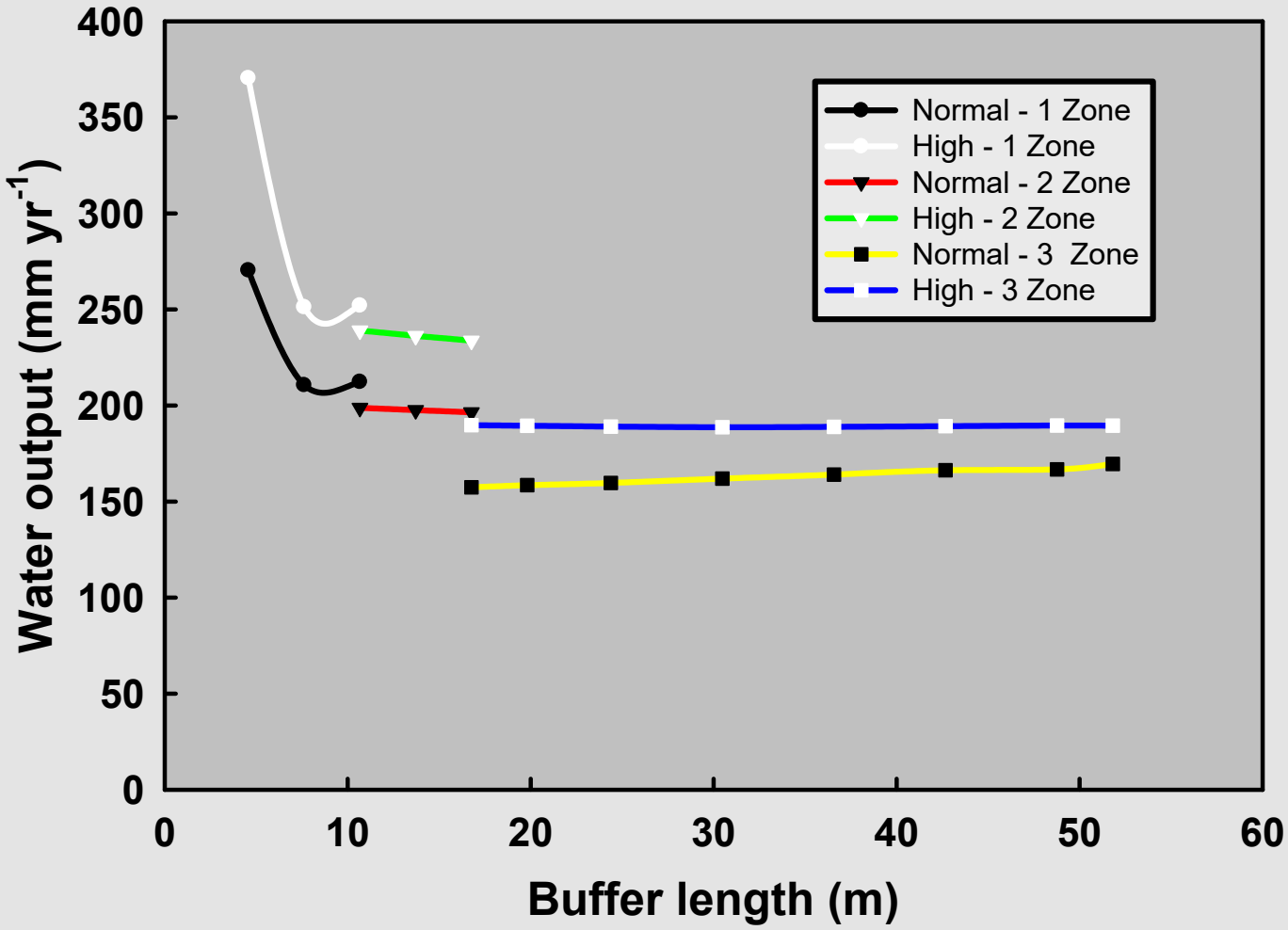
Loading Scenarios

Load	5-year average annual loading		
	Normal	High	Ratio
Surface runoff (mm)	149.9	149.9	1.0
Sediment (kg/ha)	300	300	1.0
Subsurface runoff (mm)	46.7	93.3	2.0
Total field runoff (mm)	196.6	243.2	1.2
Total Nitrogen (kg/ha)	21.7	108.8	5.0
Total Nitrate (kg/ha)	8.1	50.2	6.2
Total Ammonium (kg/ha)	6.0	47.9	8.0
Surface Nitrogen (kg/ha)	13.3	57.3	4.3
Surface Nitrate (kg/ha)	2.4	4.9	2.0
Subsurface Ammonium (kg/ha)	5.5	44.1	8.0
Subsurface Nitrogen (kg/ha)	7.4	51.5	7.0
Subsurface Nitrate (kg/ha)	5.7	45.3	7.9
Subsurface Ammonium (kg/ha)	0.5	3.8	7.6
Total Phosphorus (kg/ha)	3.2	8.2	2.6
Total dissolved Phosphorus (kg/ha)	3.0	7.8	2.6
Surface Phosphorus (kg/ha)	2.9	7.6	2.6
Surface Dissolved Phos. (kg/ha)	2.7	7.1	2.6
Subsurface Dissolved Phos. (kg/ha)	0.3	0.7	2.3

