RESEARCH PROGRAM ON
Forests, Trees and Agroforestry

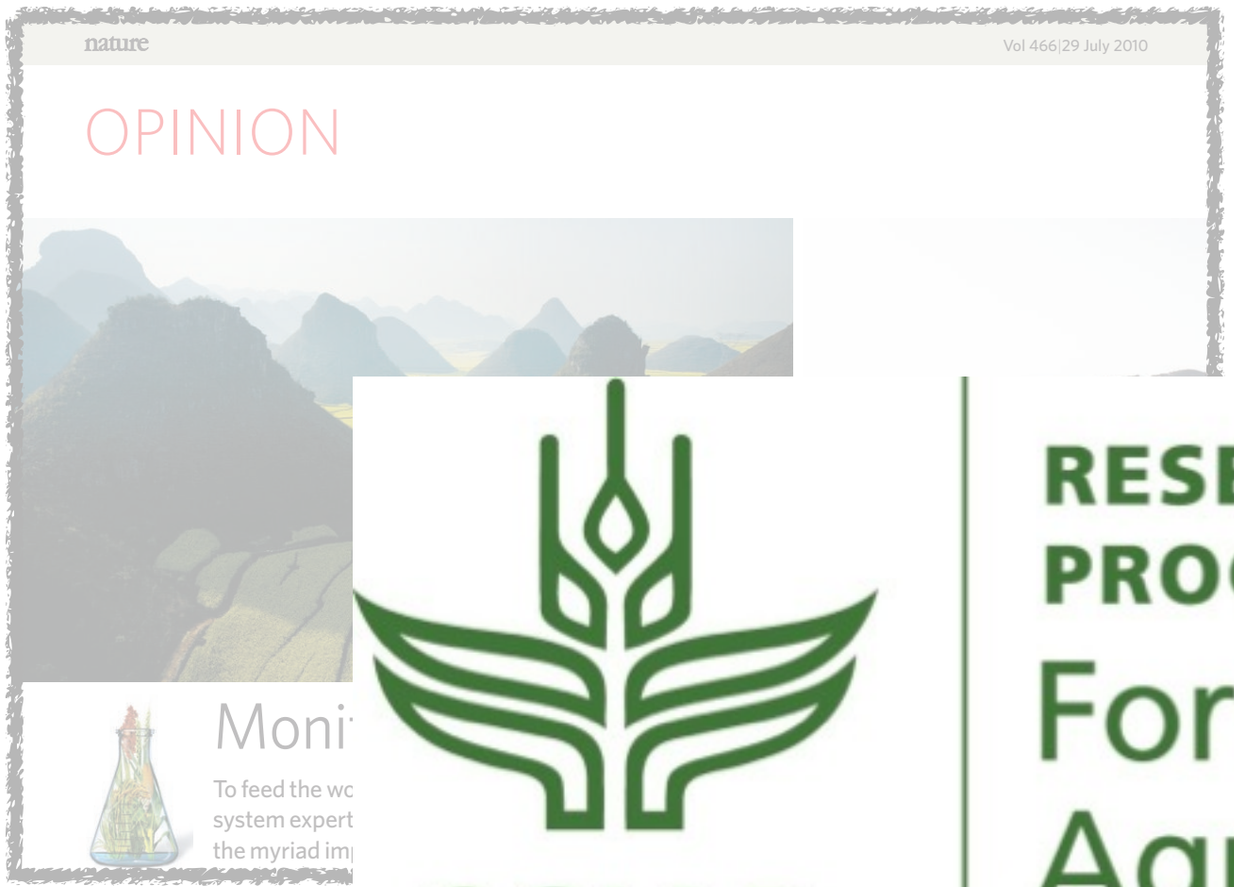
CGIAR

Using Systematic Field Surveys to Assess the Effects of Land Use on Soil Health Across Diverse Landscapes

Leigh Winowiecki*, Tor-Gunnar Vågen**
*International Center for Tropical Agriculture (CIAT)
**World Agroforestry Centre (ICRAF)
Sentinel Landscape Workshop, CATIE
3 March 2014

Land Degradation, Ecosystem Services, Land Health,
Soil Health, and Agricultural Production are inextricably linked

