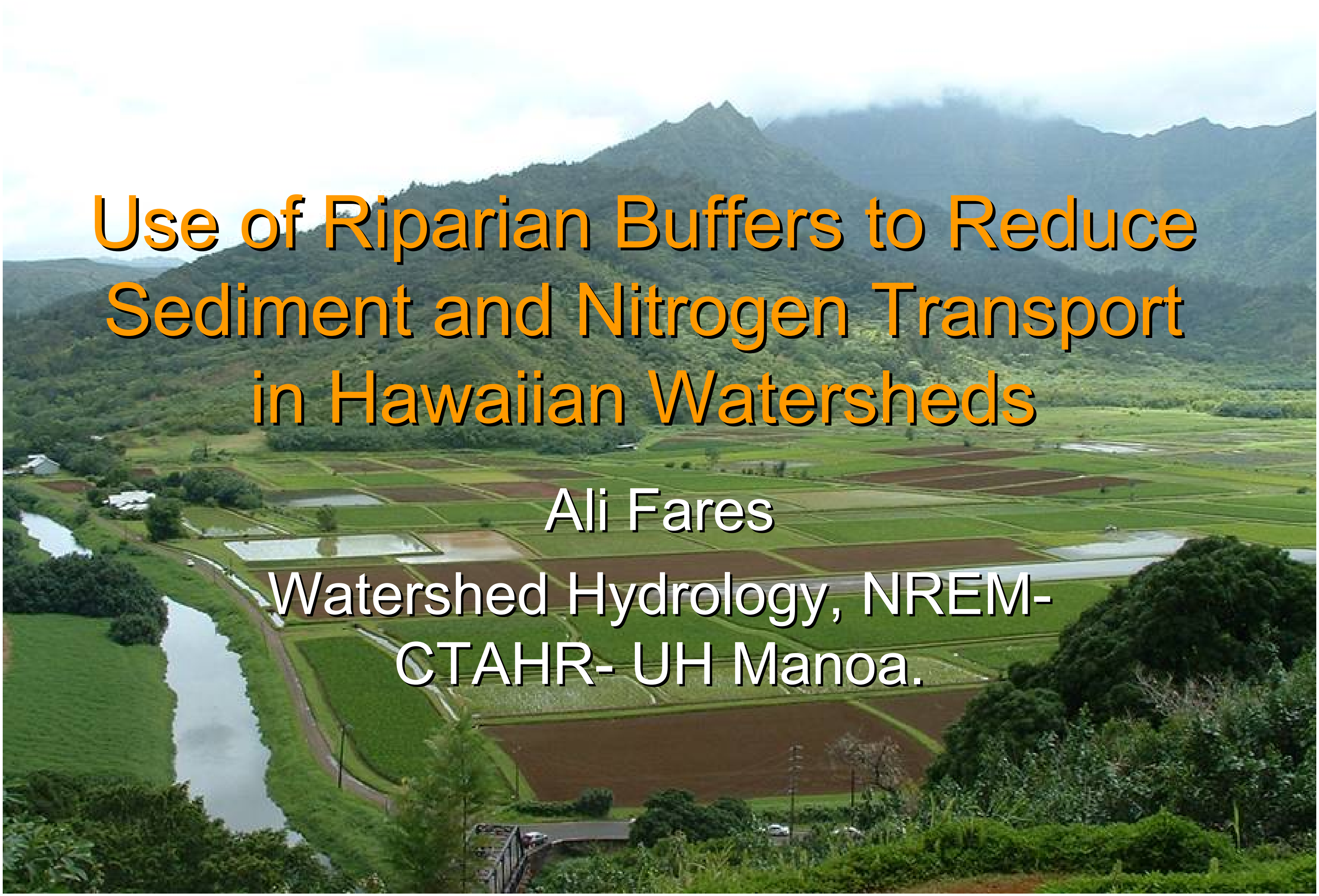


Use of Riparian Buffers to Reduce Sediment and Nitrogen Transport in Hawaiian Watersheds

Ali Fares

Watershed Hydrology, NREM-CTAHR- UH Manoa.

Outline

- Introduction
- What are Riparian buffers?
- Benefits of buffers
- Why precision buffers?
- 2 Case studies
- Conclusions

Non-point source pollution

- Land-based pollutants are identified as the primary threat to Hawaii water resources and its coastal coral reef ecosystems.
- Sediment and pollutant loads from different sources are the major causes.
- These pollutants pose human and ecosystem health risks.

- Reducing erosion in land and containing eroded material on site would substantially minimize these negative effects.
- Riparian buffers were introduced since 1960s as practical conservation management practices to mitigate the impact of agricultural operation on their surrounding environments (lakes, stream, ocean, etc…)

Riparian buffers

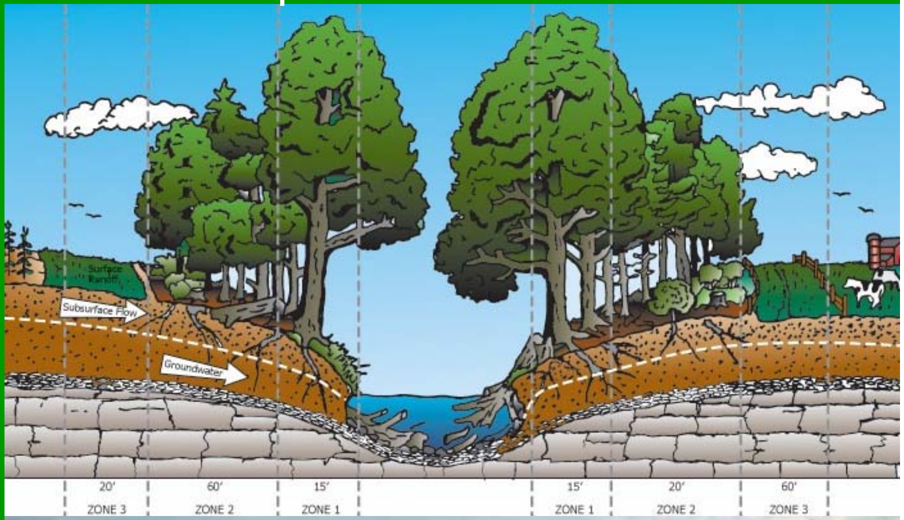
- Buffers are areas of permanent vegetation adjacent to water bodies.
- They are managed for the purpose of filtering pollutants from runoff or ground water.

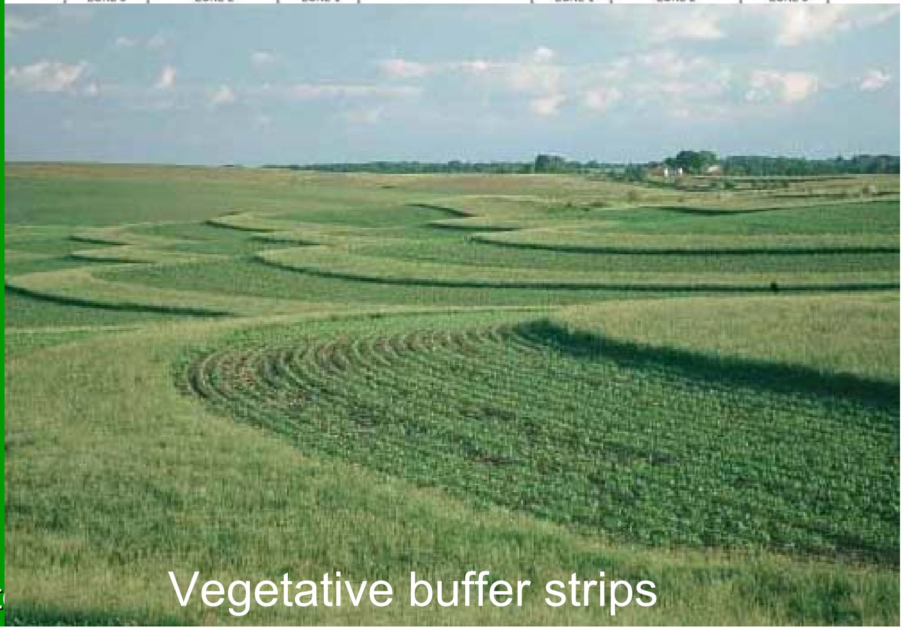
Buffer types

- Riparian buffer : a band of trees, shrubs, or grasses that border a body of water.

- Vegetative buffer strips : It is a gently sloping area of vegetative cover

Riparian buffers




Vegetative buffer strips

Buffer design

Two approaches for buffers design
1) Fixed width buffer (standard)
2) Variable (precision) width buffers

Fixed width buffer

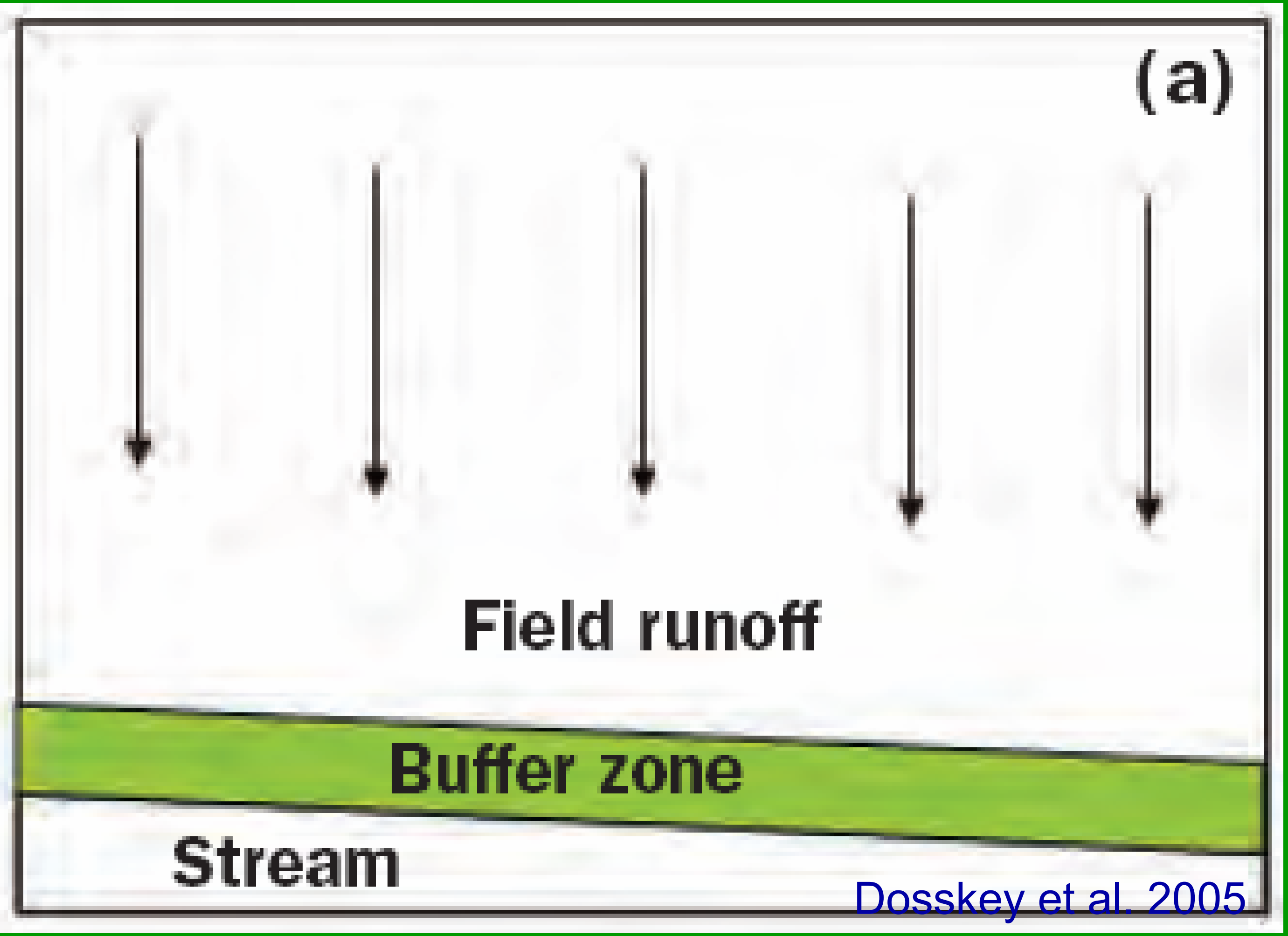
Precision buffer

Why Variable/Precision Buffers?