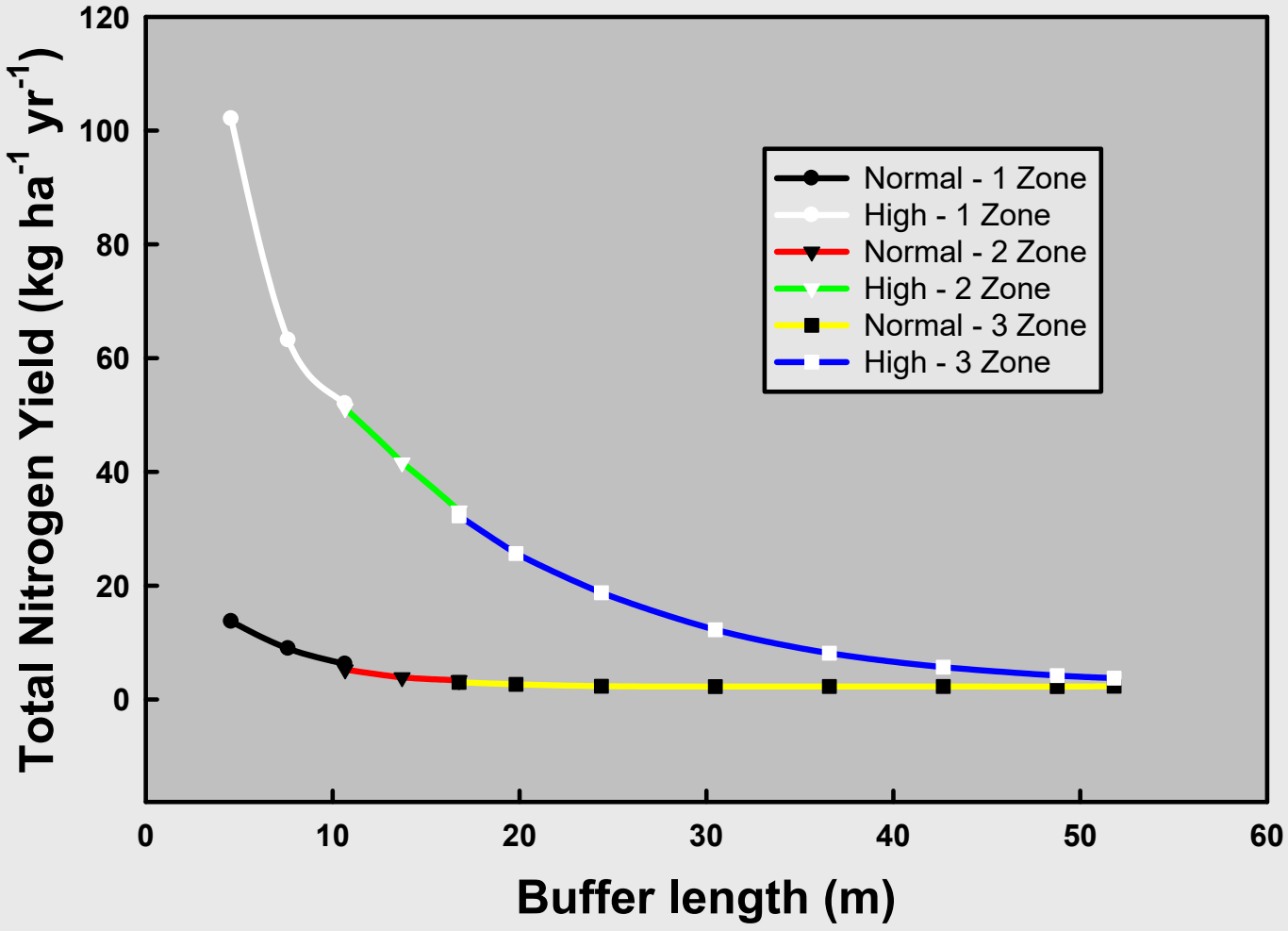
Buffer Scenarios



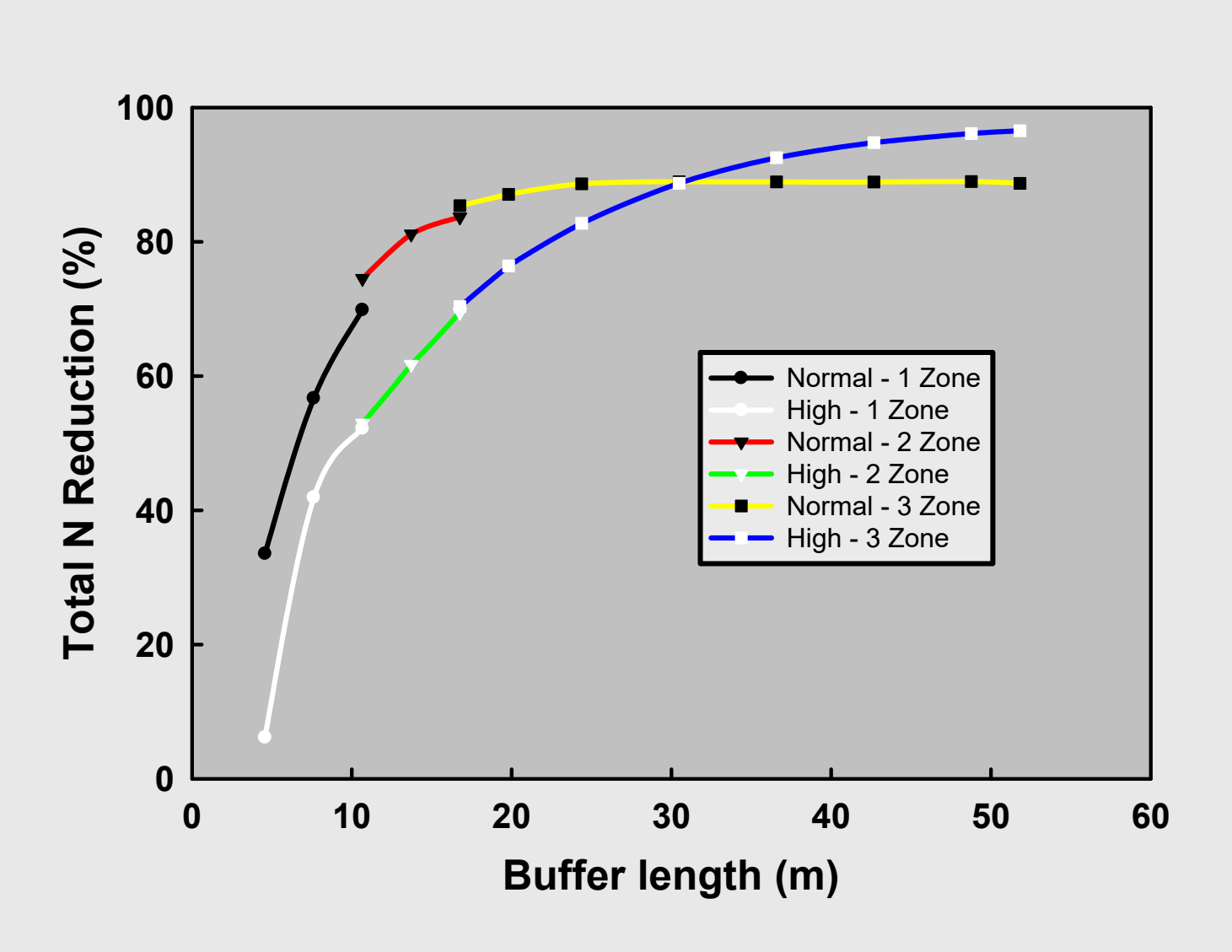
Total Water Output