Systematic assessments for cross-site analysis



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Objectives

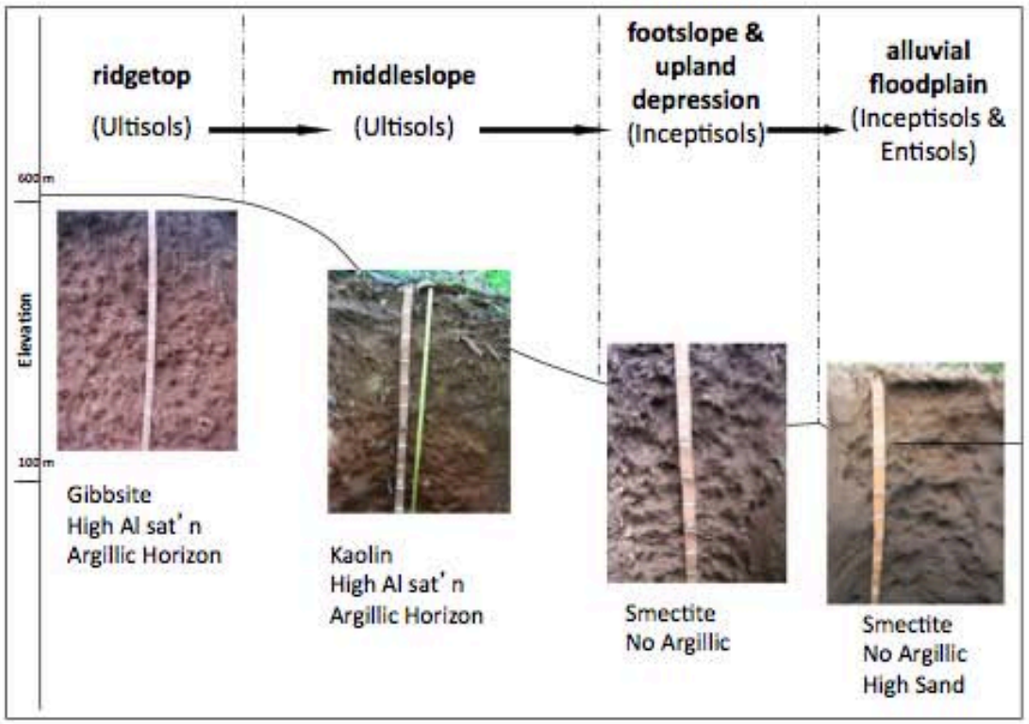
- To illustrate the use of a systematic sampling framework to multi-level modeling for cross-site/ cross-country analysis
- To assess the linkages between inherent soil properties, land cover typologies and soil health
- To explore the LDSF data from five SL

