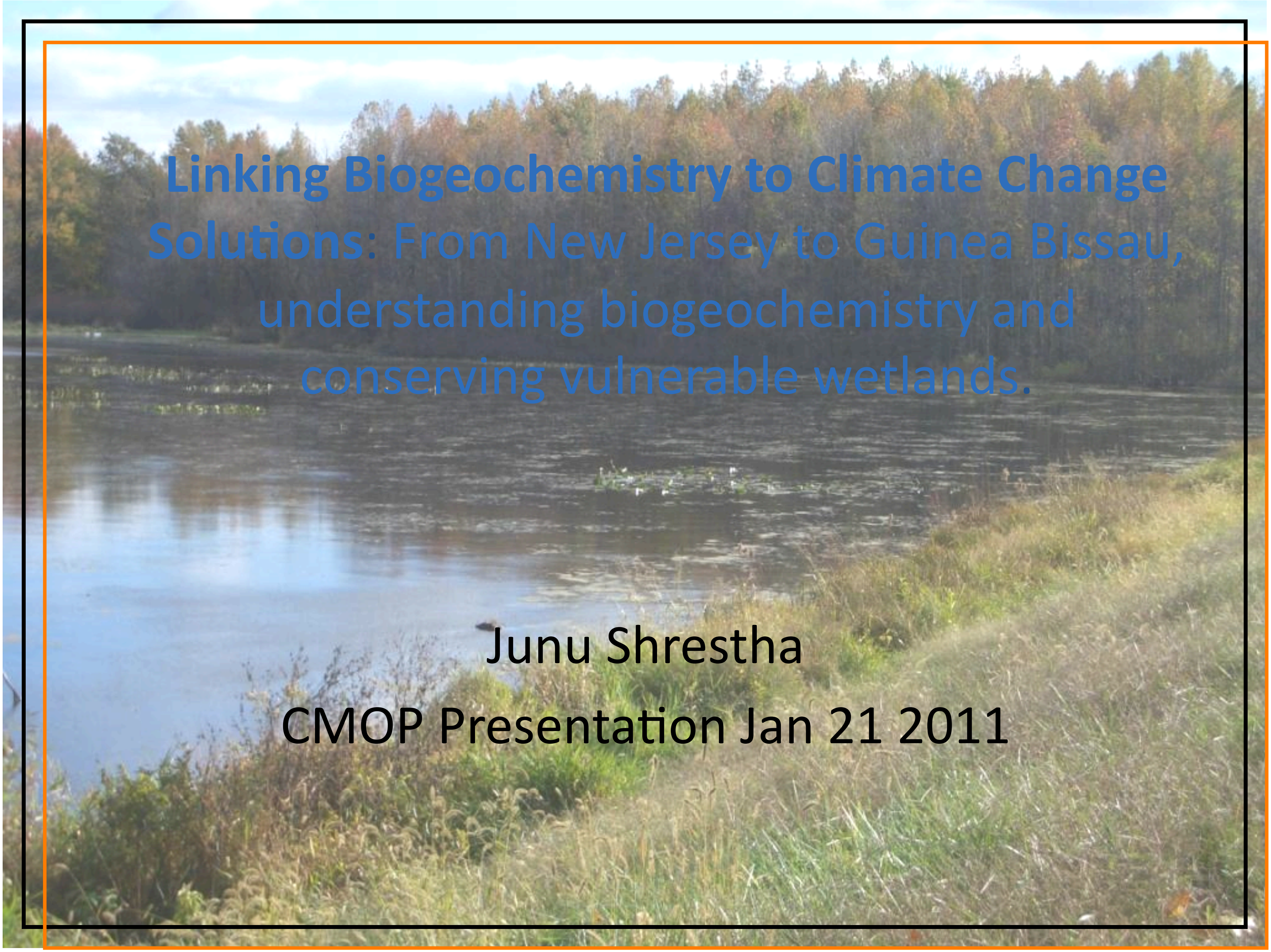


Linking Biogeochemistry to Climate Change Solutions: From New Jersey to Guinea Bissau, understanding biogeochemistry and conserving vulnerable wetlands.

Junu Shrestha

CMOP Presentation Jan 21 2011

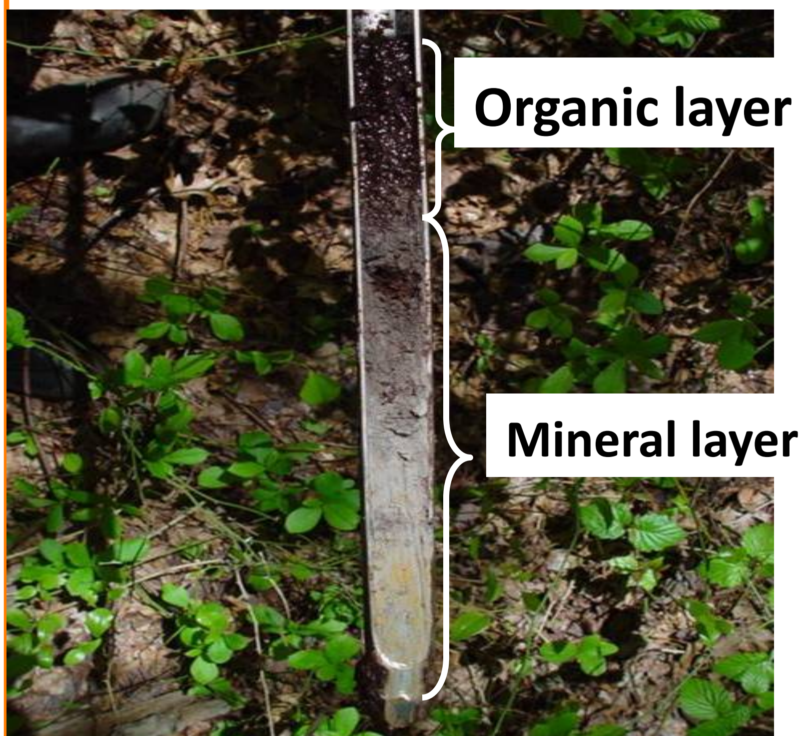
Outline

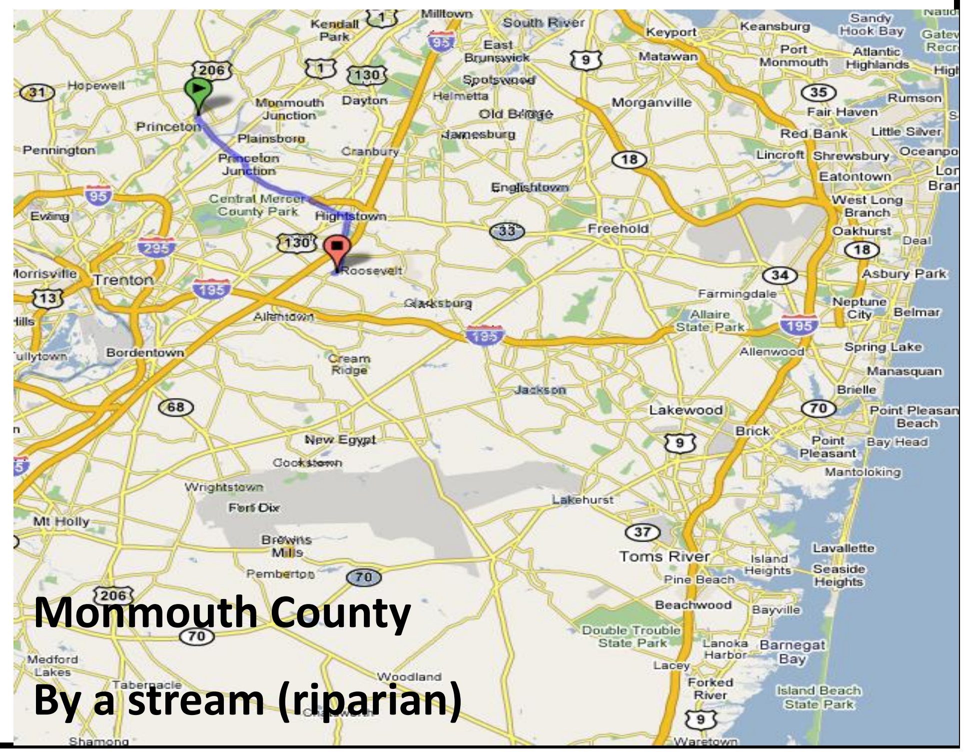
- **Introduction (Wetlands)**
  - Wetland Functions
- **Effects of Stressors**
  - Experiments of Different Scales
- **Unknown Potentials**
  - Anaerobic Ammonium Oxidation
- **Mechanisms for Conservation**
  - Mitigation Banking - New Jersey
  - Reduced Emissions from Degradation and Deforestation (REDD) – Guinea Bissau
- **Conclusions**