- Using constant buffers, we are assuming that riparian areas receive runoff in a uniform sheet flow under which the maximum buffer efficiency is observed.
- However, Dosskey et al. (2002) showed that only 9-18% of the total buffers actually contacted runoff water

Fixed width buffer

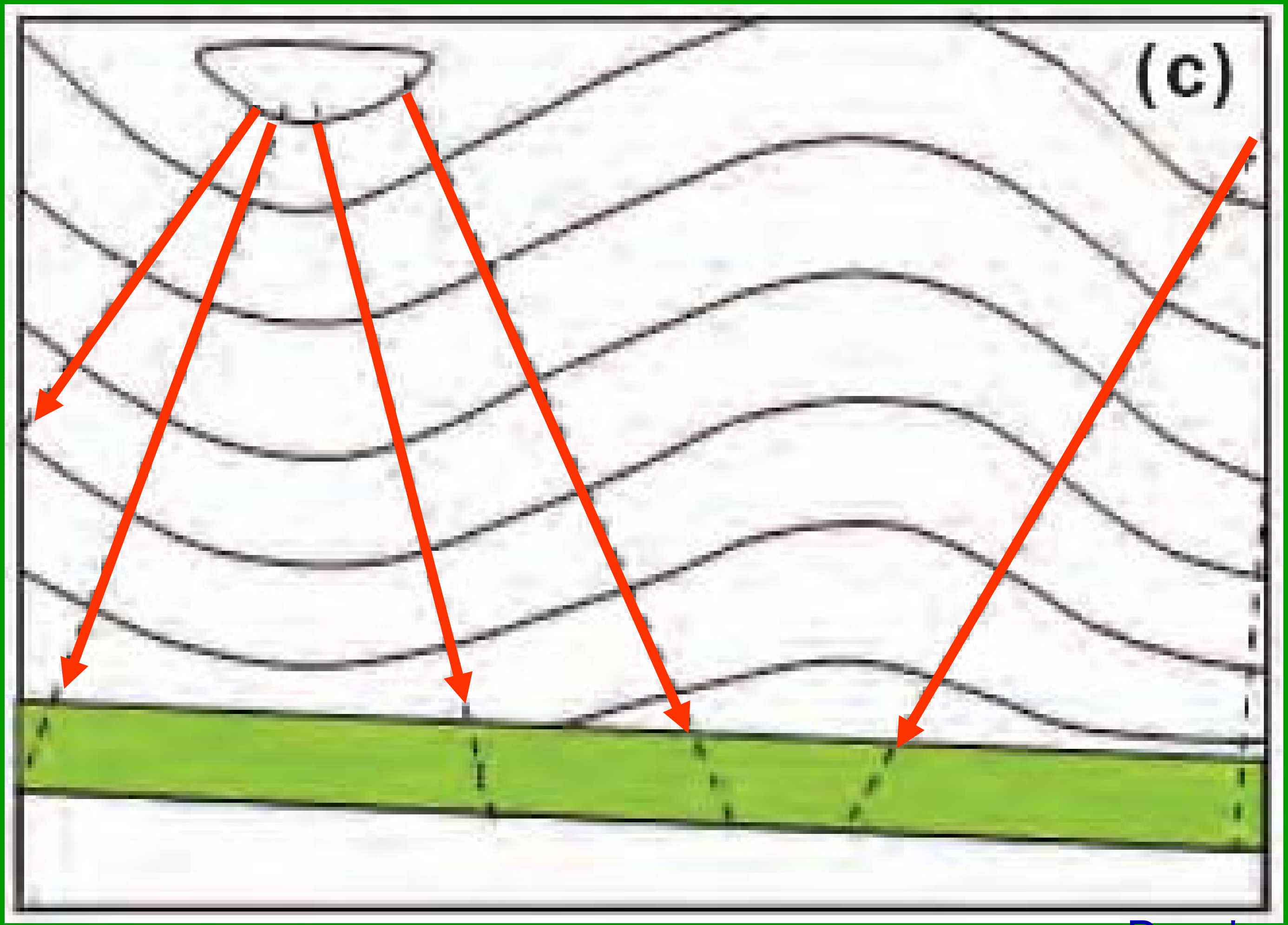
Uniform runoff flow needs a fixed width buffer



Dosskey et al. 2005

Fixed width buffer

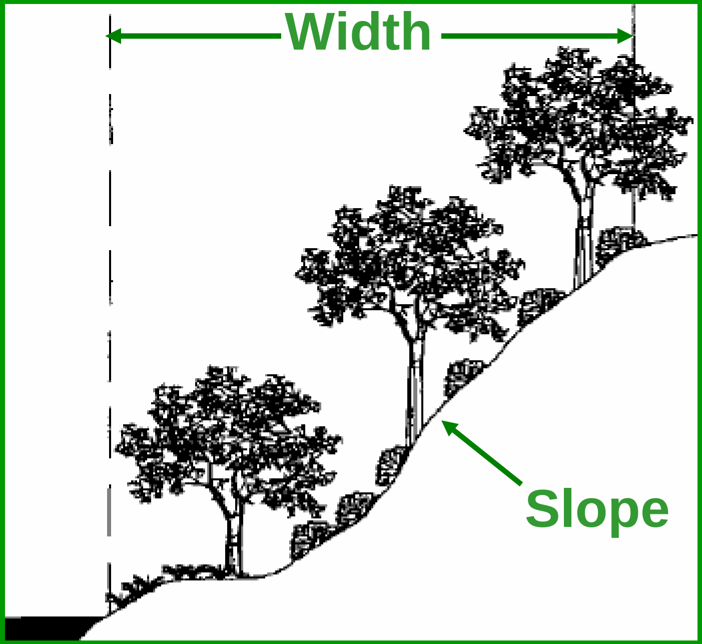
Non-uniform runoff flow should not be dealt with a fixed width buffer



Dosskey et al. 2005

Site topography

Slope, %	Width, ft
8%	100
20%	125
25%	150

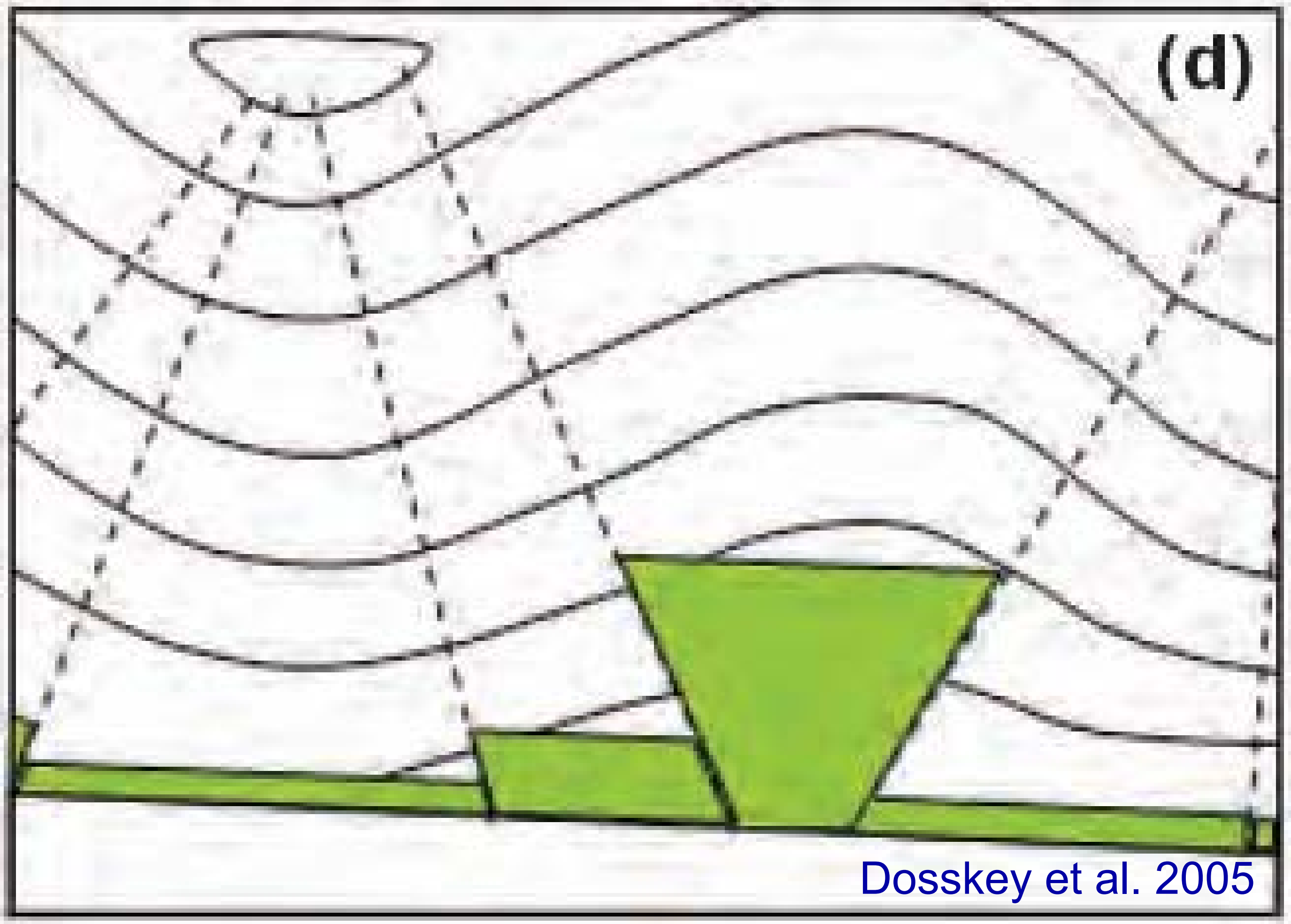


$$\text{Width} = 0.17\text{slope}^2 - 2.7\text{slope} + 111 \quad (R^2 = 0.99)$$

Source: The Maryland-National Capital Park and Planning Commission

Variable width buffer

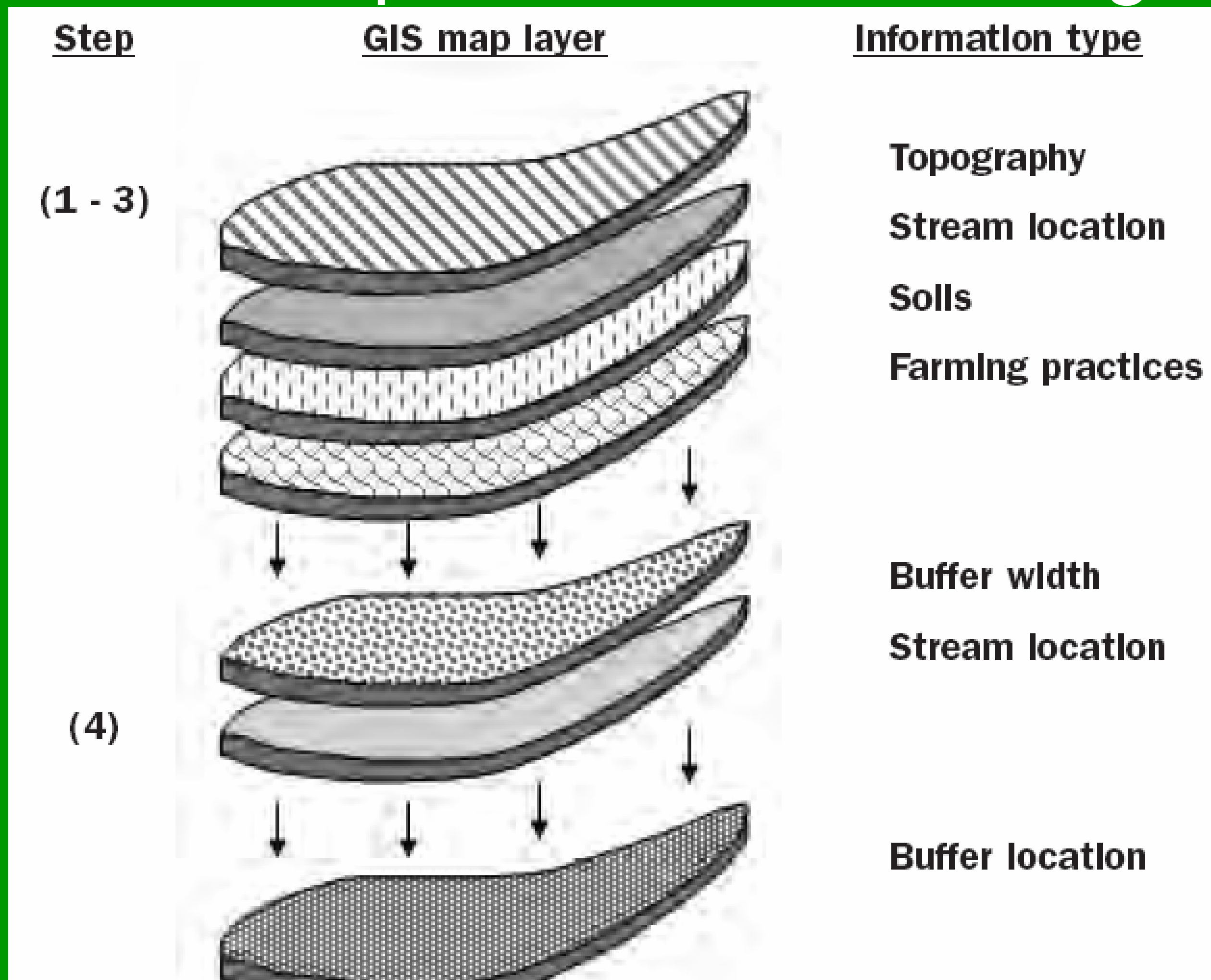
Non-uniform runoff flow should be dealt with a variable width buffer