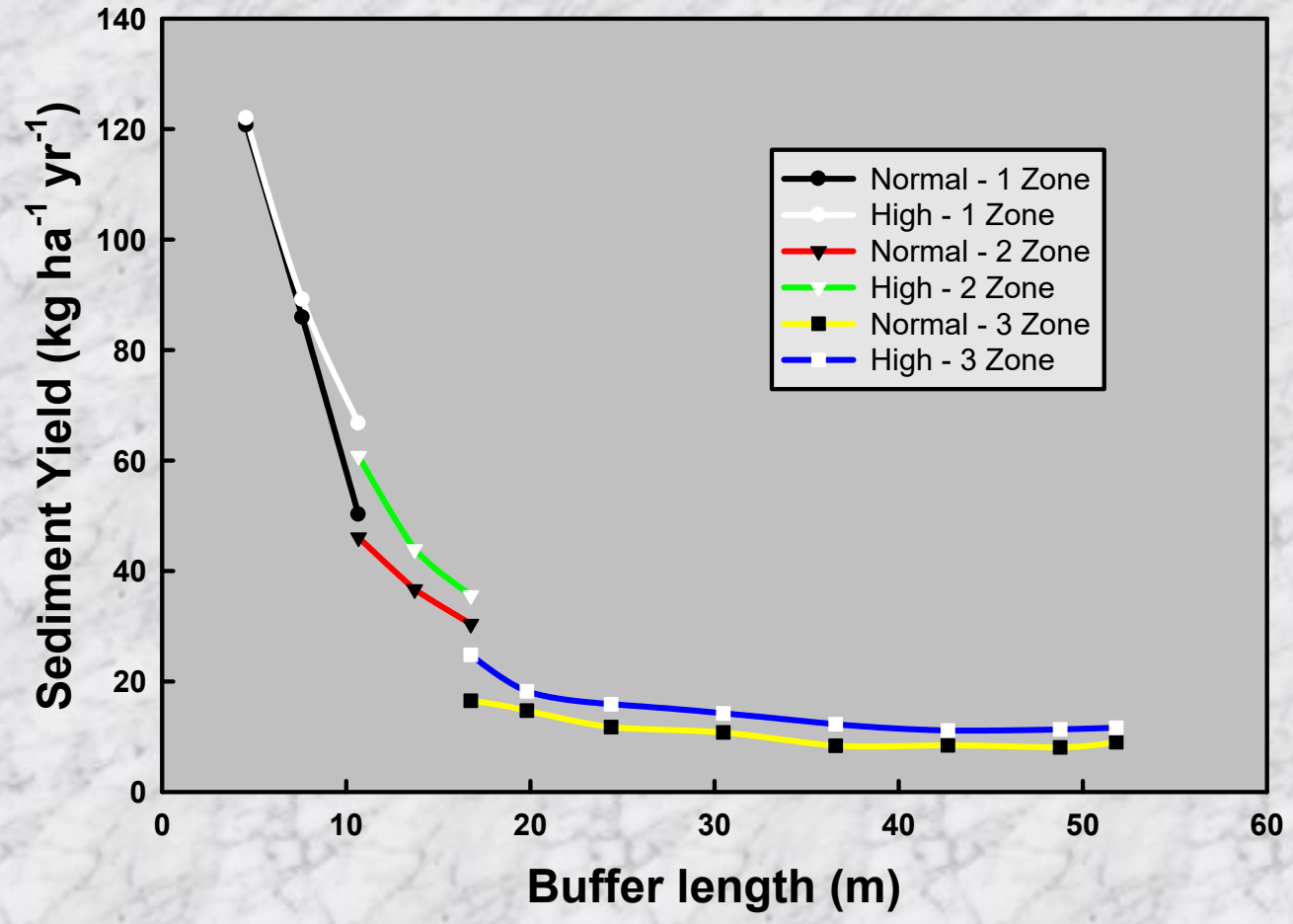
Total N Output



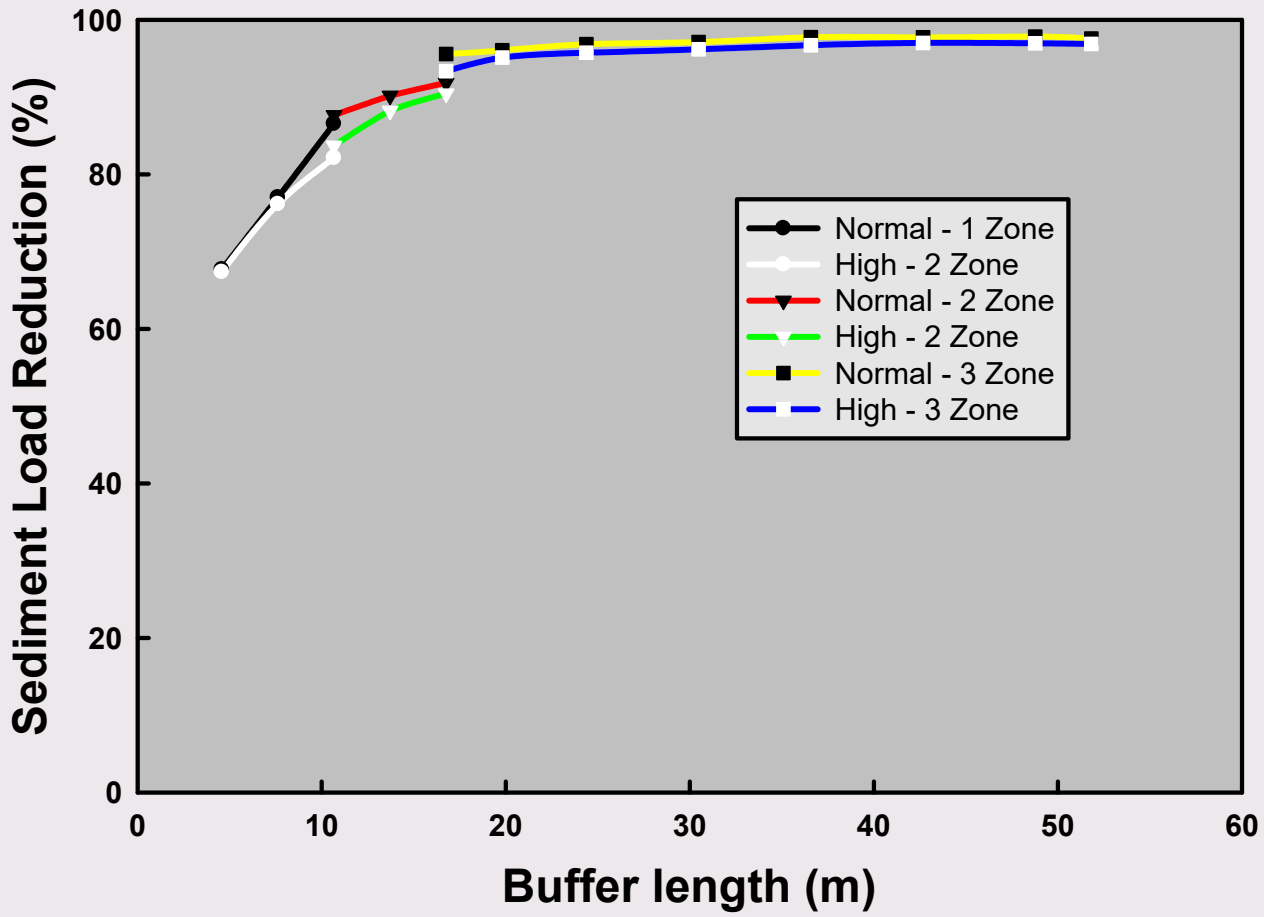
Total N load reduction