Wetland Characteristics

– Hydric Soils

– Water tolerant vegetation





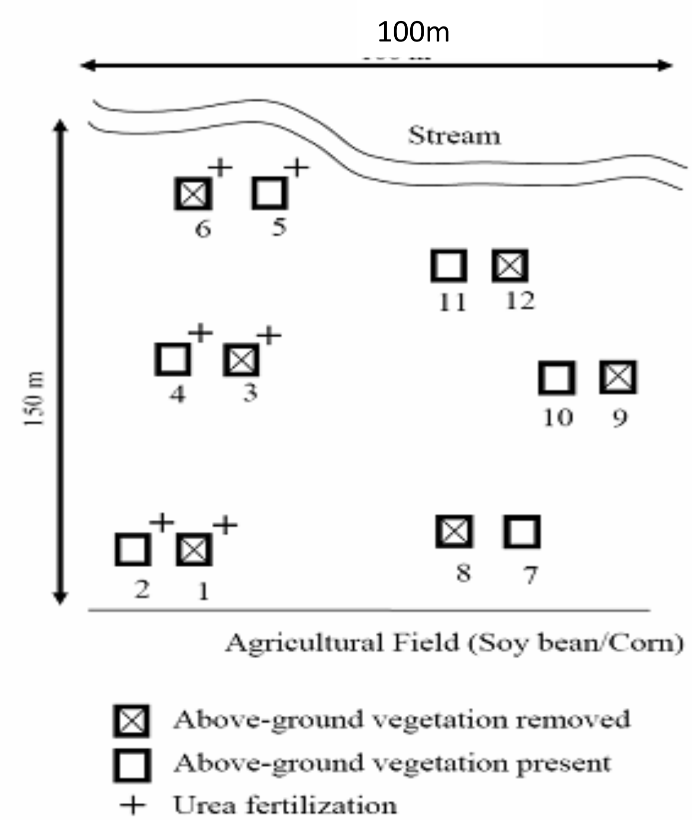
Why Wetlands are Important

- **High Biodiversity**
- **Flood water storage**
- **Nutrient and Contaminant Removal**
  - **Filter for nutrients**
  - **Adsorption of contaminants (Fe complexes)**

Research Question

- What would be the effects of nitrogen addition and vegetation removal on the wetland Iron and Nitrogen Cycles?
  - Agriculture – Fertilizer Application –Urea
  - Development – Vegetation Removal
  - Iron Cycle – Major Redox Component
  - Nitrogen Cycle – Nutrient Cycling

Effects of Vegetation Removal and Nitrogen Addition



Changes in N-Pool

After treatment (µmoles.g^{-1}dw)	***Vegetation (Control)***	***Nitrogen Added***	***Vegetation Removed***	***Both Treatments***
NH_4^+	*0.12±0.01*	*1.41±0.24*	*0.11±0.01*	*1.77±0.48*
NO_3^-	*0.04±0.01*	*0.25±0.03*	*0.17±0.00*	*1.20±0.24*
Dissolved Organic Nitrogen	*13.60±0.64*	*13.63±1.67*	*10.19±1.06*	*27.15±1.03*

- Individual treatments affected inorganic N pool
- Combined treatments affected both the organic and inorganic N pool

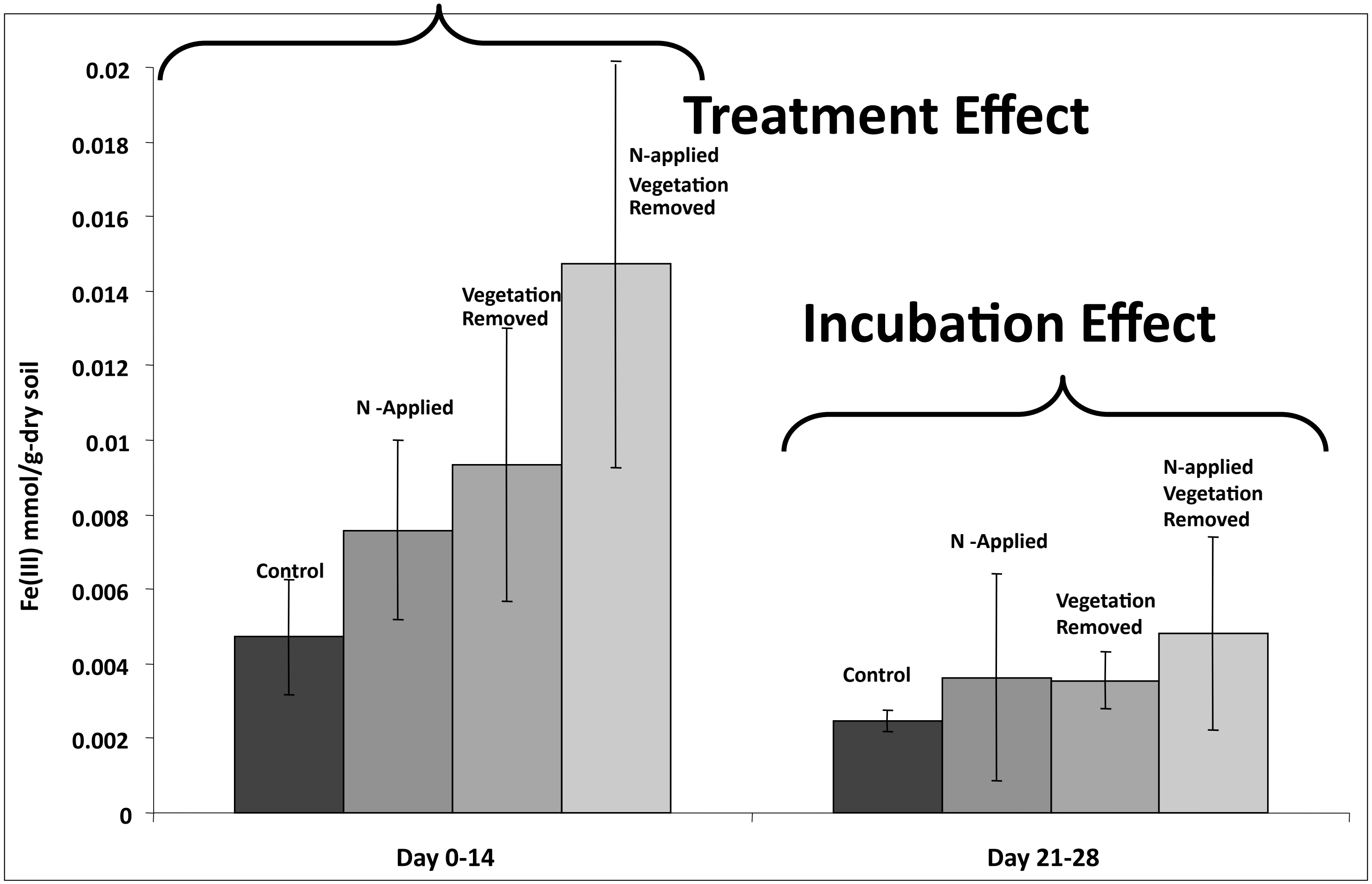
Effects of Vegetation Removal and Urea Application on Fe Cycle

Method:

Soil from different treatment plots incubated under anaerobic conditions

Simulation of flooded wetland conditions

Incubation Results



- Increase in HCl extractable Fe(III)