Dosskey et al. 2005

Variable width buffer

Basics of precision buffer design



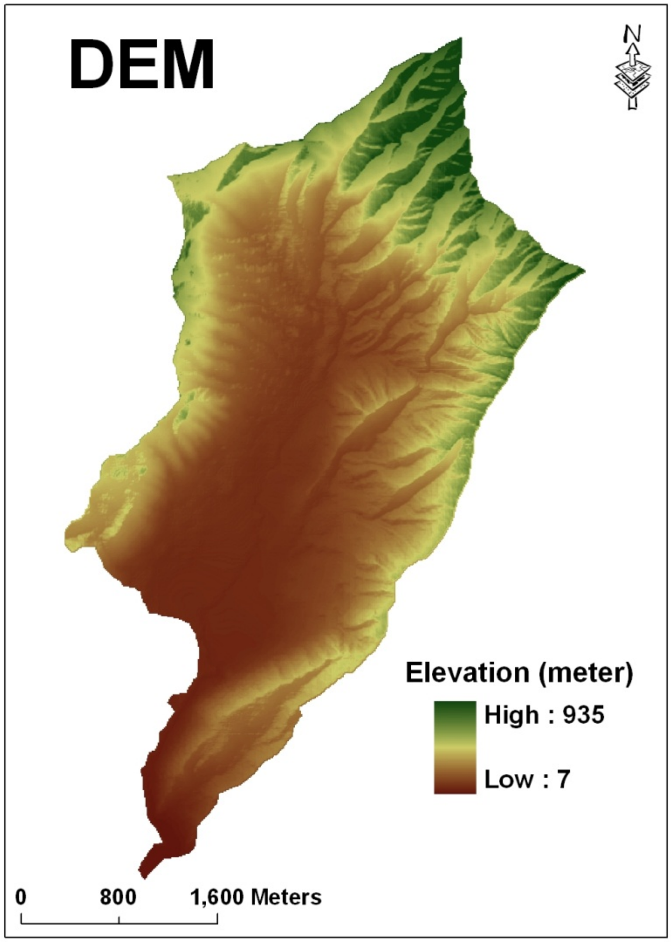
Dosskey et al. 2005

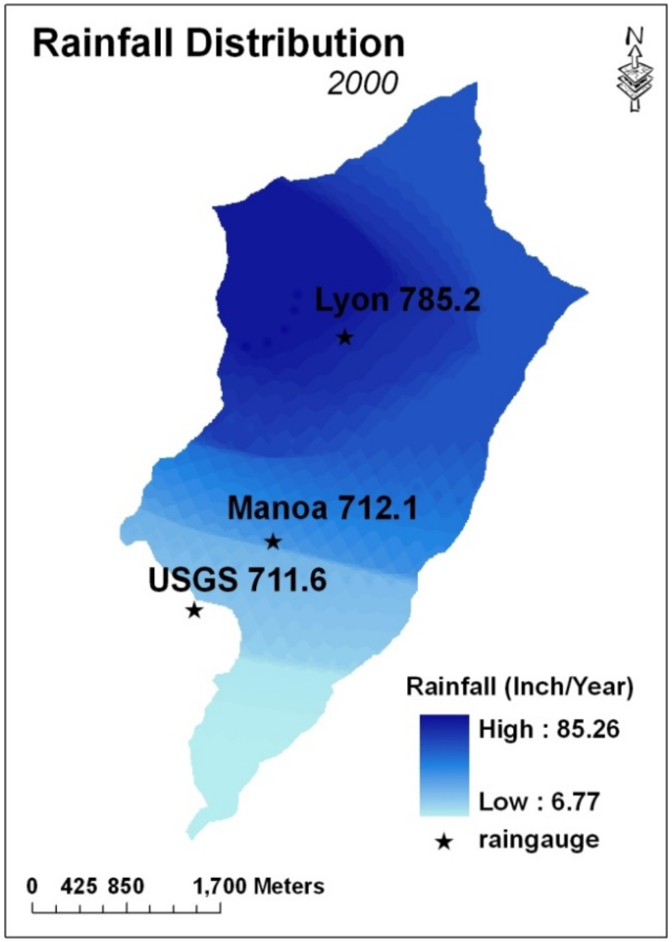
Variable width or precision buffers

There is a need for precision buffers in Hawaii because of:

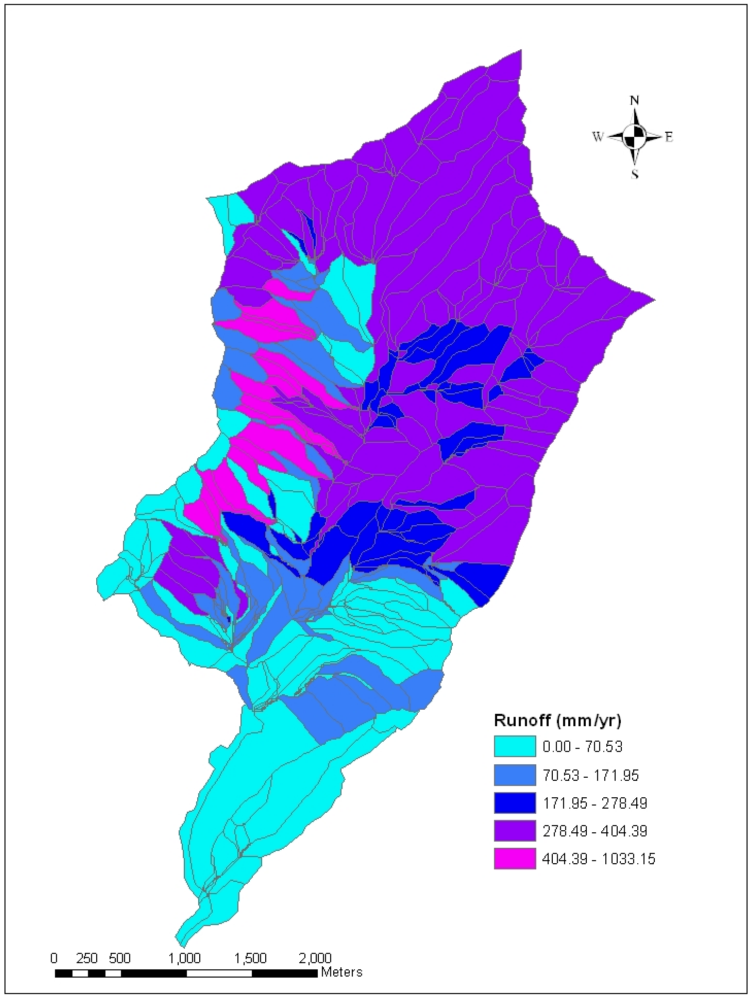
- Steep slopes,
- Limited and expensive land,
- Specific vegetative species,
- Availability of the necessary tools and technologies to implement them.