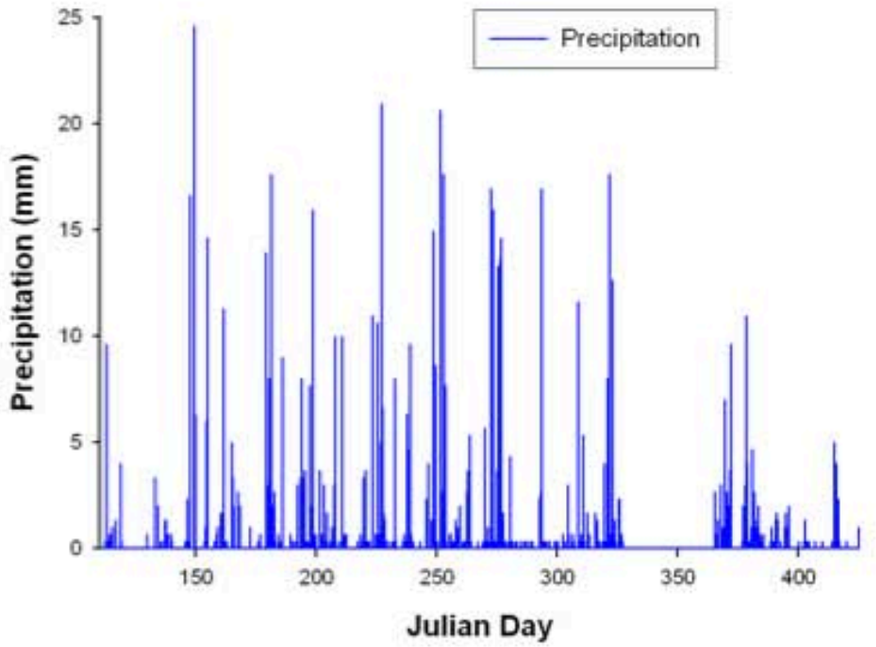
Importance of Soil

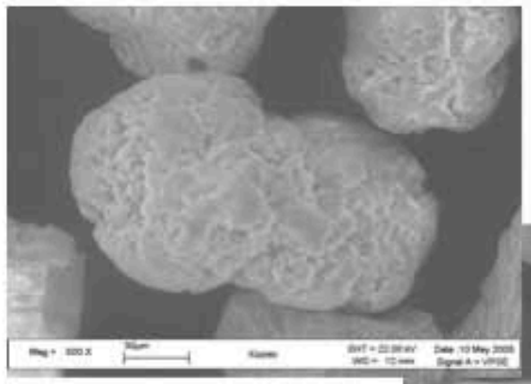
- Soil provides multiple ecosystem services:
  - medium for plant and ag production;
  - filter for toxins;
  - regulating hydrologic cycle (Millennium EcoSystem Assessment, 2005)
- Plant-soil relationships that determine the distribution of aboveground vegetation

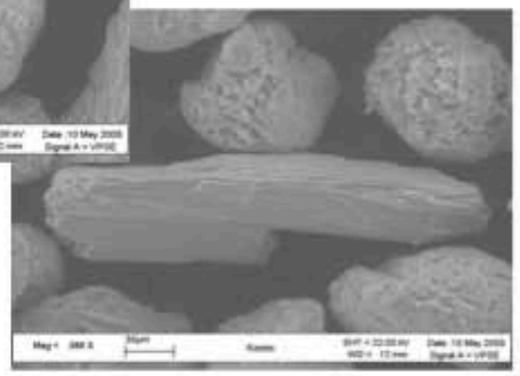
Factors of Soil Formation

Climate, organisms, relief, parent material, time....









Influence of Soil Forming Factors on Inherent Soil Properties

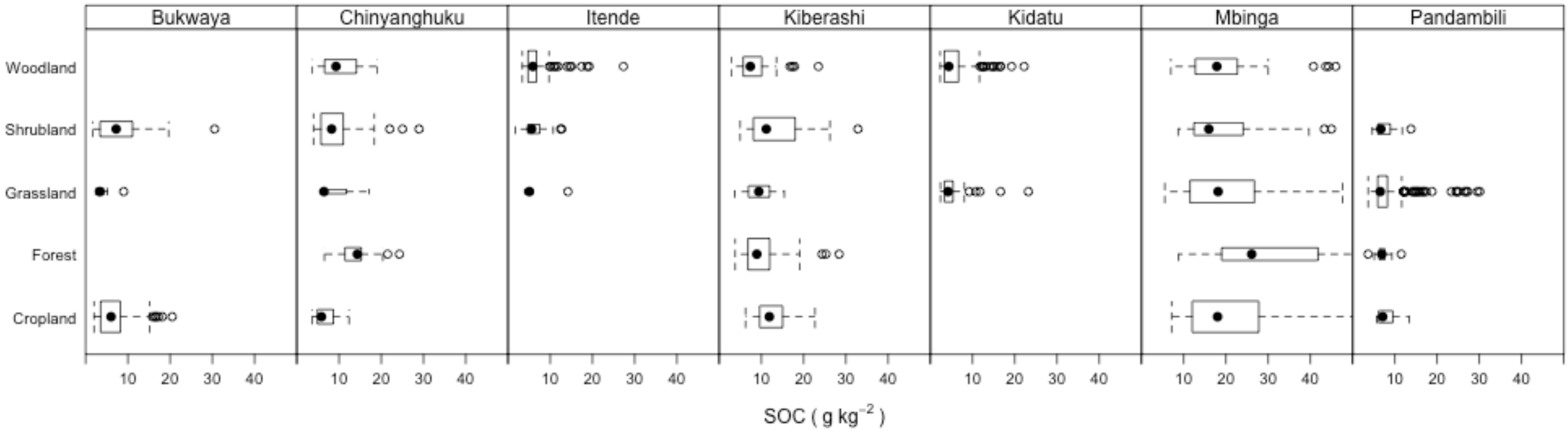
- **Parent material - >** soil texture (% clay), total elemental composition
- **Climate - >** degree of weathering and available nutrients