Effects of Vegetation Removal and Nitrogen Addition

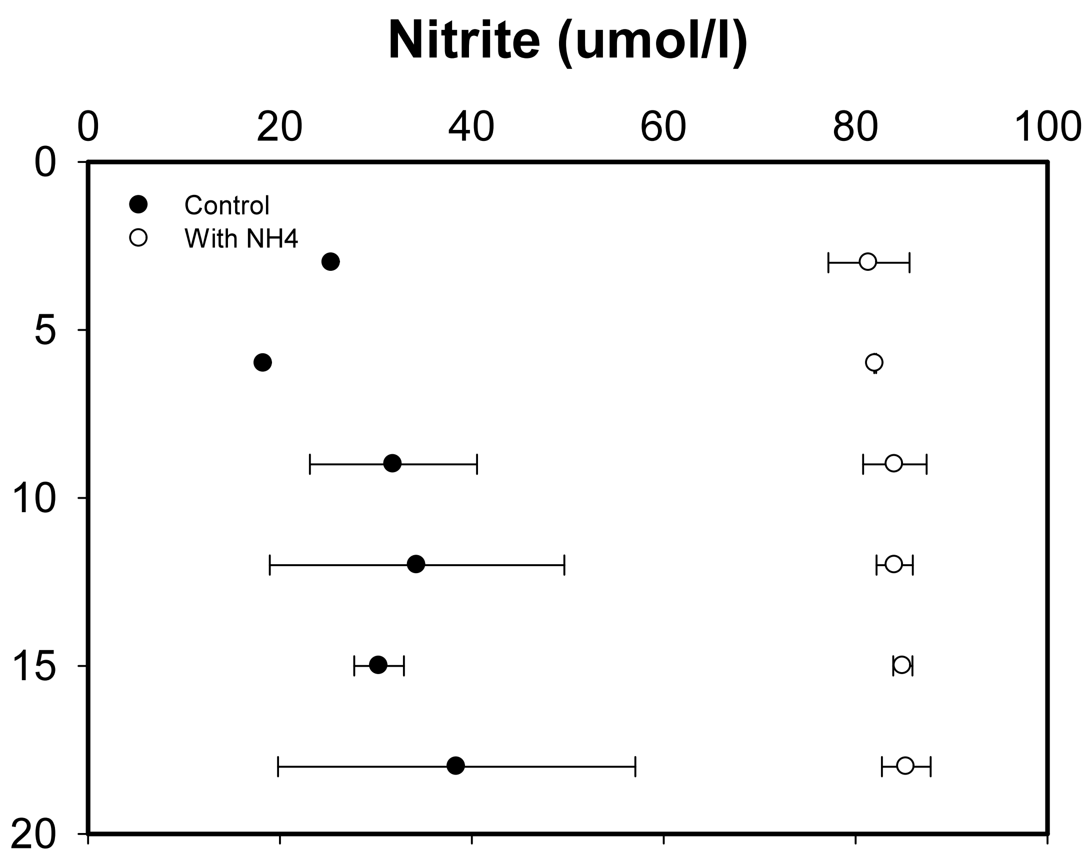
- Both organic and inorganic nitrogen pools can be affected depending on the disturbance
- More bioavailable Fe in disturbed soils

Shrestha et al. 2010, Water, Air and Soil Pollution

Microcosm Experiment

- Flow through microcosm system
- Wetland soil
- 20 mM KCl (Control)
- 20 mM KCl and 2 mM Ammonium

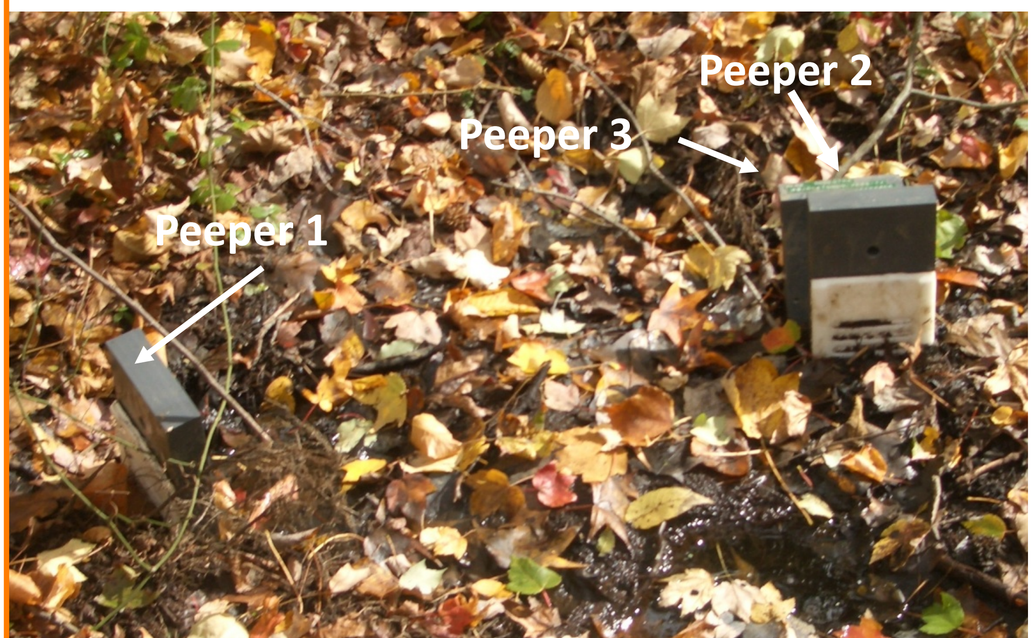
Porewater Profile (NO_2^-)