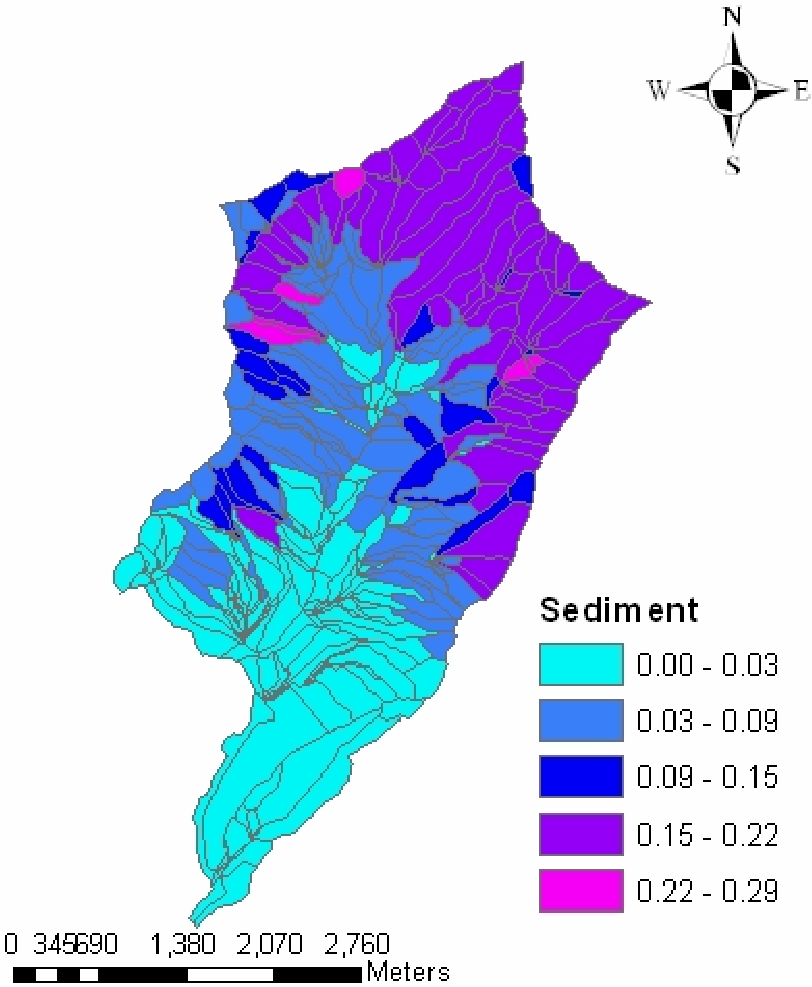
DEM and Rain Spatial Distribution





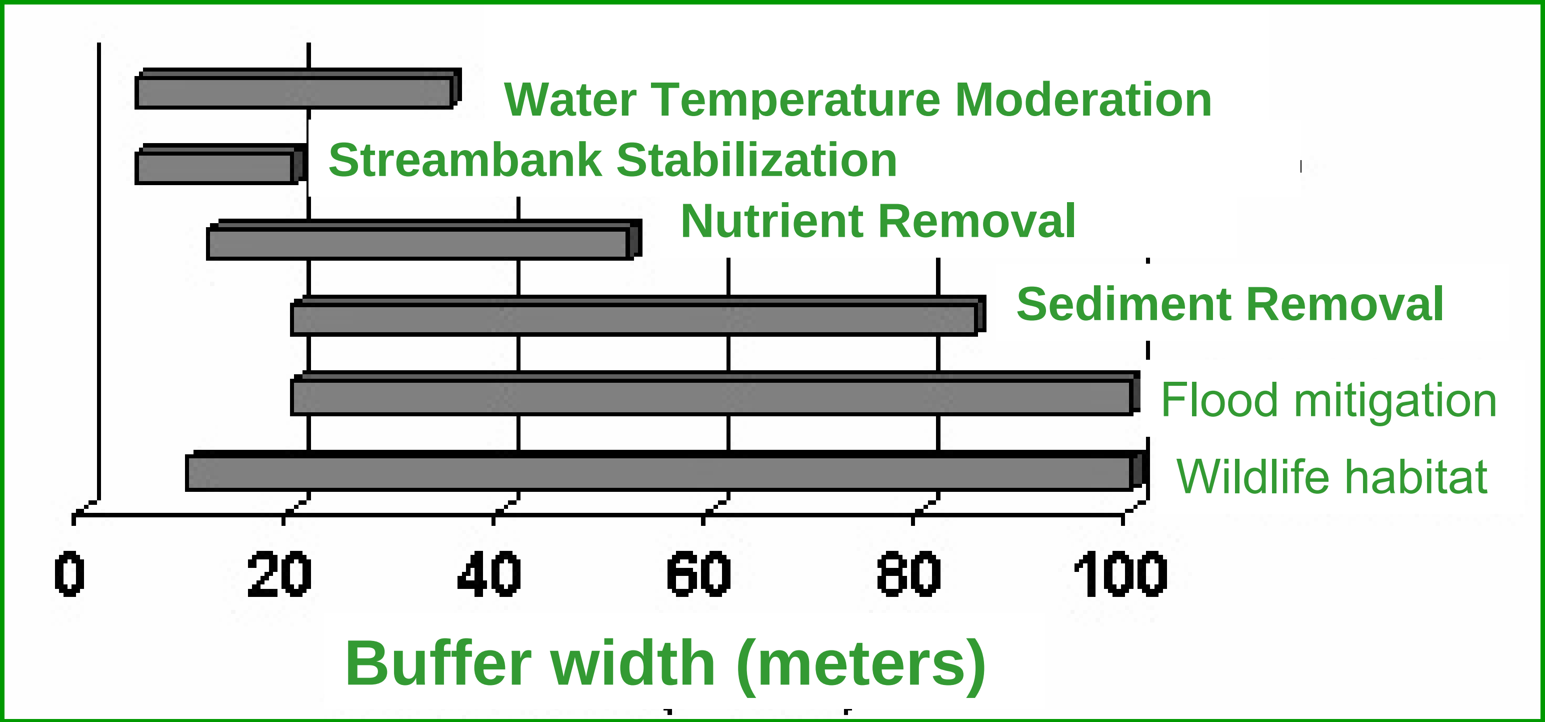
Spatial distribution of Runoff & Sediment





Buffer width

Buffer width is function of desired function (after A.H. Todd, 2000)



Buffer width for nutrient removal is narrower than that for sediment removal

Benefits of Riparian Buffers

- Numerous studies have shown the effectiveness of riparian buffers in reducing sediment, pathogens, and nutrient loads into surface and groundwater in agricultural watersheds.
- Reported retention rates of sediment, N and P were as high as 97%, 85%, and 84%, respectively.
- RBs provide habitat for different organisms; they also reduce surface water temperature.
- RBs serve recreational and aesthetical purposes.

Benefits to the Farmers

- Riparian buffer can be a source of stable income to farmers and landowners.
- Various benefit programs across the States:
  - Environmental Quality Incentive Program (EQIP)
  - Wildlife Habitat Incentive Program (WHIP)
  - Wetland Reserve Program (WRP)
  - Conservation Reserve Program (CRP)

Case Studies

1. Effect of width of fencing, riparian buffer width and plant types (native and invasive) on the performance of RBs and the water quality of adjacent stream.
2. Performance of Cover Crops as vegetative buffer strips to Control Water contaminants at the Source in Tropical Agricultural Land

Goal of the Project

- Stream rehabilitation using native riparian plant species as buffer zones to decrease:
  - Sediment loadings into stream surface water
  - microbial contamination to surface and groundwater systems due to cattle grazing,
  - decrease stream temperature.
  - Evaluate economical viability of these management practices.




Removal of invasive species

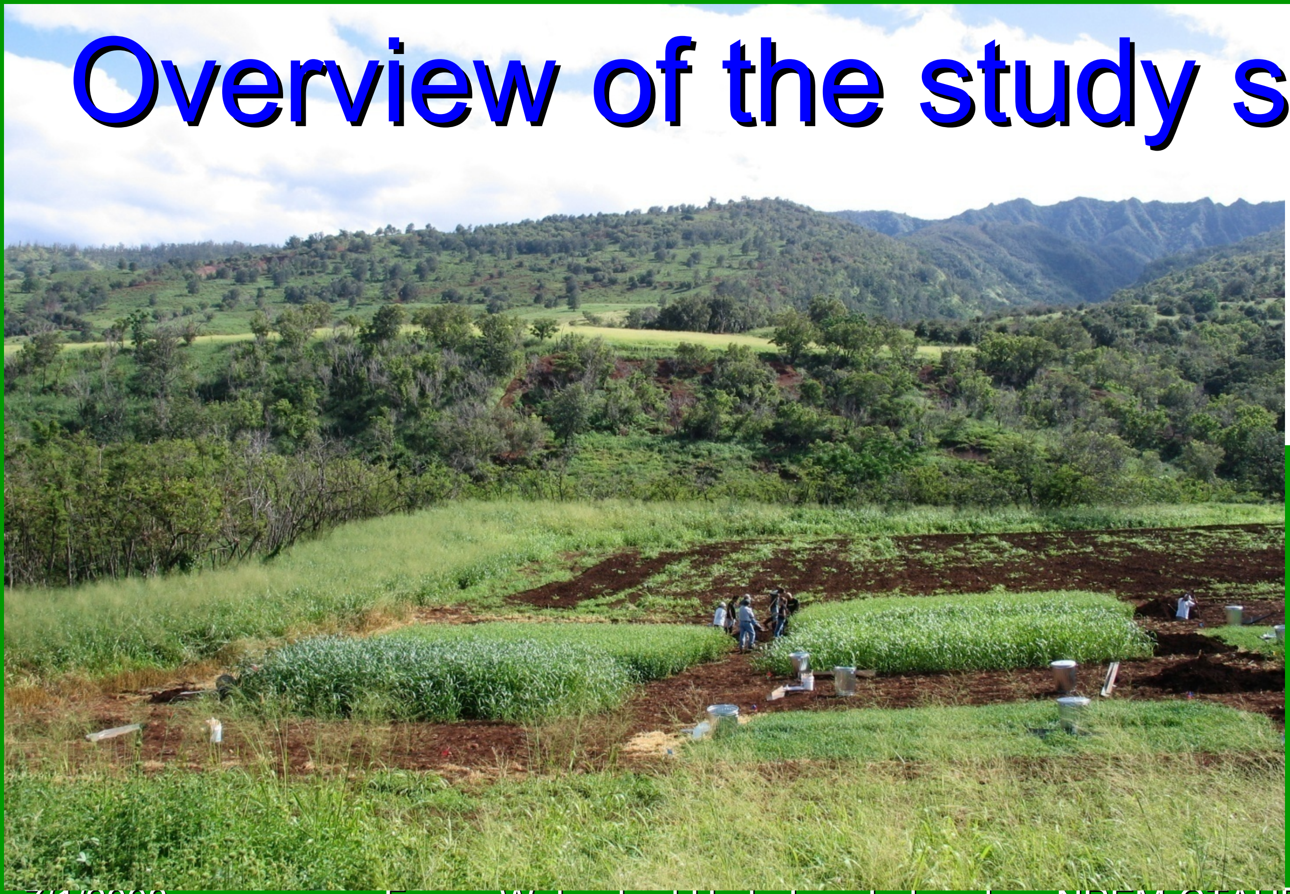
Native Plant Used

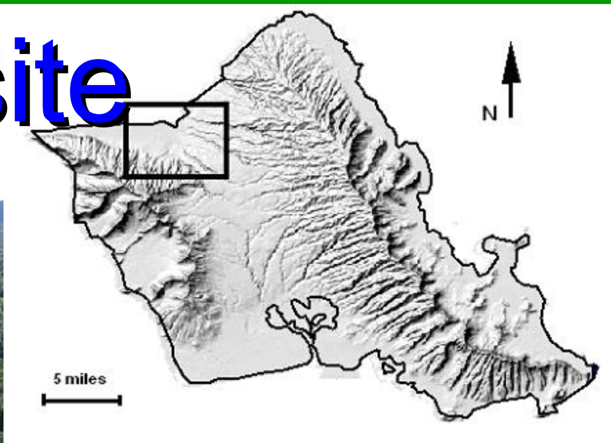
Case study 2

Vegetative buffer strips

Performance of Cover Crops as vegetative buffer strips to Control Water contaminants at the Source in Tropical Agricultural Land

Overview of the study site



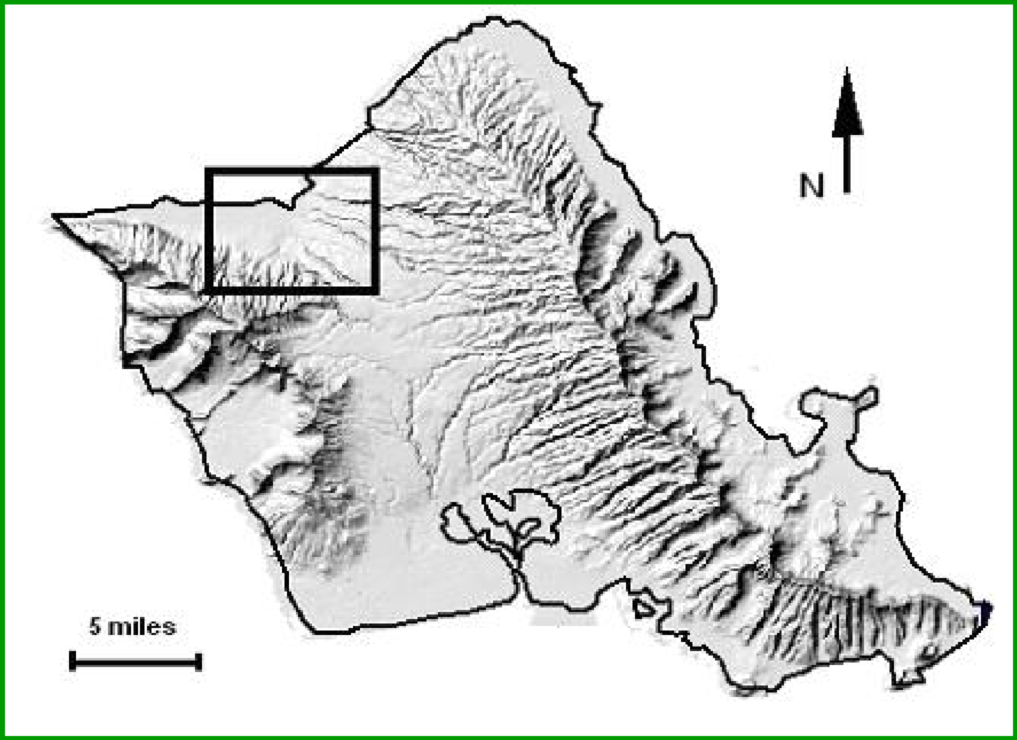


Kaika-Wailua Watershed (Oahu’s north shore)

Objectives

- The goal of this project is to **implement** and **demonstrate** erosion control practices to help manage erosion throughout Kaiaka-Waialua watershed, thereby reducing sediment and potential pollutant loads (P, N) into the surface water resources, and consequently improving water quality of the coastal area.