Sediment Output



Sediment Load Reduction

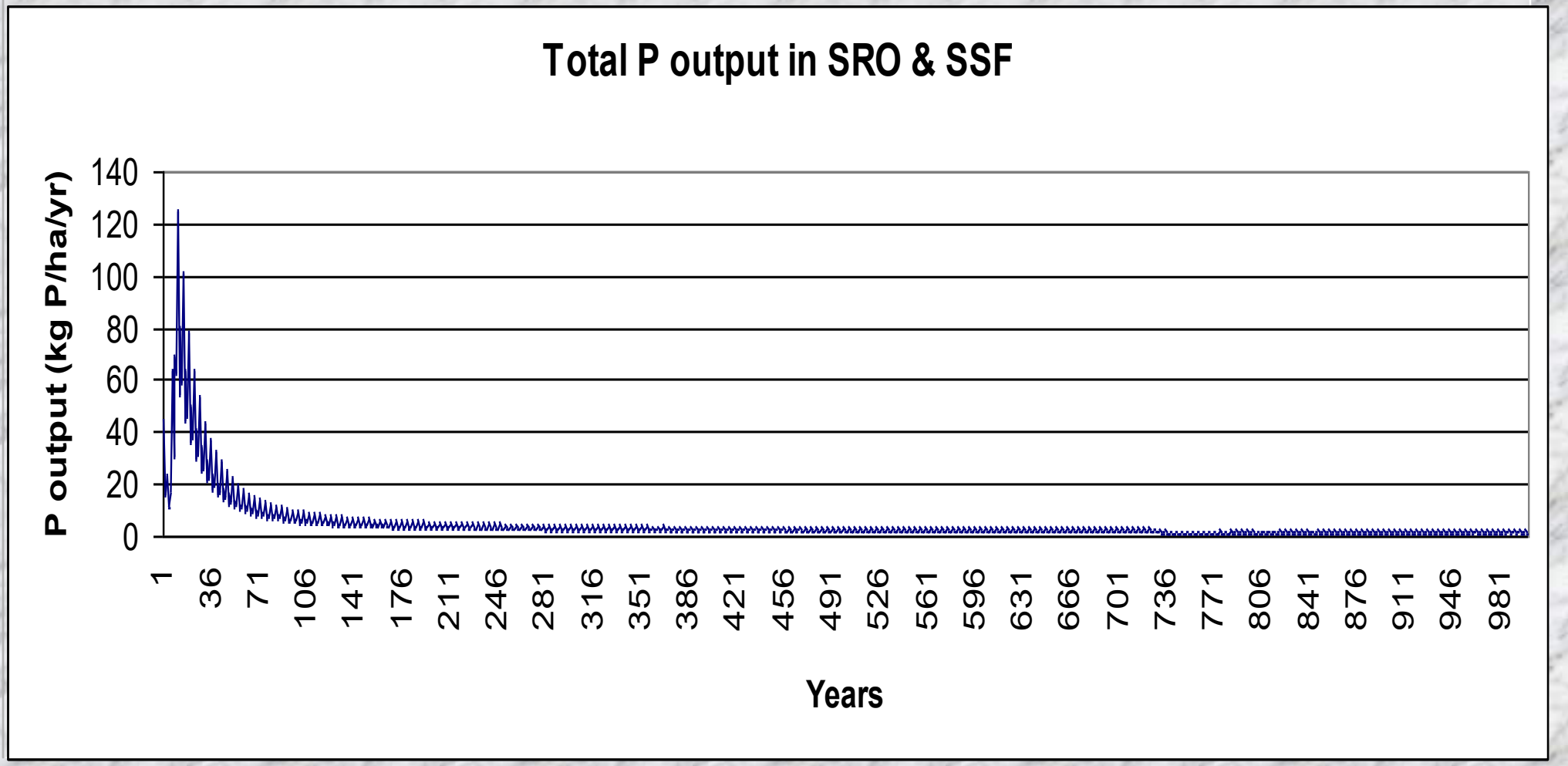


Use of REMM to Simulate Mature Buffer