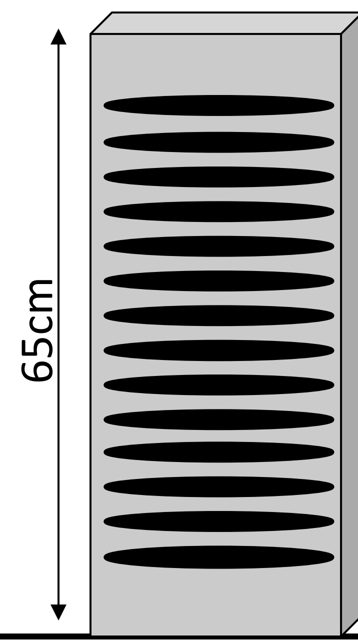


Five Months after the microcosms were started

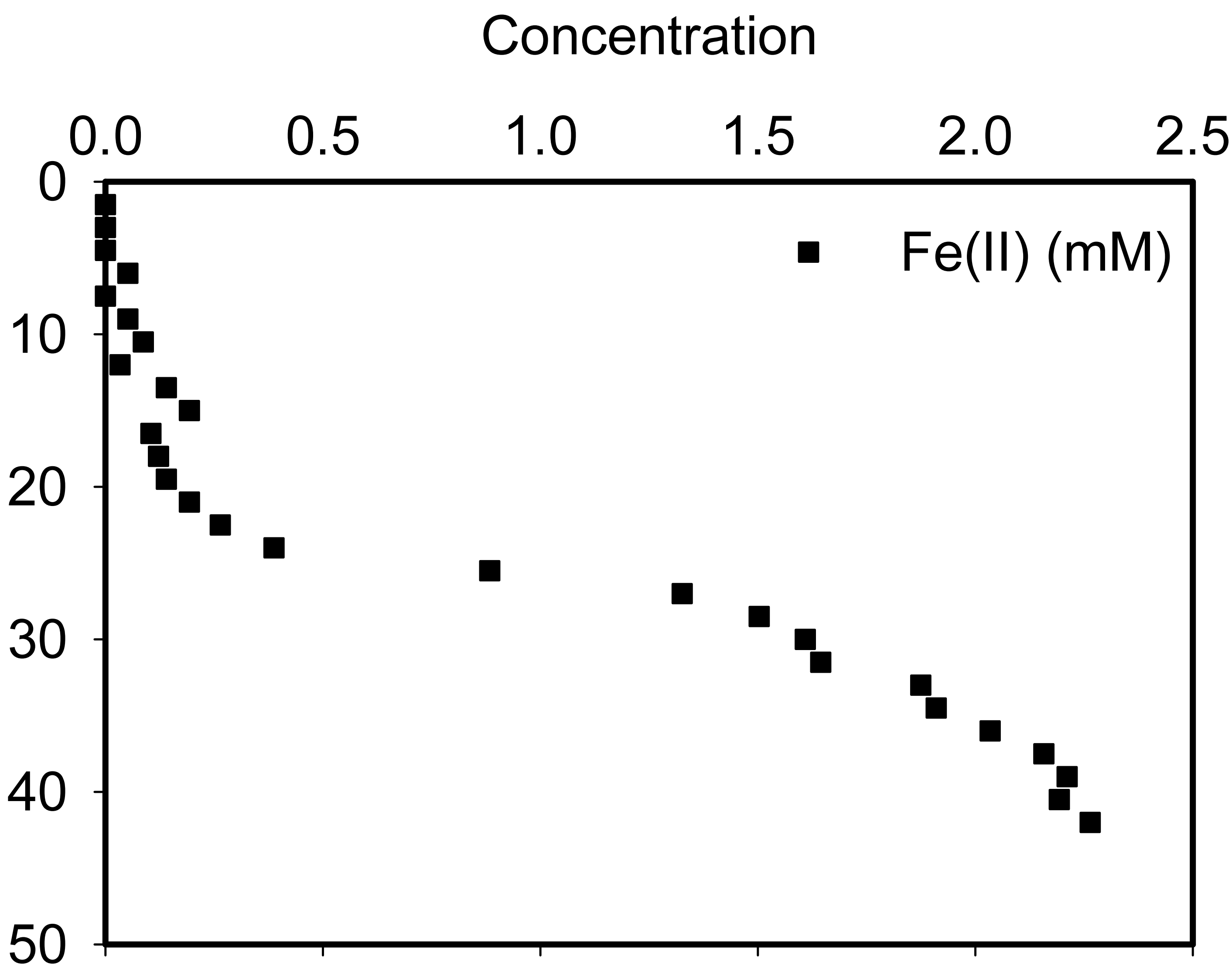
Profile Experiment

- Peepers placed in saturated field soil for 1 month

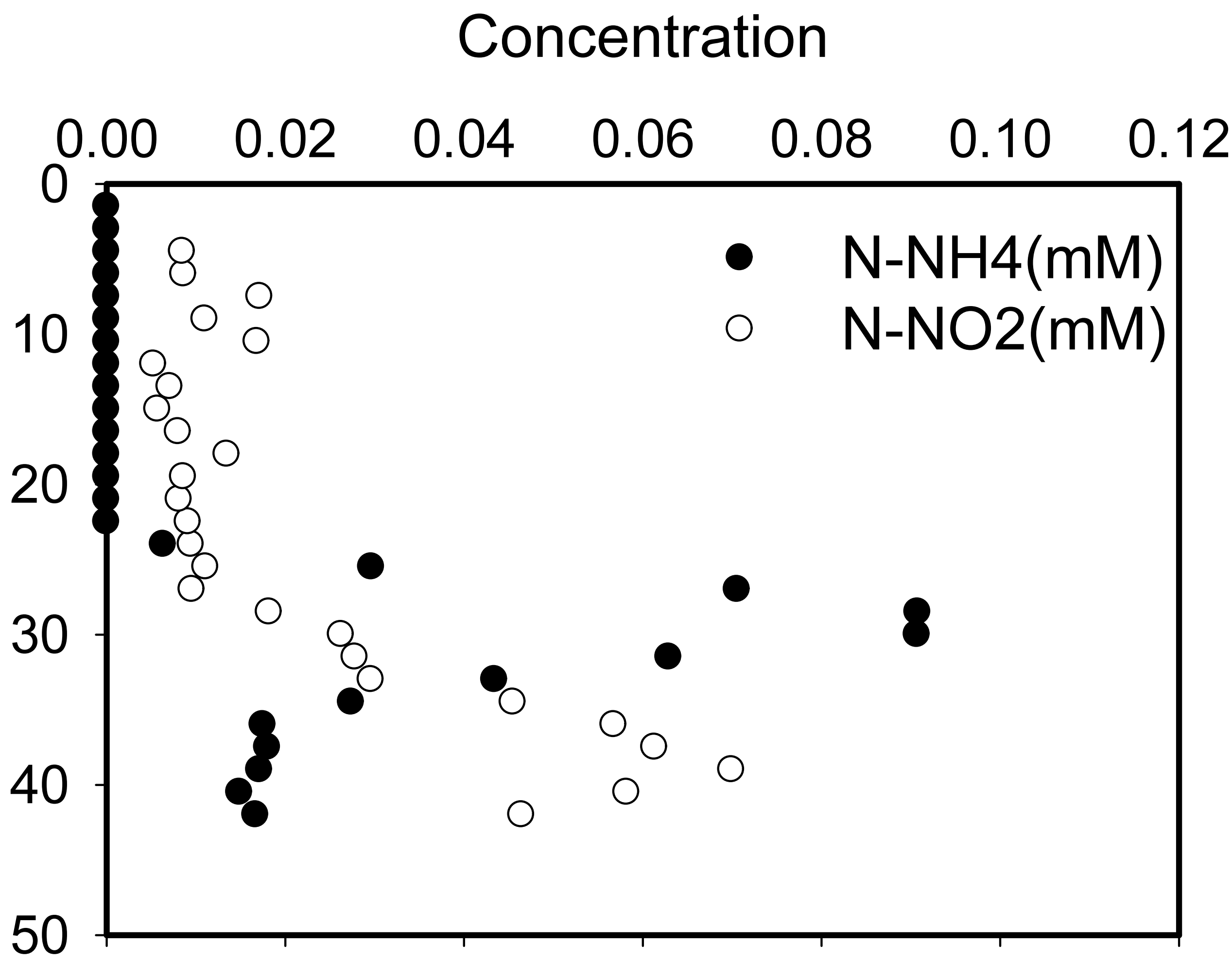




Fe(II) Profile

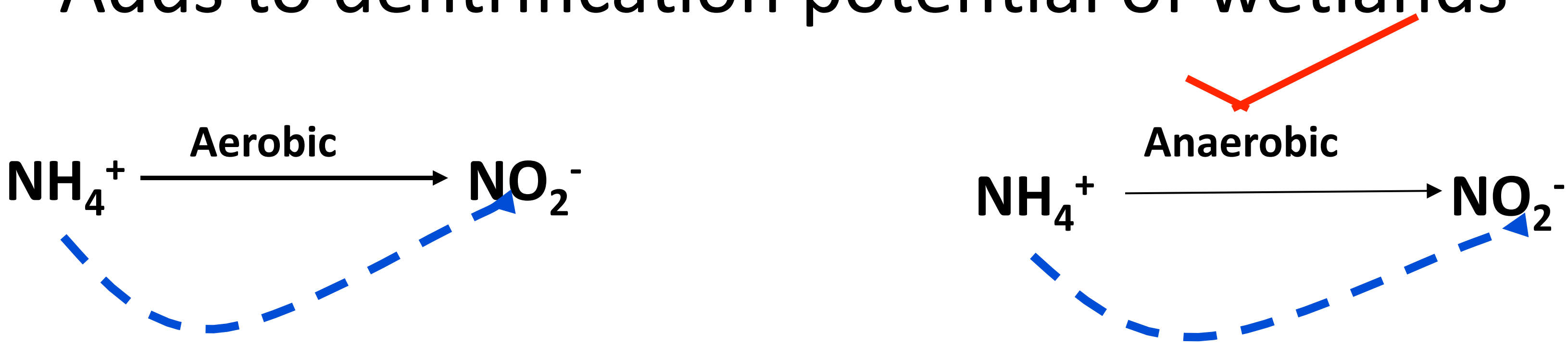


Nitrogen Species



Nitrite in Anoxic Conditions

- Demonstration of nitrite in anoxic iron reducing conditions without any initial presence of nitrate
- Adds to dentrification potential of wetlands



Shrestha et al. 2009
Clement et al. 2005

Connections

- Provides quantitative demonstration of how stressors affect wetland processes and services
- Identifies practices that harm ecosystems
- Demonstrates the need to understand the processes and potential of ecosystems and how they link with our lives