Demonstration Site



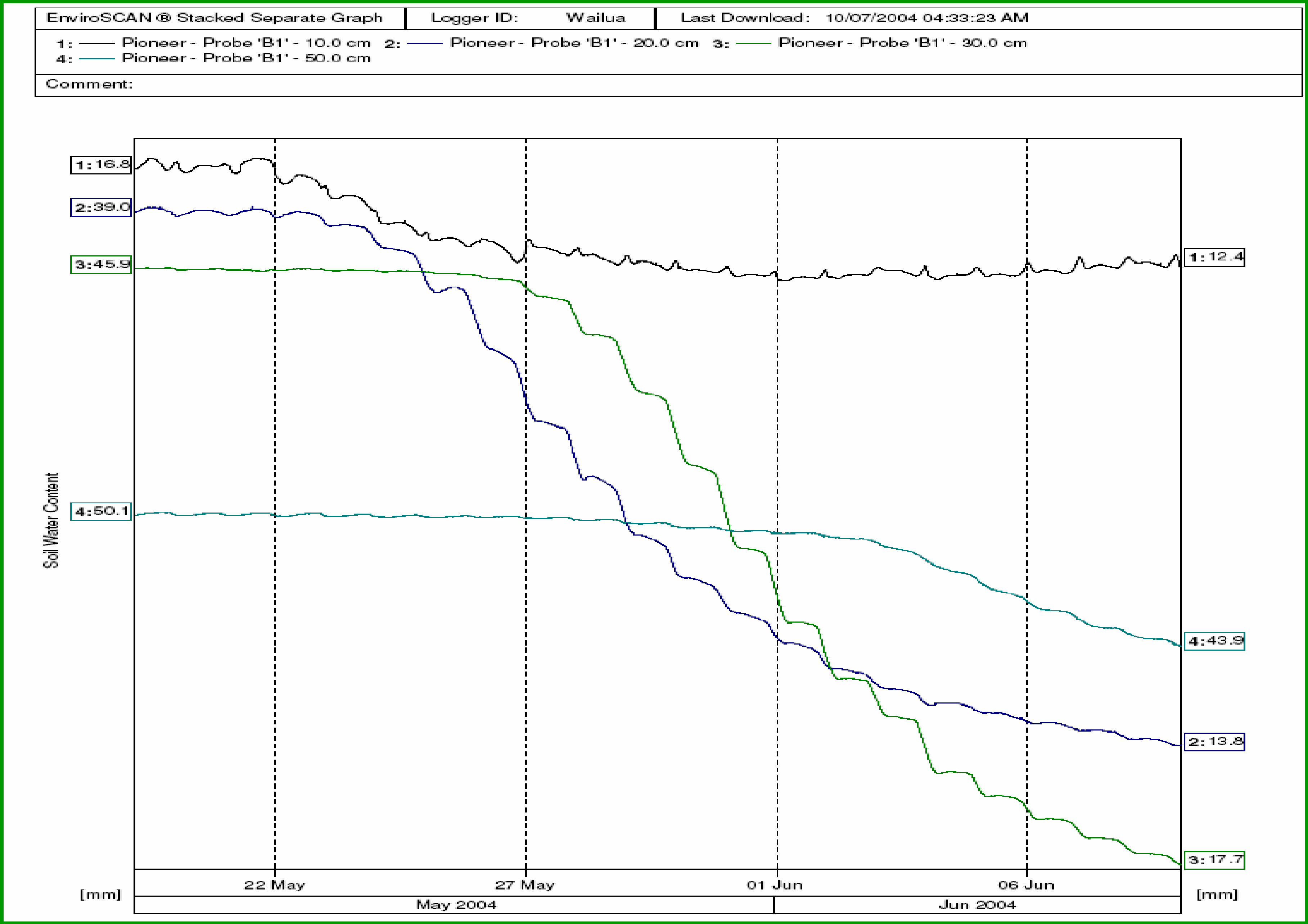
- The selected site is located within the property of Pioneer HI-Bred International, INC, Wailua.

Monitoring

- Surface water:
  - Quantity and
  - Quality:
    - Sediments: TDS and TSS
    - Nutrient: N,P
- Subsurface water:
  - Quantity: water contents @ 10,20,30 & 50cm
  - Quantity: Nutrient P, NO3, NH4 and TN
- Rainfall: @ 15 minute interval


JOHN DEERE
410C


84

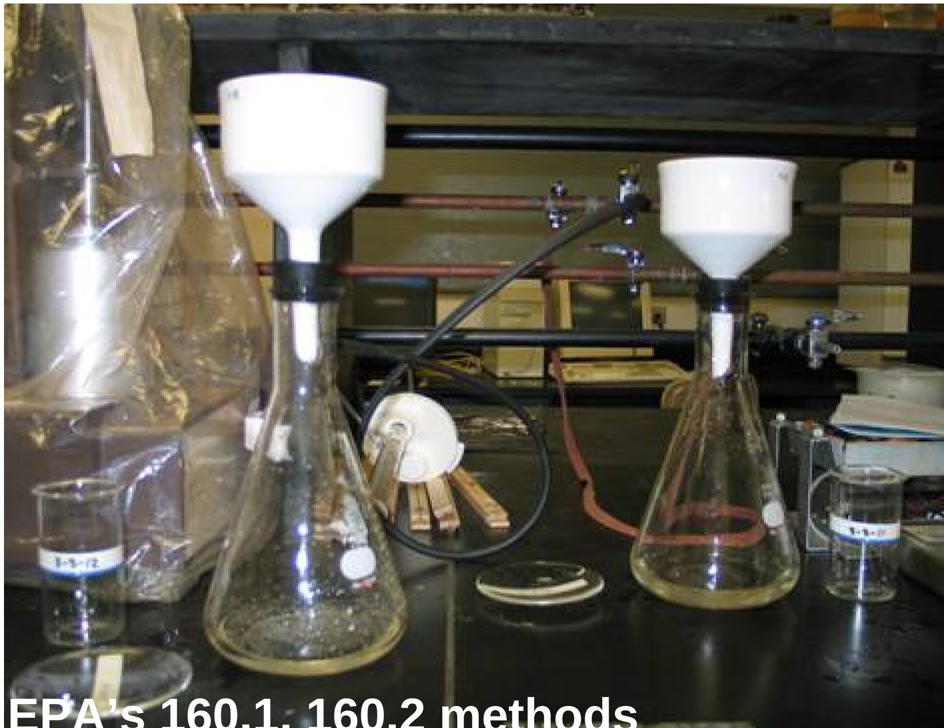


EnviroSCAN ® Stacked Separate Graph
Logger ID: Wailua
Last Download: 10/07/2004 04:33:23 AM
1: Pioneer - Probe 'B1' - 10.0 cm
2: Pioneer - Probe 'B1' - 20.0 cm
3: Pioneer - Probe 'B1' - 30.0 cm
4: Pioneer - Probe 'B1' - 50.0 cm
Comment:
1:16.8
2:39.0
3:45.9
4:50.1
Soil Water Content
1:12.4
4:43.9
2:13.8
3:17.7
[mm]
22 May
27 May
01 Jun
06 Jun
[mm]
May 2004
Jun 2004

Subsurface Water Quality Analysis

- Collected soil solution samples were analyzed at the University of Hawai'i (ADSC) for:
  - Ammonium
  - Nitrate
  - Total Nitrogen and
  - Phosphorus