on Highly P Loaded Soils

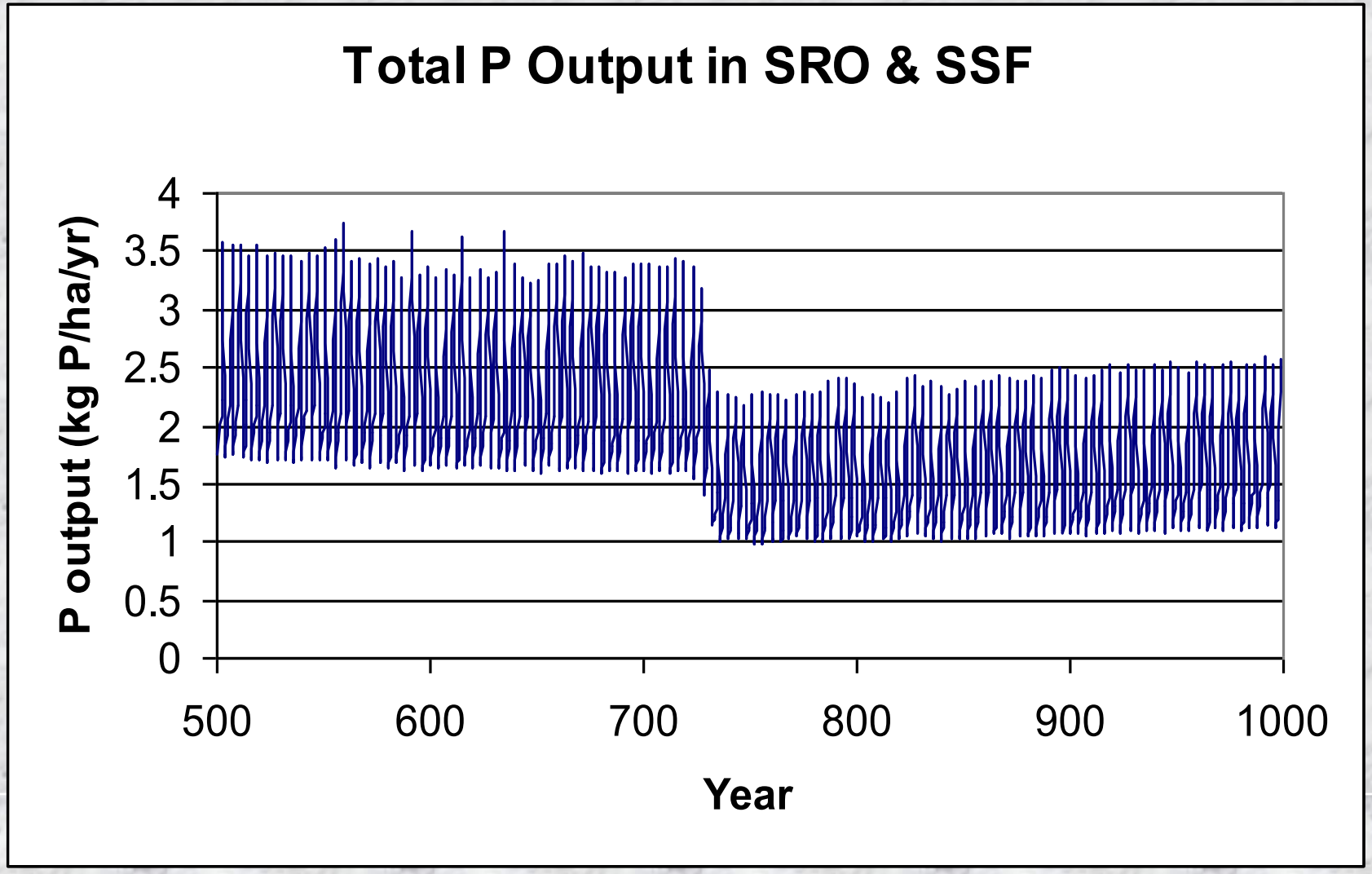
(All values kg P/ha)

	Residue	Humus	Labile Inorganic	Active Inorganic	Stable Inorganic
Litter +Soil **(Base)**	17.5	398	130	244	1079
Litter+ Soil **(High)**	33	1448	1304	2445	10788