Forming inherent constraint envelopes for the soil (e.g., capacity to store and exchange cations (nutrients)

Influence of Organisms (Land Cover/Land Use) on Dynamic Soil Properties

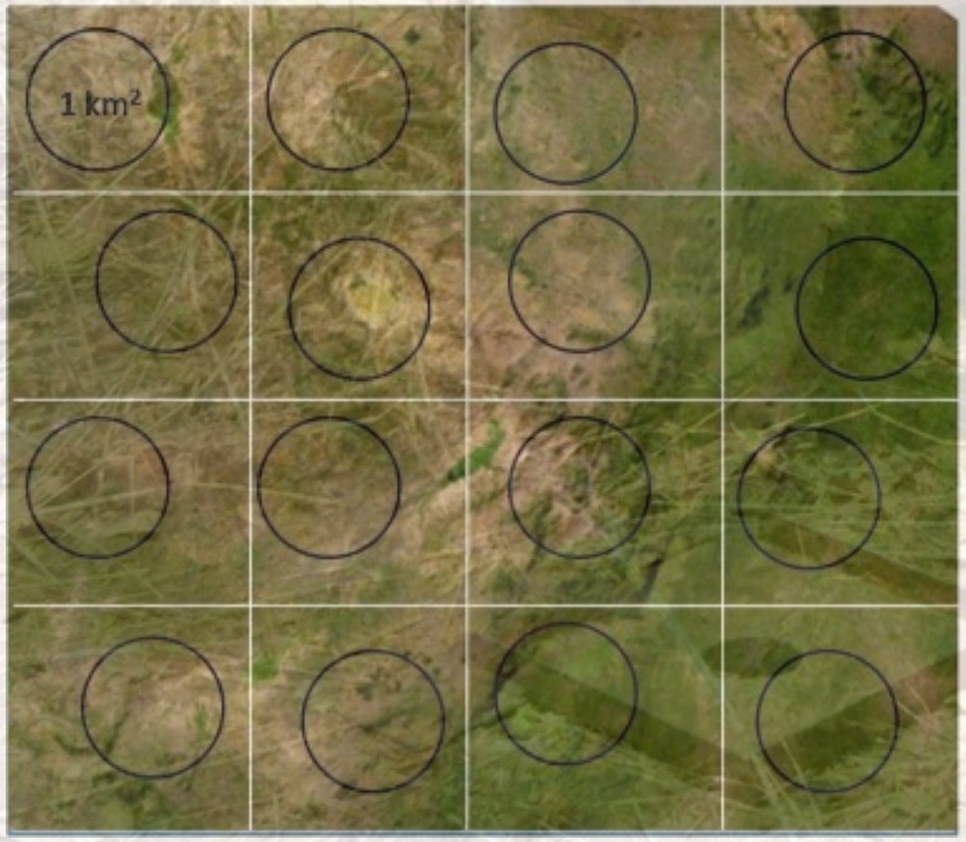
Land use can influence soil health but inherent soil properties determine the magnitude of these effects.