Materials and Methods

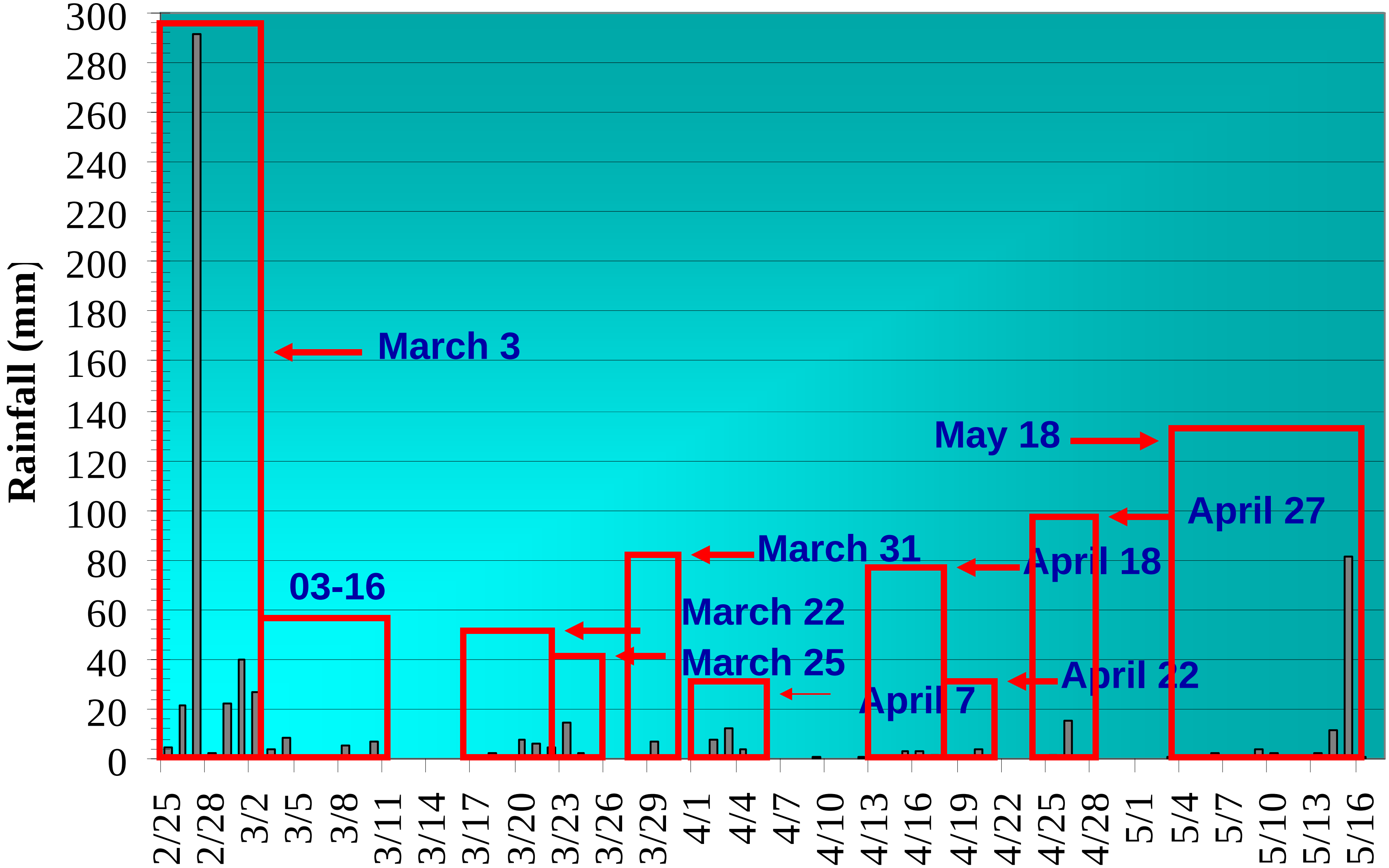


EPA’s 160.1, 160.2 methods

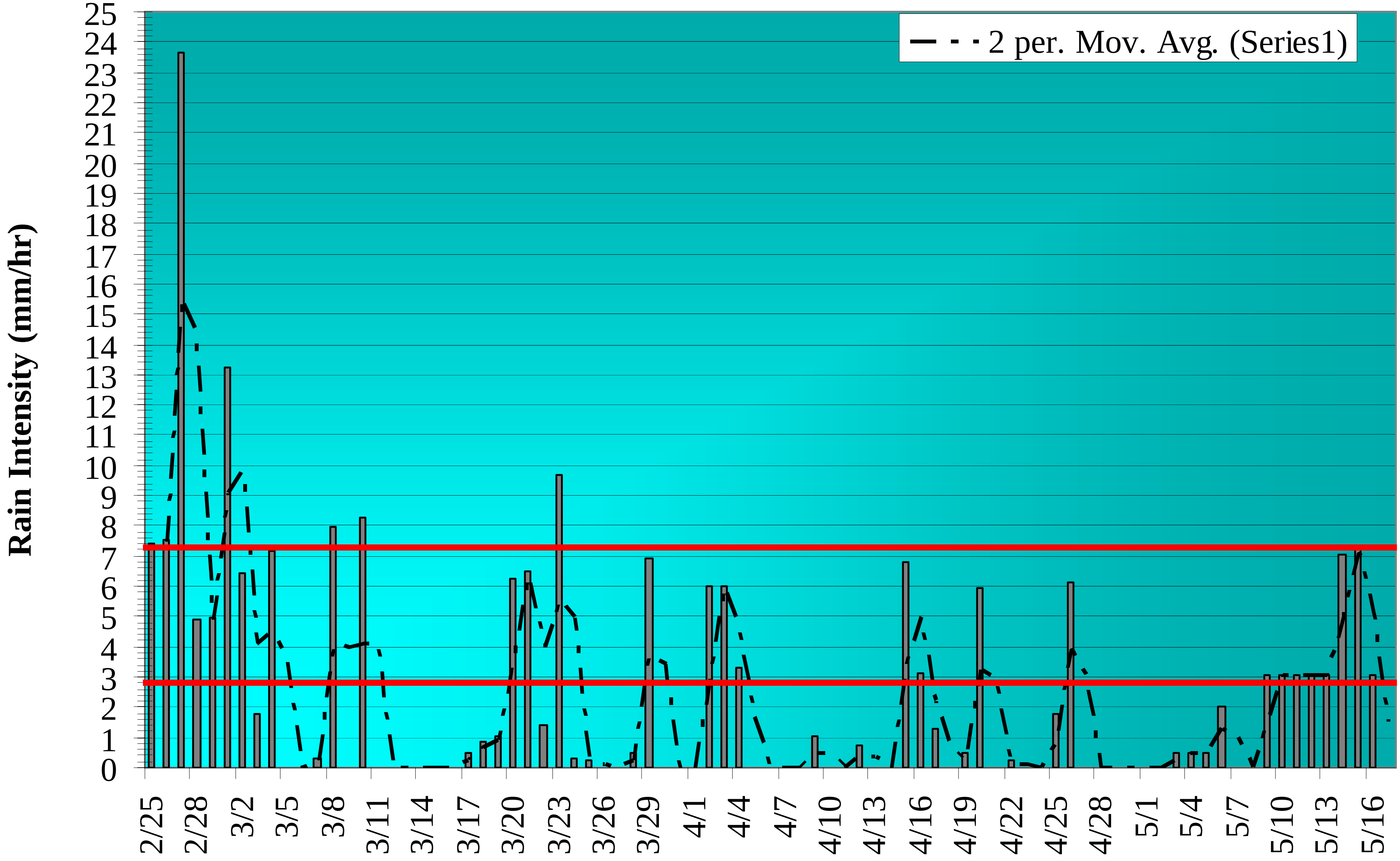
Results

- Runoff water quantity and quality
- Subsurface water quality

292 mm occurred in 11 hr, 2/27 at a rate of 24 mm hr-1



Average Rainfall Intensity



Results of Surface Water

Surface Runoff Collection


4-7-04
Plot 4
Plot 10
Plot 12

Removal Efficiencies

- Calculation for Removal Efficiencies (RE):
- RE = [1- (Cover Crop (g) / Fallow (g))]x100
- A positive RE means that there was a reduction in pollutant levels in comparison to the fallow
- A negative RE means that there was an increase in pollutant levels in comparison to the fallow treatment

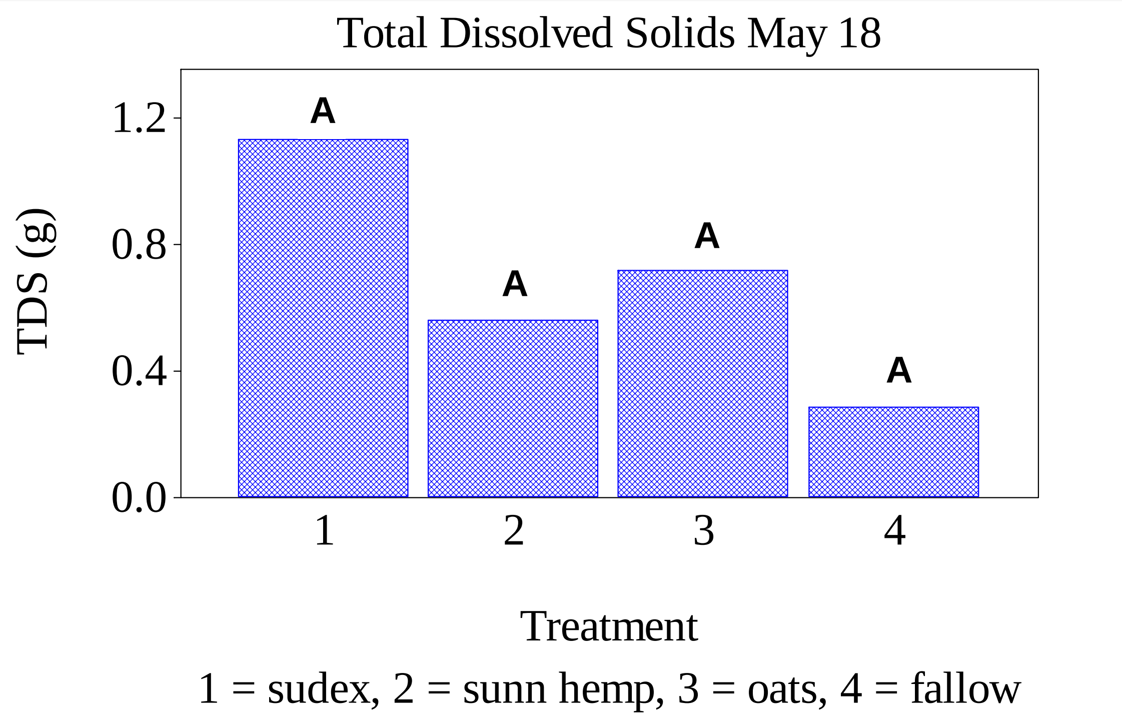
ANOVA Runoff Results

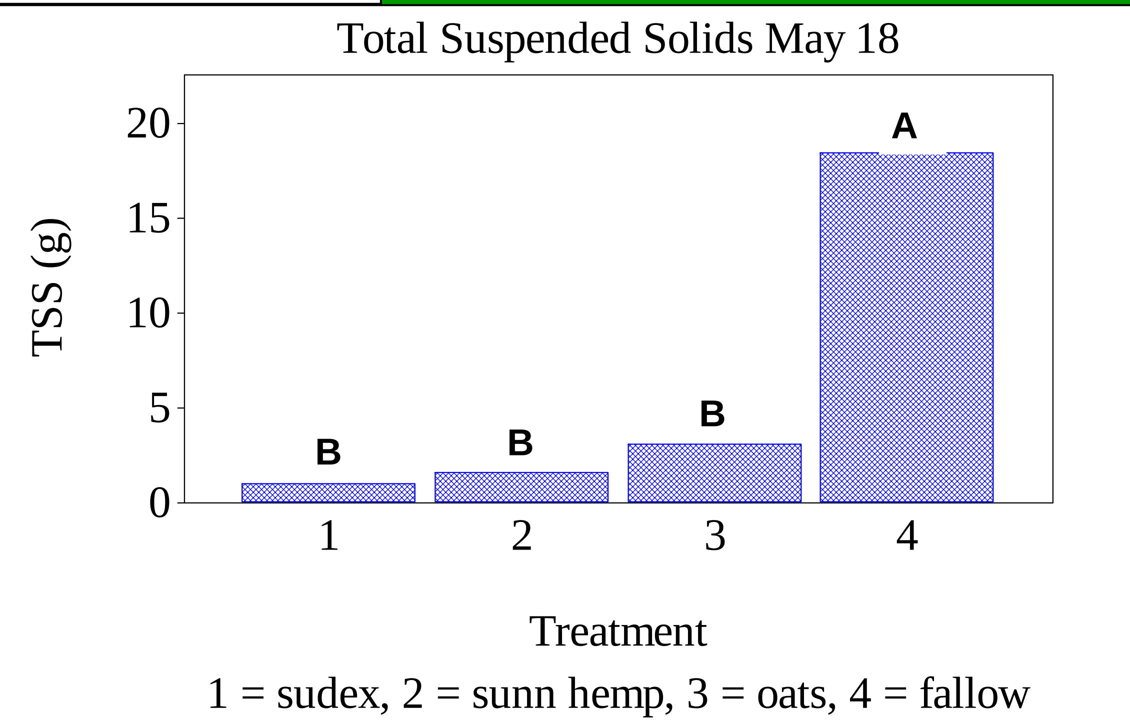
	---------------March----------------					--------------April------------				May
Variable	**3**	**16**	**22**	**25**	**31**	**7**	**18**	**22**	**27**	**18**
TSS	NS	NS	*	**	*	NS	*	*	*	**
TDS	NS	NS	NS	NS	NS	NS	NS	**	NS	NS
Nitrate	*	NS	NS	*	NS	**	NS	**	NS	**
Ammonium	NS	NS	NS	**	**	NS	**	NS	**	NS
TN	*	NS	NS	**	**	**	**	NS	**	NS
Phosphorous	NS	NS	NS	NS	NS	NS	NS	**	**	**

*, ** denotes a significant or highly significant difference was detected between treatment means, respectively.

Removal Efficiencies for TSS

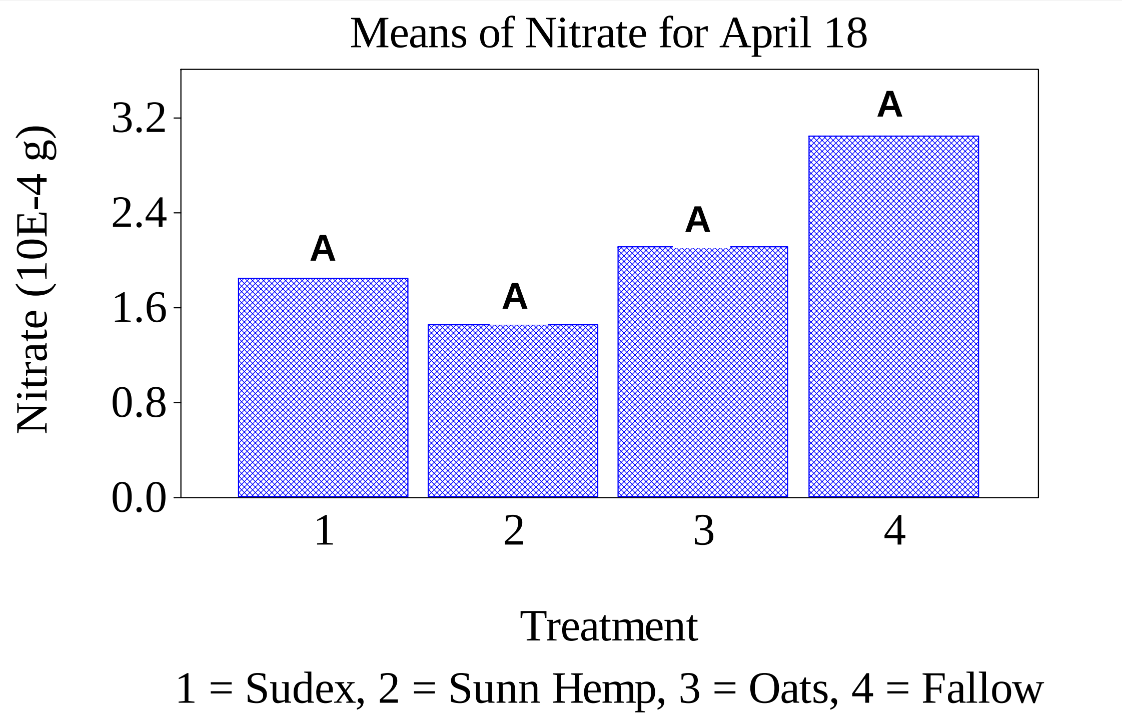
Date	3/3	3/16	3/22	3/25	3/31	4/7	4/18	4/22	4/27	5/18	AVG
Rainfall (mm)	406	21	19	17	8	24	9	5	17	105	
Sudex	73	72	57	84	51	81	86	60	52	94	74
Sunn Hemp	77	58	70	93	70	72	90	95	87	91	77
Oats	86	42	80	97	79	80	91	96	90	83	85