Long Term Phosphorus Losses from Buffer with Highly Enriched Soil P



After about 500 years – near background levels



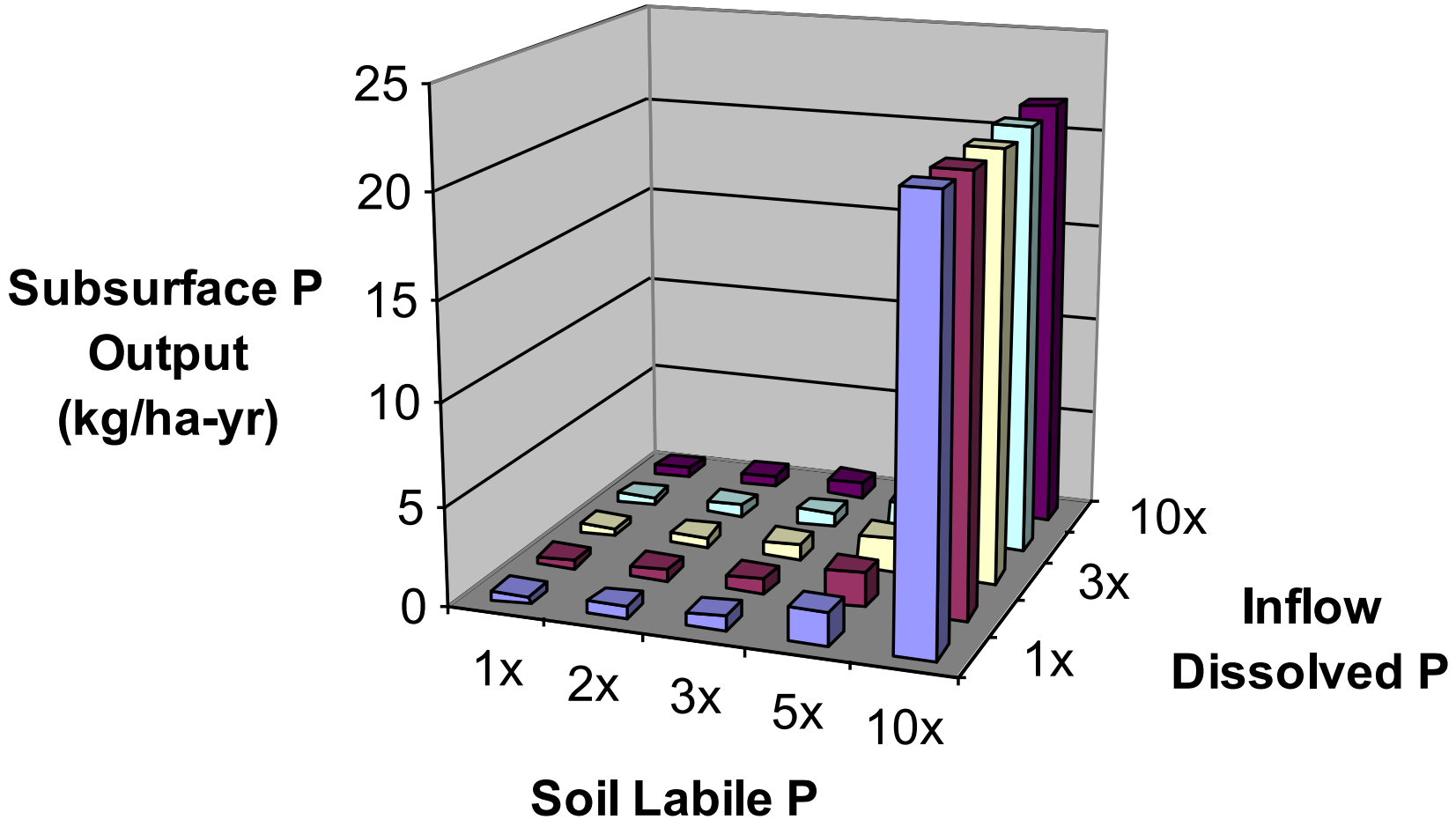
Use of REMM to simulate mature buffer receiving increased loadings of P

- Increase the P pools in buffer from measured (base case) to 10x base case
- Increase the dissolved P input in surface runoff from measured (base case) to 10x base case