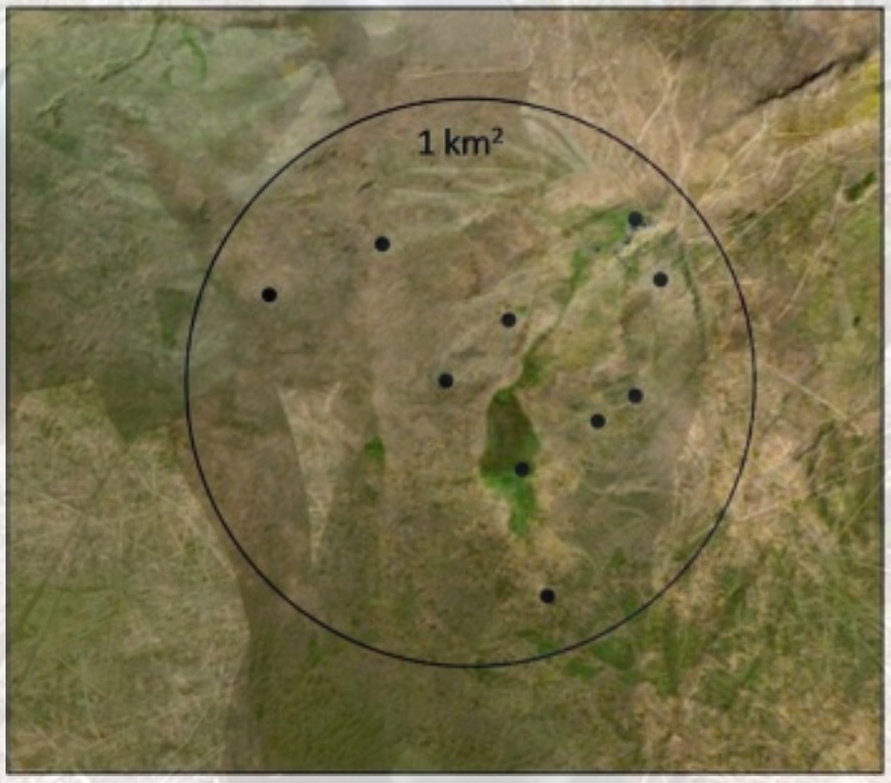
Hence it is important to understand the complexity of the soil system.

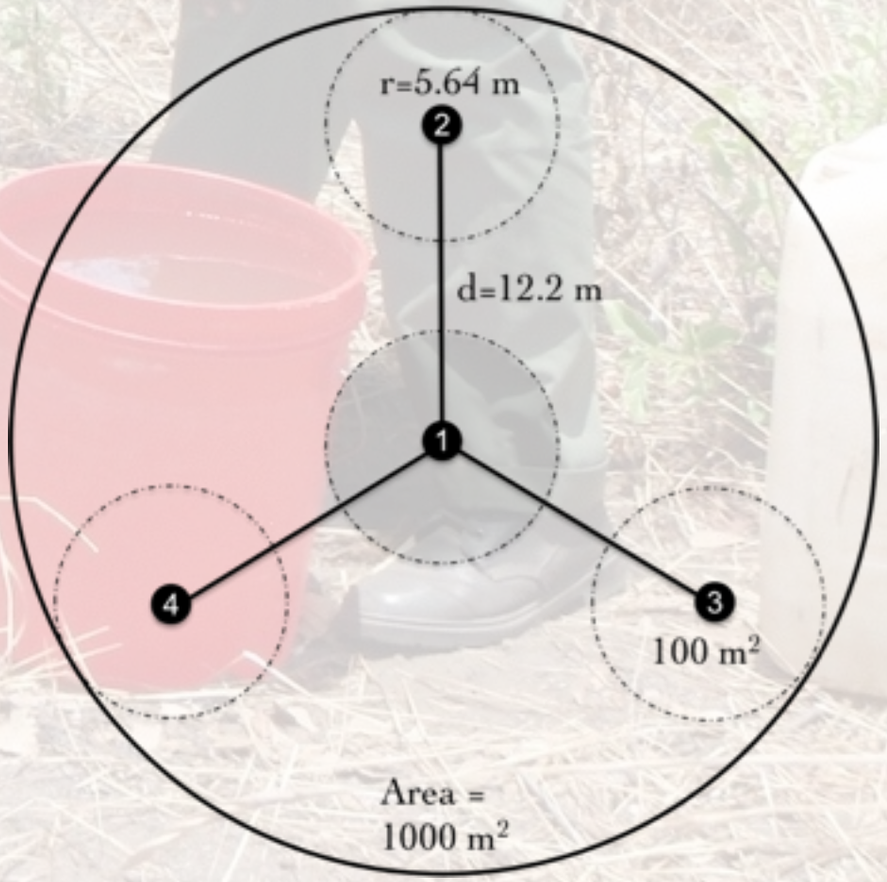


Land Degradation Surveillance Framework (LDSF)