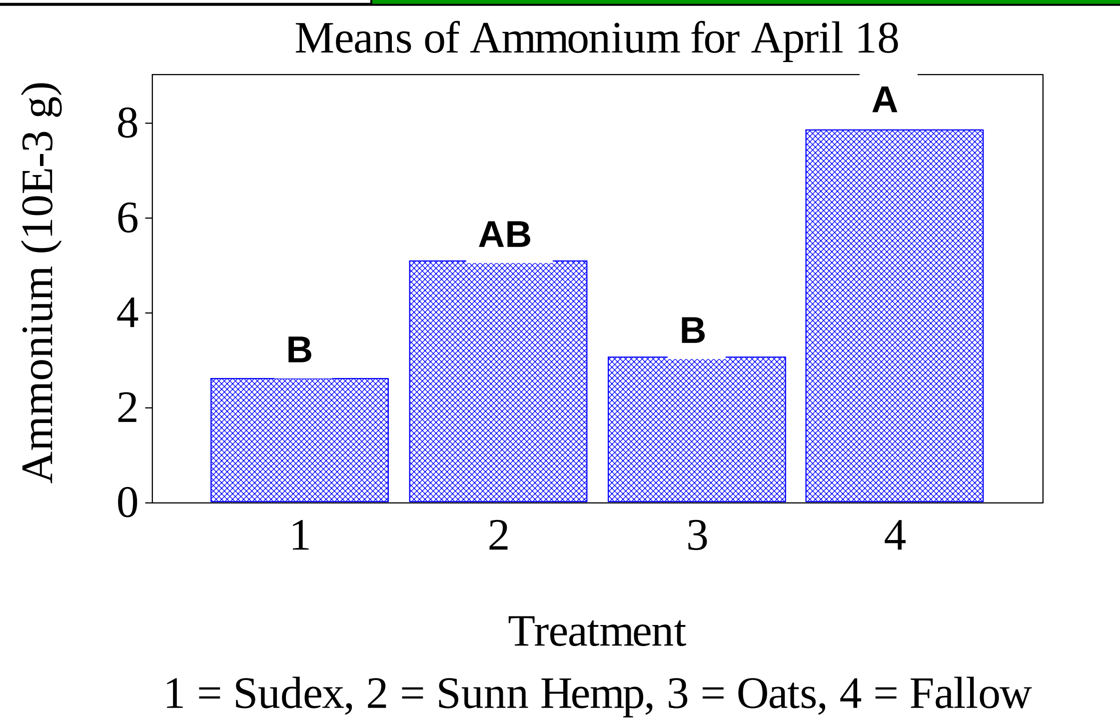

Total Dissolved Solids May 18
TDS (g)
1.2
0.8
0.4
0.0
A
A
A
A
1
2
3
4
Treatment
1 = sudex, 2 = sunn hemp, 3 = oats, 4 = fallow


Total Suspended Solids May 18
TSS (g)
20
15
10
5
0
B
B
B
A
1
2
3
4
Treatment
1 = sudex, 2 = sunn hemp, 3 = oats, 4 = fallow

Removal Efficiencies for Total Nitrogen

Date	3/3	3/16	3/22	3/25	3/31	4/7	4/18	4/22	4/27	5/18	AVG
Rainfall (mm)	406	21	19	17	8	24	9	5	17	105	
Sudex	-7	-4	-7	0	44	46	72	-9	-58	51	13
Sunn Hemp	-53	-53	-52	-196	-8	-38	19	-17	-102	34	-47
Oats	43	-69	-68	18	57	70	60	61	12	31	22


Means of Nitrate for April 18
Nitrate (10E-4 g)
3.2
2.4
1.6
0.8
0.0
A
A
A
A
1
2
3
4
Treatment
1 = Sudex, 2 = Sunn Hemp, 3 = Oats, 4 = Fallow


Means of Ammonium for April 18
Ammonium (10E-3 g)
8
6
4
2
0
B
AB
B
A
1
2
3
4
Treatment
1 = Sudex, 2 = Sunn Hemp, 3 = Oats, 4 = Fallow

Removal Efficiencies for Ammonium

Date	3/3	3/16	3/22	3/25	3/31	4/7	4/18	4/22	4/27	5/18	AVG
Rainfall (mm)	406	21	19	17	8	24	9	5	17	105	
Sudex	2.4	-5	-25	-15	45	-132	67	-46	-68	57	-12
Sunn Hemp	-43	-65	-83	-242	-13	36	35	-43	-145	32	-53
Oats	49	-53	-75	30	73	65	61	53	-12	39	23

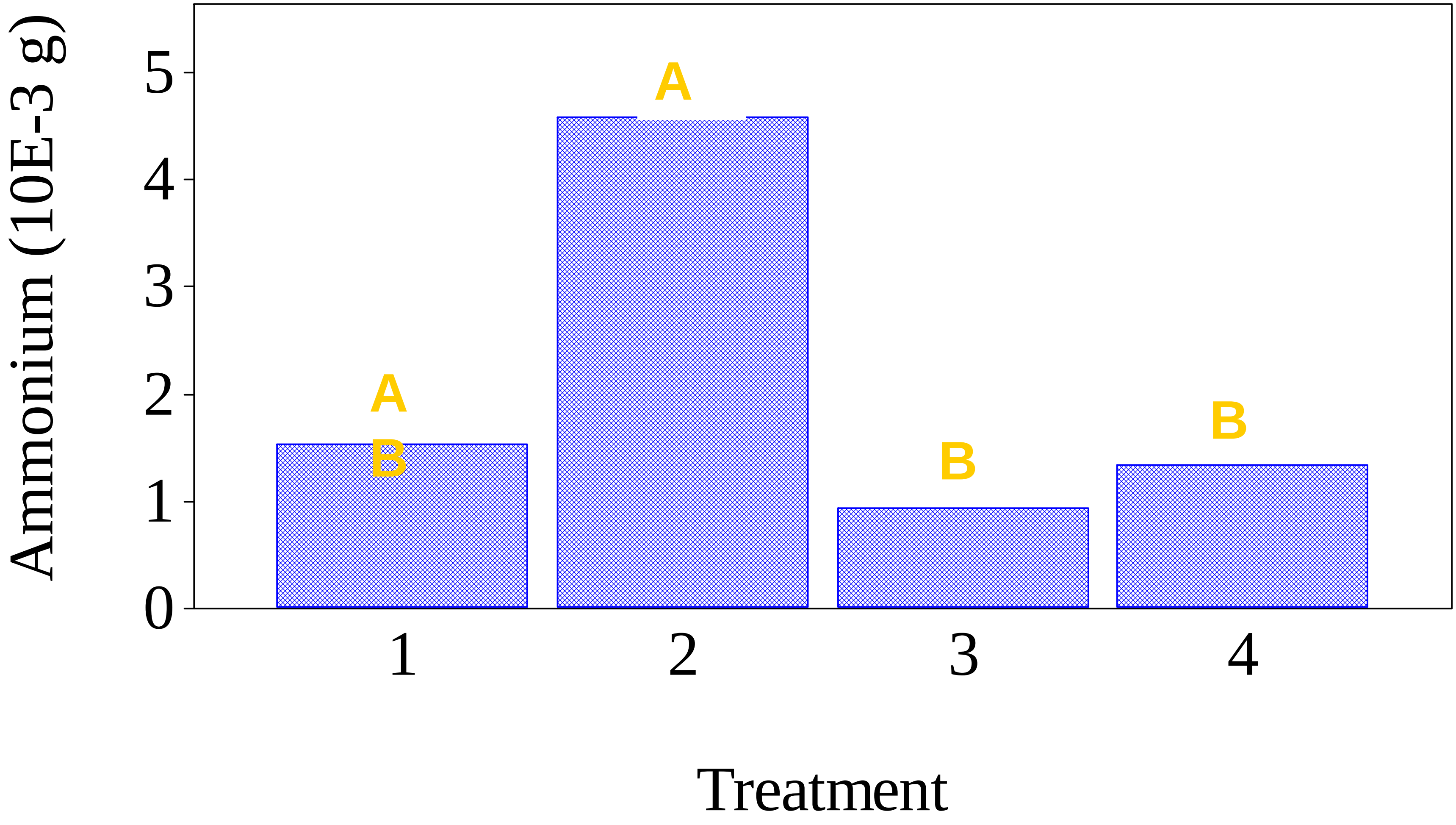
Soil Solution Samples ANOVA

Variable	3/22	3/25	3/31	4/7
Nitrate	**	*	**	NS
Ammonium	NS	NS	NS	NS
TN	**	*	**	NS
Phosphorous	NS	NS	NS	NS

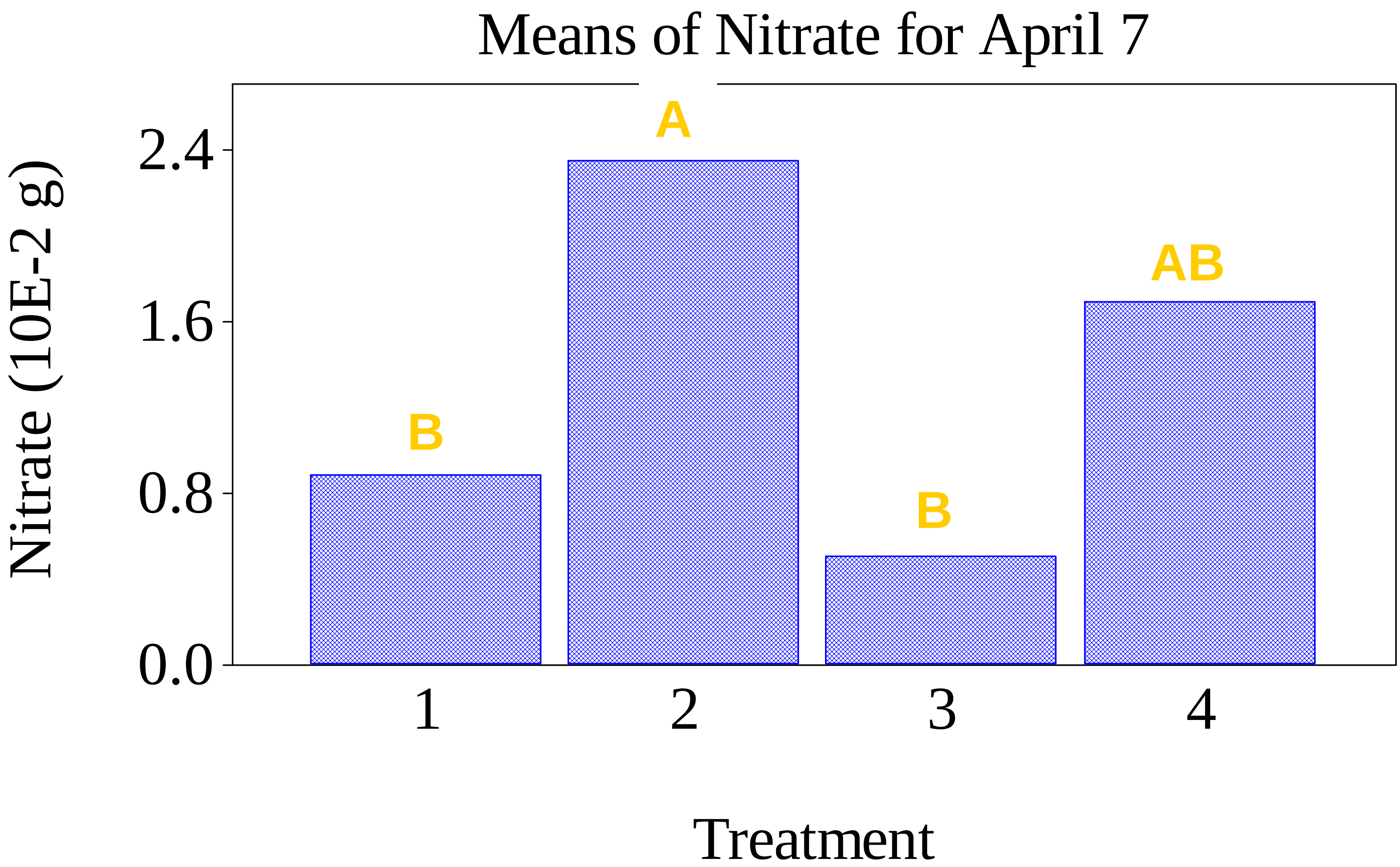
* denotes a significant difference was detected