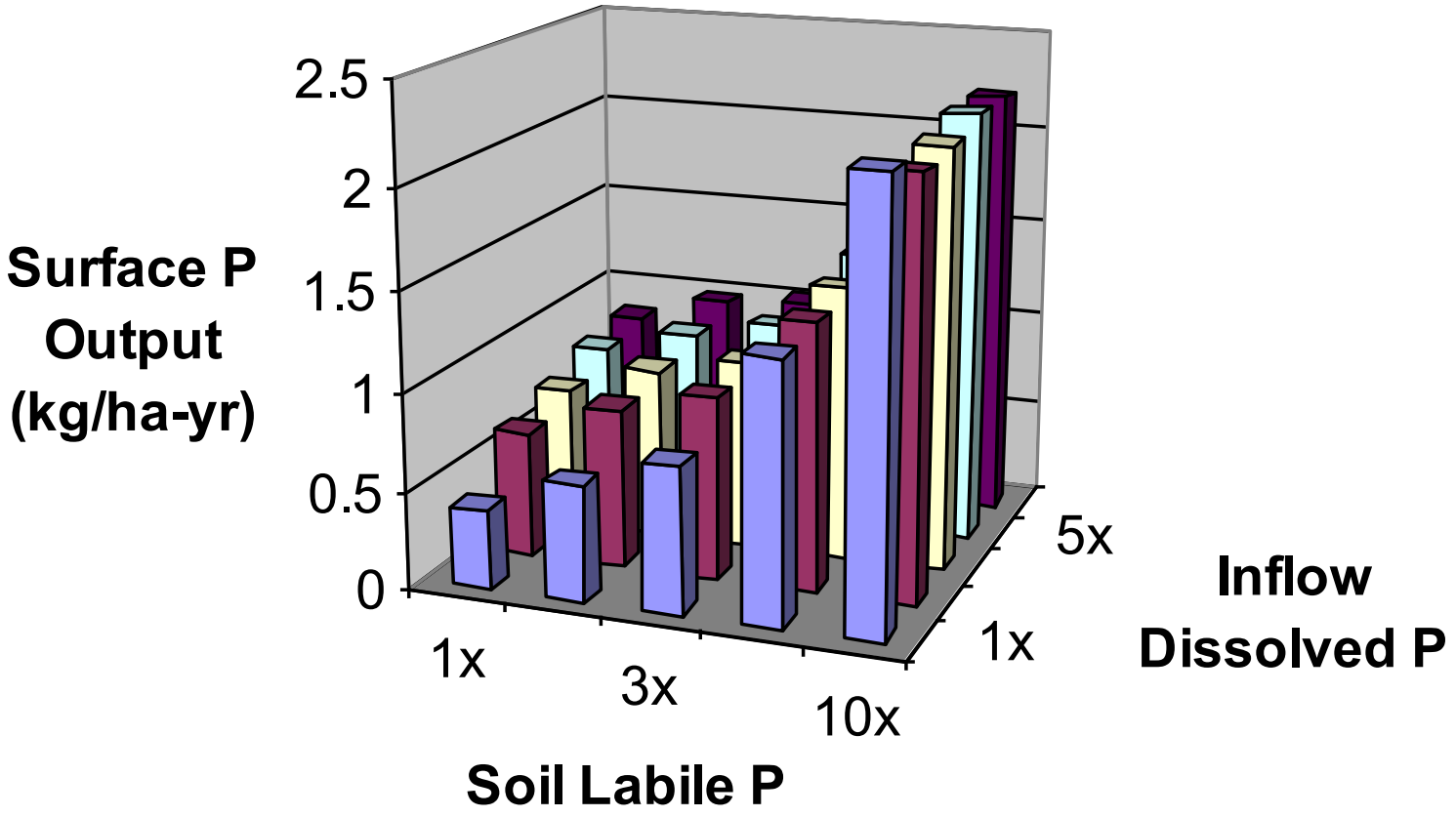
Use of REMM to simulate mature buffer receiving increased loadings of P

Litter + Soil (kg P/ha) (1x to 10x)	Dissolved P Surface Runoff inputs (kg P/ha/yr) (1x to 10x)
1,868 to 18,680	6 to 60

Base case sediment - 1x to 10x Dissolved P



Base case sediment P - 1x to 10x Dissolved P



Model nonpoint source pollution control by a wide range of buffers

Future Work with REMM

- Integration with ARS watershed models – SWAT and AnnAGNPS
- Testing with data from ARS buffer research sites – currently working on Beltsville site, Ames, Corvallis, Coshocton, Florence, Oxford, Tifton, University Park.
- Addition of new components for pesticides to be compatible with WS models
- Consultation with diverse groups of users

Integration with SWAT

- Conceptually fits between upland sources areas and channel processes.
- Preliminary work plan developed between modeling teams

Integration with SWAT

- Require surface and subsurface outputs from source areas
- Change from 3 zone to variable zone with default of one zone. Alternatively, change to one zone.

Integration with SWAT

- Change as many variables as possible in vegetation to default values. Remain as input variables but automatically use default values.

Integration with SWAT

- Change from 3 layer to multiple layer, default = 3.
- Keep all the soil and litter pools.
- Initialize all soil carbon pools directly from a soil organic matter value.

Integration with SWAT

- Initialize soil organic N and soil organic P pools directly from SOC pools based on C/N and C/P ratios.
- Standardize temperature and water factors

Integration with SWAT - General

- Functions of riparian zones will vary with stream order
- Some will receive inputs from source areas
- Some will receive inputs from upstream watersheds

Integration with SWAT -Channels

- Can provide some dynamic inputs such as root biomass and coarse woody debris inputs needed to model streams and streambanks

Integration with SWAT - VFS

- Separate use for VFS from use for riparian buffer? VFS could be based on field border area rather than channel length. Riparian buffer would be based on channel length and/or hydrologic contributing area. How is water delivered to the VFS or to the riparian buffer? Does VFS put its water into the buffer? Is this the same as a multiple zone buffer?