10 km







Plot observations

- Land cover and land-use history
- Topographic position
- Primary use
- Woody leaf types
- Landform
- Slope
- Vegetation structure
- Impact on habitat

PLOT (1,000 m²) **LDSF Field Form v4 2013**

Site: **Date (ddmmyy):** **Latitude (DD):**
Cluster: **Photo ID:** **Longitude (DD):** **Country:**
Plot: **Elevation (m):** **Pos error (m):** **Name:**

Slope Up °: ____ **Slope Down °:** ____

Major landform: ☐ Level ☐ Sloping ☐ Steep ☐ Composite

Position on topographic sequence:
☐ Upland ☐ Ridge/Crest ☐ Midslope ☐ Footslope ☐ Bottomland

Landform designation:

☐ Medium gradient mountain	☐ Dissected plain	☐ Major depression
☐ Medium gradient hill	☐ High gradient mountain	☐ Narrow plateau
☐ Medium gradient escarpment	☐ High gradient hill	☐ Plain
☐ Ridges	☐ High gradient escarpment	☐ Low gradient mountain
☐ Mountainous highland	☐ Valley	☐ Low gradient hill

Plot bare?	☐ Yes	☐ No
Plot regularly flooded?	☐ Yes	☐ No
Plot cultivated?	☐ Yes	☐ No

Vegetation types:

Trees	☐ Yes	☐ No
Shrubs	☐ Yes	☐ No
Graminolds	☐ Yes	☐ No
Forbs	☐ Yes	☐ No
Other	☐ Yes	☐ No

Woody leaf types:

Broadleaf	☐ Yes	☐ No
Needle leaf	☐ Yes	☐ No
Allophytic	☐ Yes	☐ No
Evergreen	☐ Yes	☐ No
Deciduous	☐ Yes	☐ No

Vegetation structure*:

Other description:

**** Forest, Woodland, Bushland, Thicket, Shrubland, Grassland, Wooded grassland, Cropland, Mangrove, Freshwater aquatic, Halophytic, Other***

Herb height (m): ☐ 0.8-3.0 (m) ☐ 0.3-3.0 (m) ☐ 0.3-0.8 (m) ☐ 0.03-0.3 (m) **Herbaceous anual:** ☐ Yes ☐ No

Same landuse since 1990: ☐ Yes ☐ No **Land ownership:** ☐ Private ☐ Communal ☐ Government ☐ Don't Know

Primary current use:

Food/Beverage	☐ Yes	☐ No
Timber/fuelwood	☐ Yes	☐ No
Forage:	☐ Yes	☐ No
Other:	☐ Yes	☐ No

Soil and water conservation:
Number:____
☐ None
☐ Vegetative
☐ Structural
Other:

Impact on habitat:

0	1	2	3	
☐	☐	☐	☐	Impact of tree cutting
☐	☐	☐	☐	Impact of agriculture
☐	☐	☐	☐	Impact of grazing/browsing
☐	☐	☐	☐	Impact of fire
☐	☐	☐	☐	Impact of urban activities
☐	☐	☐	☐	Impact of industry
☐	☐	☐	☐	Impact of erosion
☐	☐	☐	☐	Impat of alien vegetation
☐	☐	☐	☐	Impact of firewood collection
☐	☐	☐	☐	Other:

Vegetation strata description:

Describe land cover/ use history:

SUB-PLOT (100 m²)		**1**		**2**		**3**		**4**	
Rock/stone, Gravel cover (%)		☐ <5 ☐ 5-40 ☐ >40		☐ <5 ☐ 5-40 ☐ >40		☐ <5 ☐ 5-40 ☐ >40		☐ <5 ☐ 5-40 ☐ >40	
Visible erosion		☐ None ☐ Sheet ☐ Rill ☐ Gully/Mass		☐ None ☐ Sheet ☐ Rill ☐ Gully/Mass		☐ None ☐ Sheet ☐ Rill ☐ Gully/Mass		☐ None ☐ Sheet ☐ Rill ☐ Gully/Mass	
Woody Cover rating (%)		☐ Absent ☐ 15-40 ☐ < 4 ☐ 40-65 ☐ 4-15 ☐ > 65		☐ Absent ☐ 15-40 ☐ < 4 ☐ 40-65 ☐ 4-15 ☐ > 65		☐ Absent ☐ 15-40 ☐ < 4 ☐ 40-65 ☐ 4-15 ☐ > 65		☐ Absent ☐ 15-40 ☐ < 4 ☐ 40-65 ☐ 4-15 ☐ > 65	
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Auger depth restriction (cm)		cm		cm		cm		cm	
Topsoil ribbon length (mm)	Texture:(*Gritty/ Smooth/ Neither	Length: mm	*Texture:	Length: mm	*Texture:	Length: mm	*Texture:	Length: mm	*Texture:
Subsoil ribbon length (mm)	Texture:(*Gritty/ Smooth/ Neither)	Length: mm	*Texture:	Length: mm	*Texture:	Length: mm	*Texture:	Length: mm	*Texture:
Notes:									