Outline

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  - Threats
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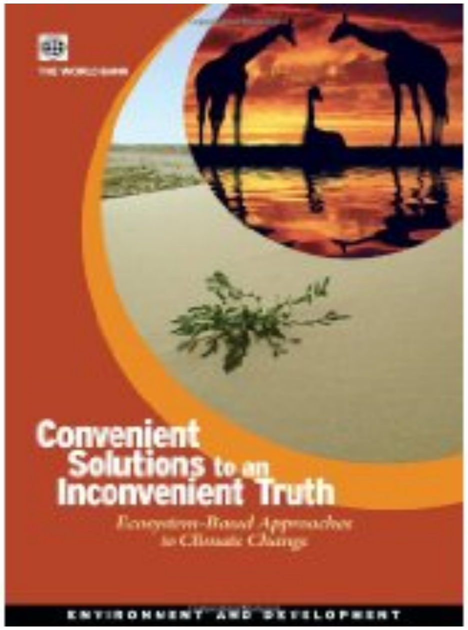
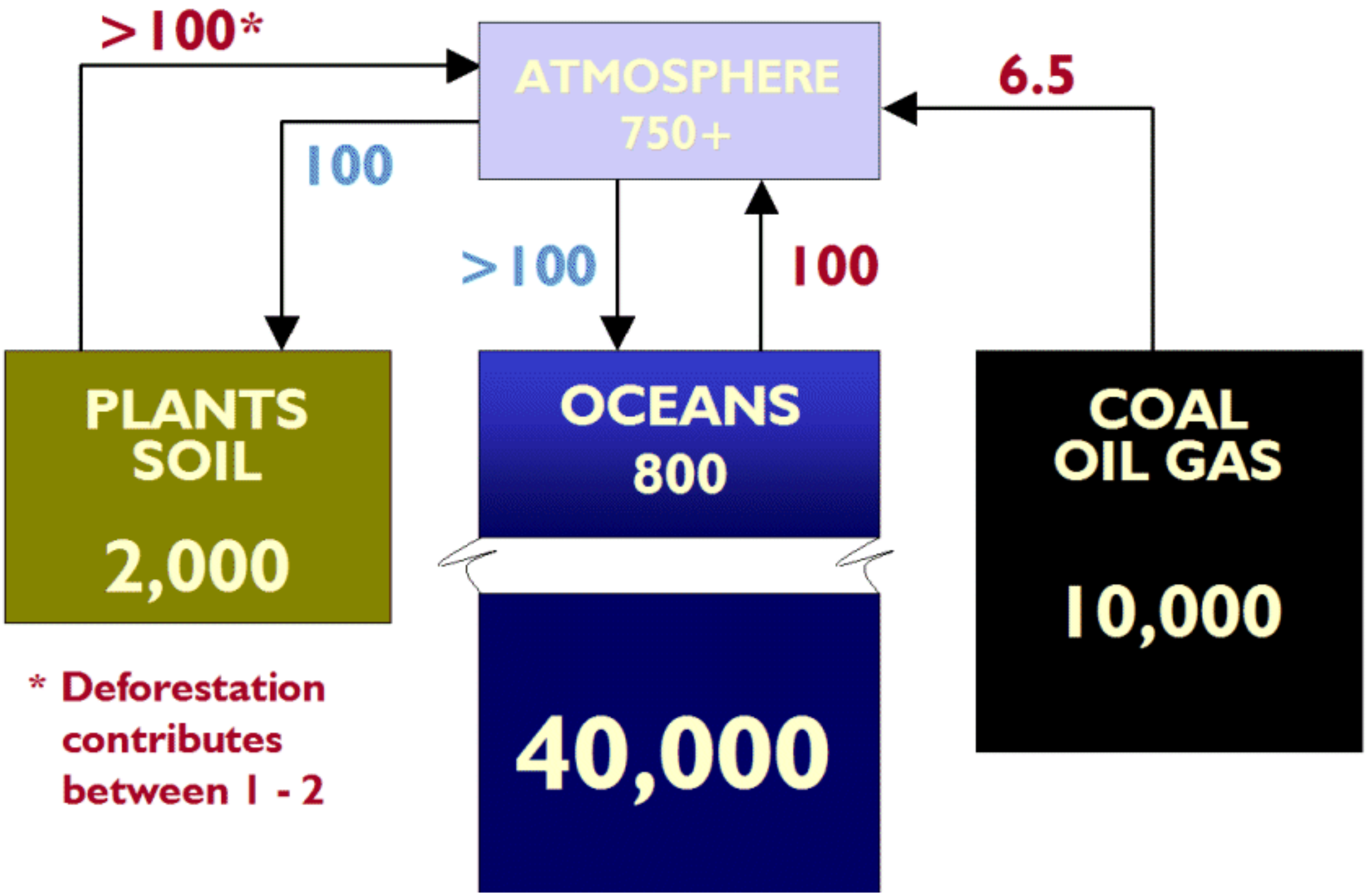
Natural Ecosystems and Opportunities

- Natural ecosystems are an essential part of the global response to climate change
- Natural ecosystems can contribute to the two main responses to climate change through:
    - **Mitigation**
    - **Adaptation**



Carbon storage in and fluxes between different systems



Source: Woods Hole Institute (http://www.whrc.org/carbon/index.htm) Petagrams Carbon/Year

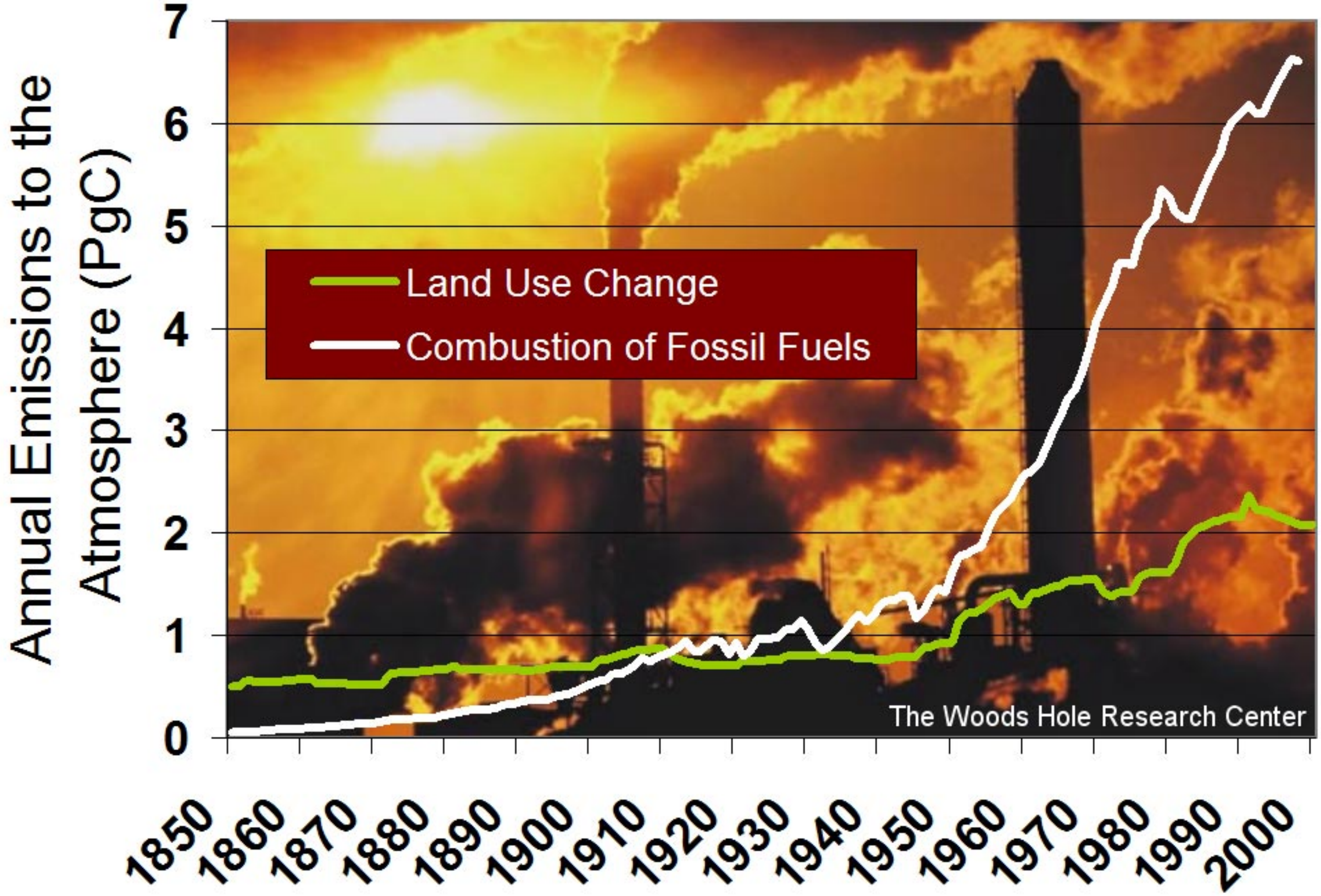


Figure 2.2: Contribution of land use change in the annual carbon emission (Source: The Woods Hole Institute)