** denotes a highly significant difference was detected

Means of Ammonium for March 25

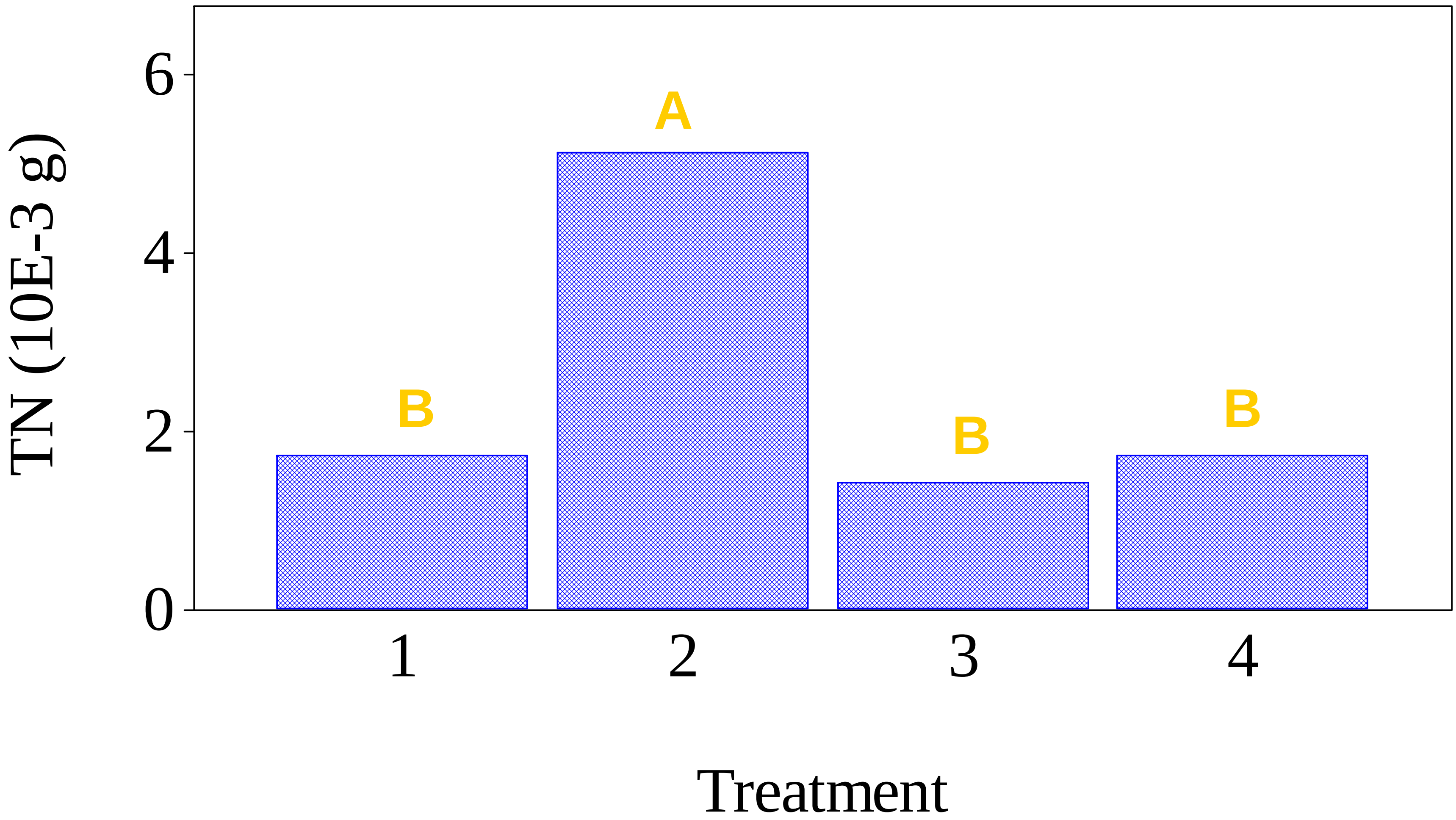


1 = Sudex, 2 = Sunn Hemp, 3 = Oats, 4 = Fallow



1 = Sudex, 2 = Sunn Hemp, 3 = Oats, 4 = Fallow

Means of Total Nitrogen for March 25



1 = Sudex, 2 = Sunn Hemp, 3 = Oats, 4 = Fallow

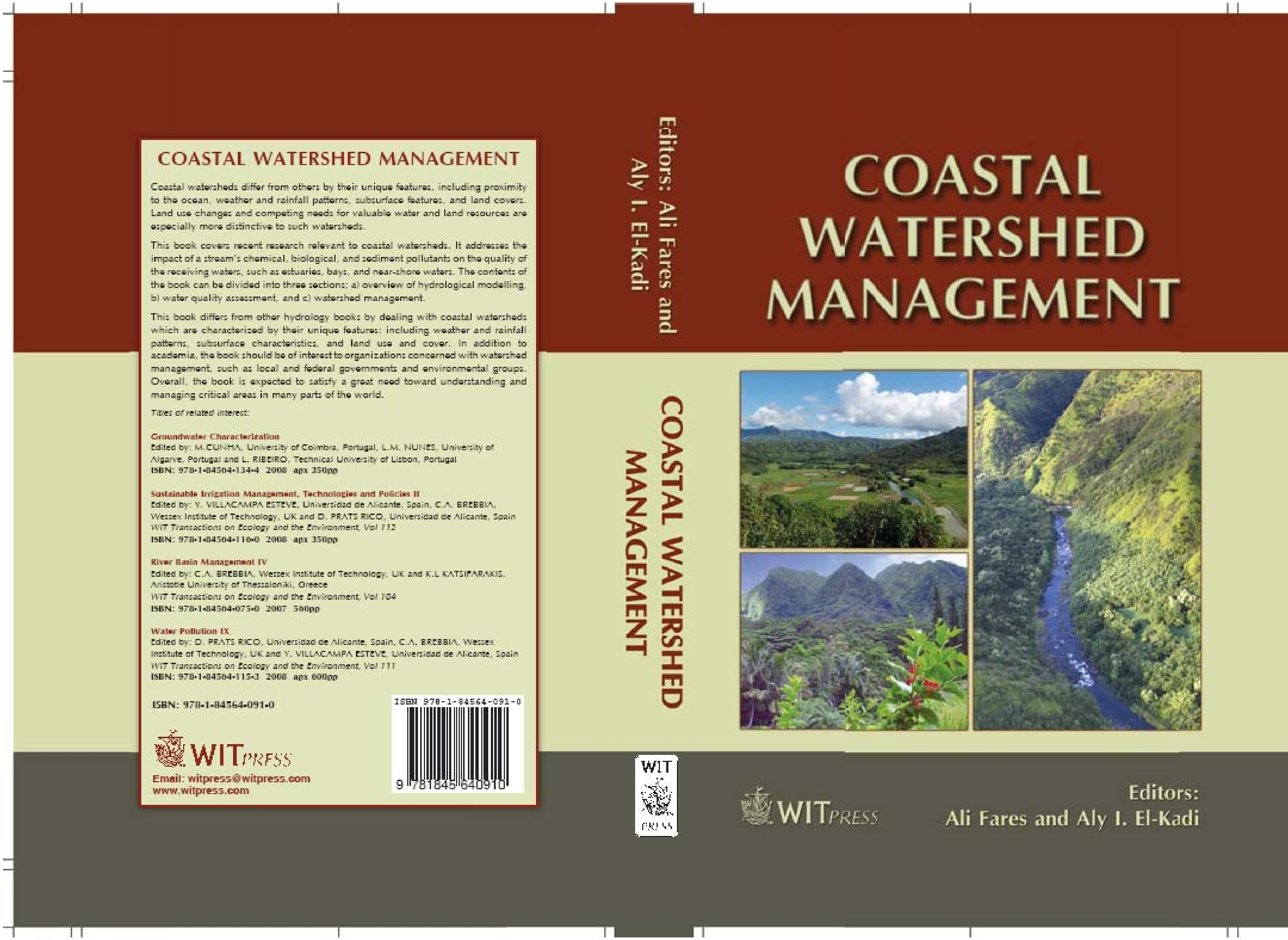

Field Day 04-28-04


Integrated Approach to
ion Contr
Cover Crops Reduce Non-point Source Pollution


F.R.E.S.H. START
TEAM

Conclusions

- Hawaiian watersheds are facing the problem of non-point source pollution which pose human and ecosystem health risks
- NPS pollutants runoff into streams, lakes, and wetlands
- Cover crops reduce the NO_3 levels in the soil and sediment loads in the runoff water
- Research is need on the implementation and performance of precision RB under Hawaii conditions.



COASTAL WATERSHED MANAGEMENT
Coastal watersheds differ from others by their unique features, including proximity to the ocean, weather and rainfall patterns, subsurface features, and land covers. Land use changes and competing needs for valuable water and land resources are especially more distinctive to such watersheds.
This book covers recent research relevant to coastal watersheds. It addresses the impact of a stream's chemical, biological, and sediment pollutants on the quality of the receiving waters, such as estuaries, bays, and near-shore waters. The contents of the book can be divided into three sections: a) overview of hydrological modelling, b) water quality assessment, and c) watershed management.
This book differs from other hydrology books by dealing with coastal watersheds which are characterized by their unique features: including weather and rainfall patterns, subsurface characteristics, and land use and cover. In addition to academia, the book should be of interest to organizations concerned with watershed management, such as local and federal governments and environmental groups. Overall, the book is expected to satisfy a great need toward understanding and managing critical areas in many parts of the world.
Titles of related interest:
Groundwater Characterization
Edited by: M.CUNHA, University of Coimbra, Portugal, L.M. NUNES, University of Algarve, Portugal and L. RIBEIRO, Technical University of Lisbon, Portugal
ISBN: 978-1-84504-134-4 2008 apx 350pp
Sustainable Irrigation Management, Technologies and Policies II
Edited by: Y. VILLACAMPA ESTEVE, Universidad de Alicante, Spain, C.A. BREBBIA, Wessex Institute of Technology, UK and D. PRATS RICO, Universidad de Alicante, Spain
WIT Transactions on Ecology and the Environment, Vol 112
ISBN: 978-1-84504-116-0 2008 apx 350pp
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WIT Transactions on Ecology and the Environment, Vol 104
ISBN: 978-1-84504-075-0 2007 560pp
Water Pollution IX
Edited by: D. PRATS RICO, Universidad de Alicante, Spain, C.A. BREBBIA, Wessex Institute of Technology, UK and Y. VILLACAMPA ESTEVE, Universidad de Alicante, Spain
WIT Transactions on Ecology and the Environment, Vol 111
ISBN: 978-1-84504-115-3 2008 apx 600pp
ISBN: 978-1-84564-091-0
ISBN 978-1-84564-091-0
WIT PRESS
Email: witpress@witpress.com
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COASTAL WATERSHED MANAGEMENT
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COASTAL WATERSHED MANAGEMENT
WIT PRESS
Editors:
Ali Fares and Aly I. El-Kadi

Rational

- This book is dealing with coastal watersheds which are characterized by their unique features concerning weather and rainfall patterns, subsurface characteristics, and land use and cover.
- The book is of interest to academia, local and federal government organizations, environmental groups, and to wide range of readers working in other environments.

Major Sections of the Book

- Hydrology, Wetlands, and Sediment Tracing Techniques
  - 5 chapters
- Water Quality of stream, estuary and costal bays
  - 3 chapters
- Watershed restoration and Management :
  - 3 chapters
- Economics of Watershed Management
  - 2 chapters
- Legal aspects of watershed management
  - 1 chapter

1. Overview of the hydrological modeling of small coastal watersheds on tropical Islands, Fares
2. Nutrient bioavailability of soils and sediments in an Australian estuary influenced by agriculture: linking land to sea, Chasten et. al.
3. Sediment tracing techniques and their application to coastal watersheds, Kimoto, Fares & Polyakov
4. Coastal wetlands: Function and role in reducing impact of land-based management, Bruland

- Fine particles in small steepland streams: physical, ecological, and human connections, Salant & Hassan, UBC
- Effect of nitrogen best management practices on water quality at the watershed scale, Mulla UMC
- Effects of Changing Land use on Nutrient Loads and Water Quality in a Southeastern US Blackwater River Estuary, White LSU.
- Effects of land use changes and groundwater pumping on saltwater intrusion in coastal watersheds

- Restoration and protection plan for the Nawiliwili Watershed, Kauai, HI, ElKadi et al.
- Estimating the benefits from restoring coastal ecosystems: a case study of Biscayne Bay, FL, Lee & Bwenge. UF
- The economic value of watershed conservation. Kaiser et. al. Gettysburg College
- Impact of best management practices in a coastal watershed, Morgan UF
- Waterborne Zoonoses and Changes in Hydrologic Response Due to Watershed Development. Walker University of Nevada.
- The Waiāhole Ditch: a case study of the management and regulation of water resources in Hawai`I, Miike, HI-CWRM.

Mahalo!

Do You have any questions?