Mitigation

- Sequestration by increasing the size of carbon pools (e.g. through afforestation, reforestation and restoration of natural habitats)
- Maintaining existing carbon stores (for example, avoided deforestation or protecting wetlands)
- Maintenance of the ocean carbon sink;
- Substitution of fossil fuel energy by cleaner technologies including biomass.

Wetland Trends and Threats in New Jersey

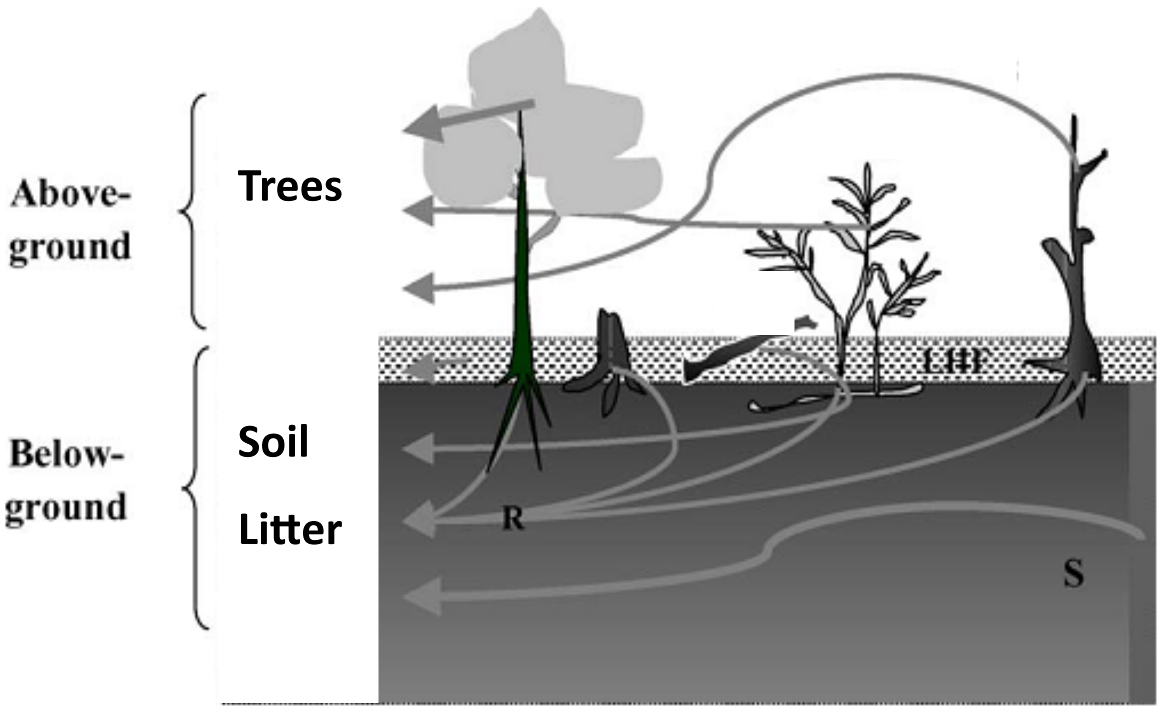
- Spatial analysis (1986-1995)
- Deciduous forested wetlands most threatened
- Net loss of deciduous forested wetlands 8400 acres

- Land use Change (Residential)
- Nutrient Enrichment (Degradation)

Wetland Conservation Policy Issues

- Mitigation Banking
  - Restoration
  - Creation
  - Enhancement
  - Preservation
- Shortcomings
  - Based on acreage system
  - Monitoring period

Carbon Storage in Forested Wetlands

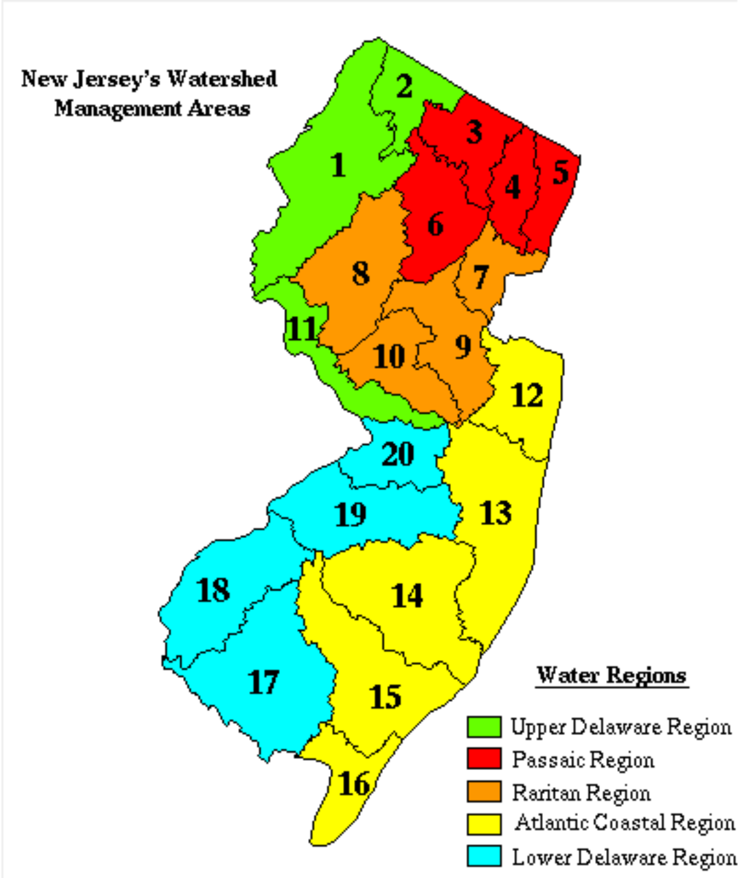


Total Carbon Storage	~ 150tC/acre

Adams, 2004

Carbon Credits in Mitigation Banking

WMA	Acres	Carbon(tons)	Value($)
2	133378	20006681	72024050
17	34108	5116182	18418255
1	26736	4010453	14437629
6	26222	3933354	14160074
9	24295	3644303	13119489
10	23682	3552260	12788134
19	21167	3175101	11430364
15	21053	3157965	11368674
12	18676	2801403	10085051
8	18341	2751114	9904010
20	17466	2619882	9431575
14	16931	2539716	9142978
18	16789	2518364	9066109
11	15421	2313185	8327464
13	15414	2312097	8323549
3	10611	1591613	5729805
4	3151	472580	1701286
16	2976	446414	1607089
5	2657	398480	1434526
7	2562	384251	1383302
Sum	**451,636**	**67,745,393**	**$243,883,413**



- **New Banks**
- **Boost Credits in existing banks**
- **Represents ecosystem services and may require a longer monitoring period**

Reducing Emissions from Deforestation and Degradation

REDD

- Management and protection of intact forested areas.
- The most cost-effective ways to lower emissions.
- Links carbon to improved conservation and other co-benefits.

REDD Project Stages

Methodologies
BioCF RED Mosaic Deforestation Methodology
AD Partners REDD Methodology

Board
American Carbon Registry
Voluntary Carbon Standard

Project Design
Land Use and Land Use Change
Carbon Assessment
Field Verification

Project Validation and Registration

Community-Based Avoided Deforestation in Guinea-Bissau

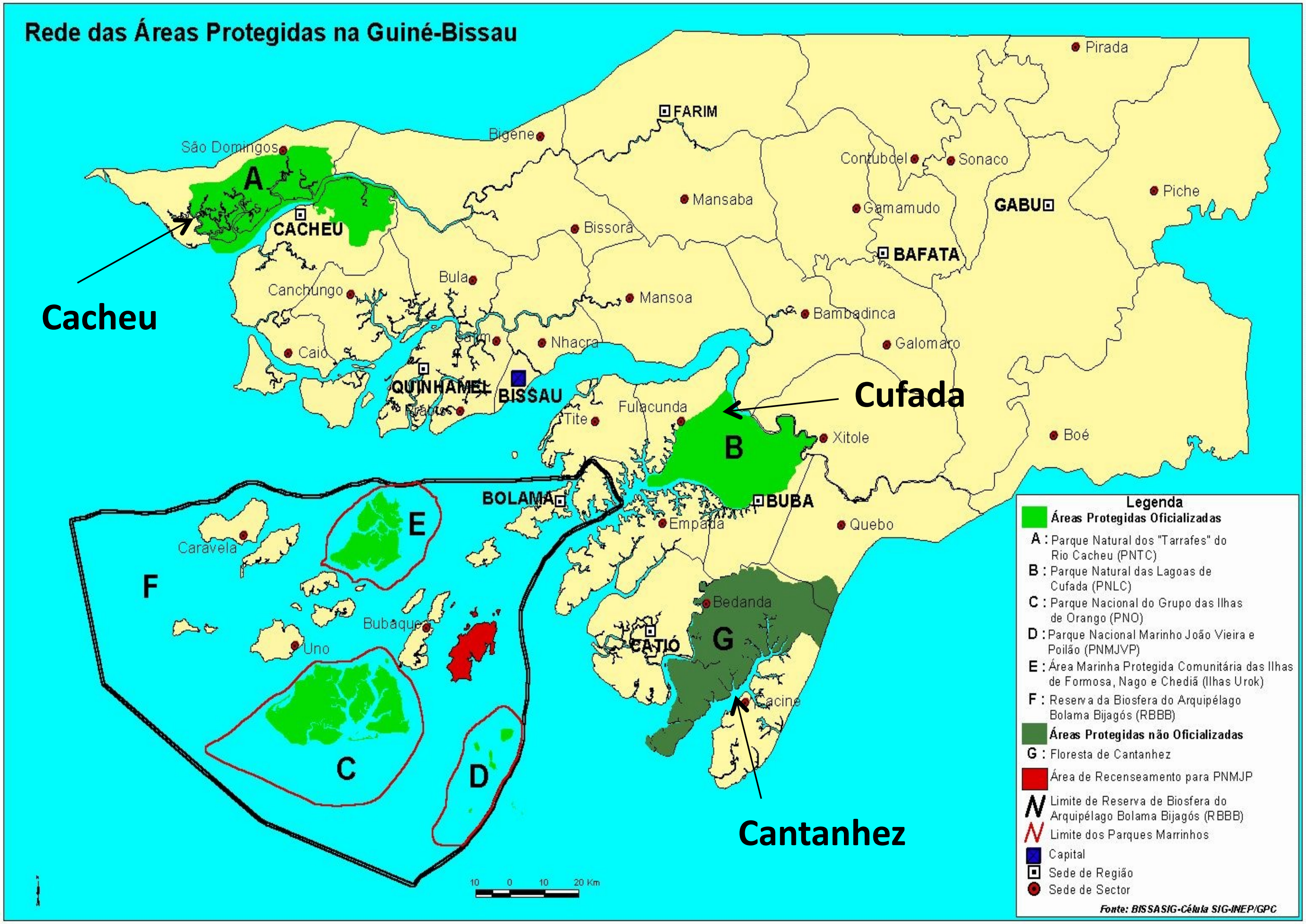
Harnessing the carbon market to sustain ecosystems and alleviate poverty

Background

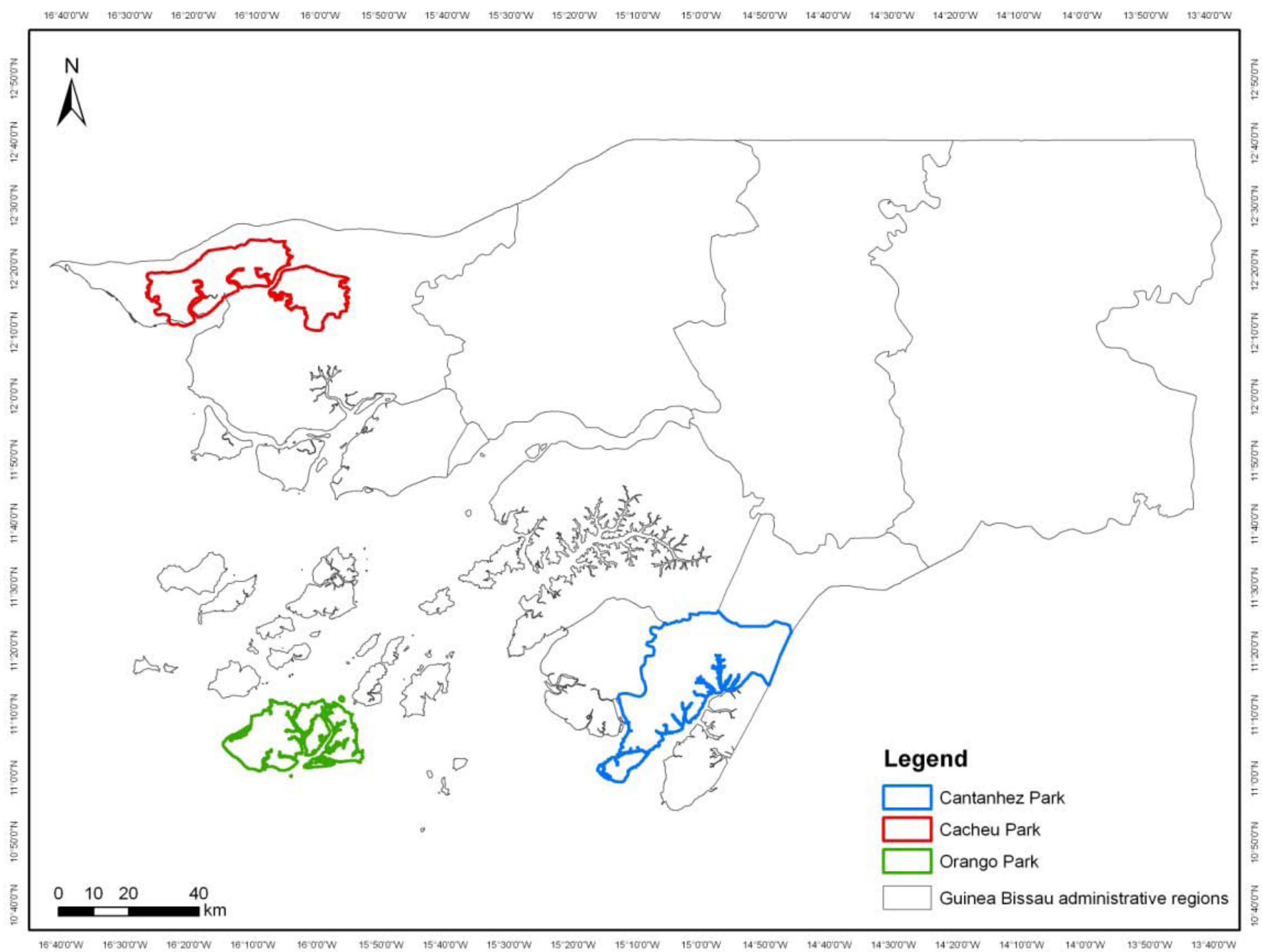
- GUINEA-BISSAU: One of the ten poorest countries in the world, with roughly 75 percent of the population living in rural areas directly dependent on the natural resources for their livelihoods;
- Resource rich country, specially in the coastal areas with important mangroves forests;
- Mangroves had been under great deforestation pressures caused by unsustainable land use practices (N.B subsistence agriculture, fuelwood collection, charcoal production) and forest exploitation for construction;

National Parks of Guinea Bissau

- Cacheu Mangrove Forest National Park
- Catanhez Forest National Park
- Cufada Lakes National Park
- Joao Vieira and Poilao National Marine Park
- Orango National Marine Park


Rede das Áreas Protegidas na Guiné-Bissau
Pirada
FARIM
Bigene
São Domingos
Contubel
Sonaco
Piche
A
Mansaba
Gamamudo
GABU
CACHEU
Bissorã
BAFATA
Cacheu
Bula
Canchungo
Mansoa
Bambadinca
Nhacra
Galomaro
Caió
QUINHAMEL
BISSAU
Cufada
Fulacunda
Tite
Xitole
Boé
B
BOLAMA
BUBA
Empada
Quebo
Caravela
E
F
Bedanda
Bubaque
CATIÓ
G
Uno
Cacine
C
D
Cantanhez
10 0 10 20 Km
Legenda
Áreas Protegidas Oficializadas
A : Parque Natural dos "Tarrafes" do Rio Cacheu (PNTC)
B : Parque Natural das Lagoas de Cufada (PNLC)
C : Parque Nacional do Grupo das Ilhas de Orango (PNO)
D : Parque Nacional Marinho João Vieira e Poilão (PNMJVP)
E : Área Marinha Protegida Comunitária das Ilhas de Formosa, Nago e Chediã (Ilhas Urok)
F : Reserva da Biosfera do Arquipélago Bolama Bijagós (RBBB)
Áreas Protegidas não Oficializadas
G : Floresta de Cantanhez
Área de Recenseamento para PNMJP
Limite de Reserva de Biosfera do Arquipélago Bolama Bijagós (RBBB)
Limite dos Parques Marrinhos
Capital
Sede de Região
Sede de Sector
Fonte: BISSASIG-Célula SIG-INEP/GPC

REDD Sites


N
Legend
Cantanhez Park
Cacheu Park
Orango Park
Guinea Bissau administrative regions
0 10 20 40
km

The REDD Project

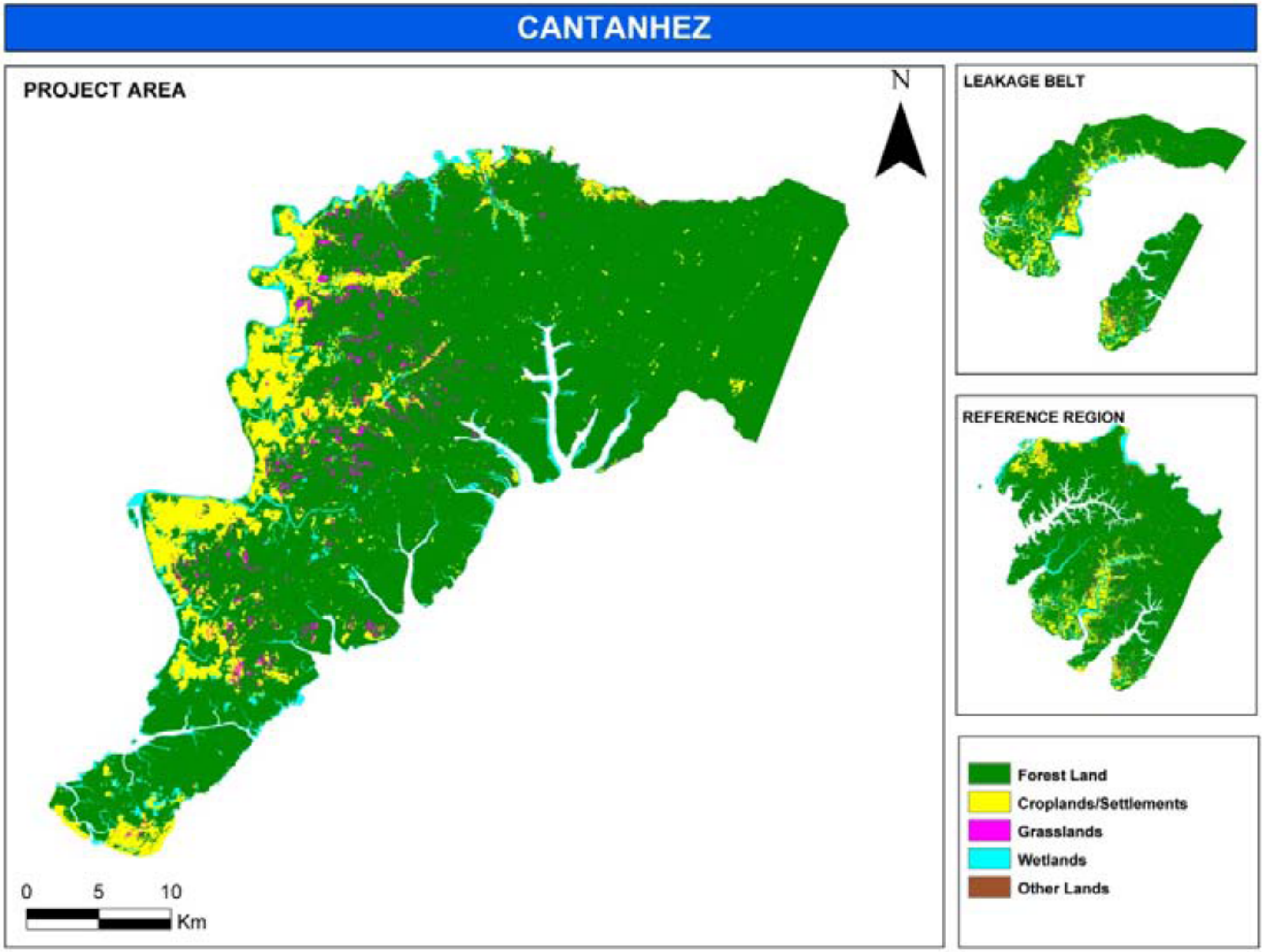
- REDD Project area includes 3 parks: Cacheu Mangrove Forest National Park, Catanhez Forest National Park, Orango National Park (totaling 113,000 ha);
- Baseline Deforestation Rate
- Test for Additionality
- Possibility for Leakage
- Carbon Assessment

Different Carbon Pools

Eligible carbon pools under the VCS include:

- Aboveground live tree biomass
- Belowground live tree biomass
- Non-tree live biomass
- Dead wood
- Forest floor/litter

Forest Types in Guinea Bissau



IPCC LU/LC 2010 map for Cantanhez reference region, leakage belt and project area.

Emissions Prevented: Approximate Calculations

Forest Type or Country	tC/ha	Source
Mangrove Forest	64	Twilley et al.(1992)
Palm Grove Forest	91	Ardiansyah, F. (2007)
Dry Forest	90	Gibbs et al. (2007)
Guinea-Bissau	161	Archard et al. (2002, 2004)

Area	$tCO_2e.y^{-1}$	**Estimated Carbon Revenues (USD)**			
Cacheu	208,536.48	Cacheu	$729,877.70	VER Price	**$3.50**
Orango	10,463.73	Orango	$36,623.07		
Catanhez	79,126.08	Catanhez	$276,941.28		
TOTAL	**298,126.30**	TOTAL	**$1,043,442.05**		

Connections

- Determination and inclusion of important carbon pools
- Soil carbon not included
- Underestimation of carbon credits
- Carbon dynamics in estuaries is not well known
- More information regarding soil processes would strengthen the methodologies
- Expansion of carbon market

Conclusions

- Biogeochemistry helps quantify effects of stressors on provision of ecosystem services.
- Natural ecosystems can play major role in climate change mitigation.
- Climate change policies and financial schemes provide mechanisms for effective ecosystem conservation.
- Conservation mechanisms can be improved and expanded through biogeochemistry

Acknowledgements

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