Subplot observations

- Tree and shrub densities
- Woody cover
- Herbaceous rating
- Erosion prevalence
- Root depth restrictions
- Composite soil samples (320 per site) (0-20 cm and 20-50 cm

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Plot: **Elevation (m):** **Pos error (m):** **Name:**

Slope Up °: ____ Slope Down °: ____

Major landform: ☐ Level ☐ Sloping ☐ Steep ☐ Composite

Position on topographic sequence:

☐ Midslope ☐ Footslope ☐ Bottomland

Page IX

☐ Dissected plain ☐ Major depression
☐ High gradient mountain ☐ Narrow plateau
☐ High gradient hill ☐ Plain
☐ High gradient escarpment ☐ Low gradient mountain
☐ Valley ☐ Low gradient hill

☐ No
☐ No
☐ No

Woody leaf types:

Broadleaf	☐ Yes	☐ No
Needle leaf	☐ Yes	☐ No
Allophytic	☐ Yes	☐ No
Evergreen	☐ Yes	☐ No
Deciduous	☐ Yes	☐ No
Forbs	☐ Yes	☐ No
Other	☐ Yes	☐ No

Vegetation structure*:

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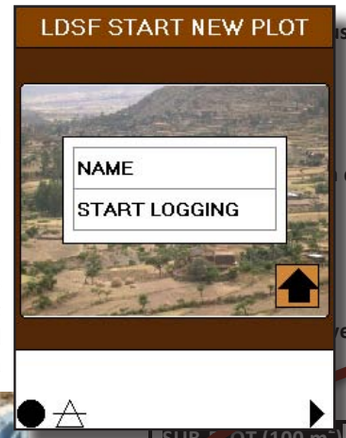
conservation:
☐ None
☐ Vegetative
☐ Structural

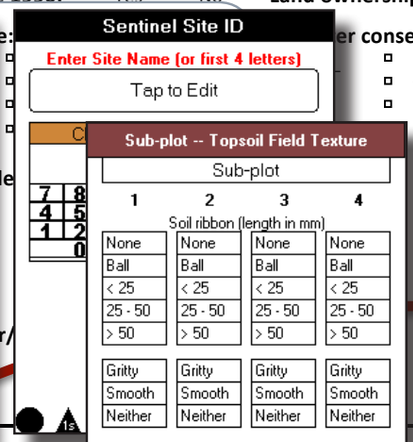
	0	1	2	3
Impact on habitat:				
Impact of tree cutting	☐	☐	☐	☐
Impact of agriculture	☐	☐	☐	☐
Impact of grazing/browsing	☐	☐	☐	☐
Impact of fire	☐	☐	☐	☐
Impact of urban activities	☐	☐	☐	☐
Impact of industry	☐	☐	☐	☐
Impact of erosion	☐	☐	☐	☐
Impat of alien vegetation	☐	☐	☐	☐
Impact of firewood collection	☐	☐	☐	☐
Other:	☐	☐	☐	☐

CyberTracker

The CyberTracker (http://www.cybertracker.org/) software is a free and efficient method for geo-field data collection and can be used on smartphones or handheld computers.

CyberTracker is primarily a data capture tool, but also has some basic GIS functionality. It was originally developed to record wildlife movement in the Central African rain forest. We developed a CyberTracker application for LSDF field data entry.





		1	2	3	4
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Visible erosion		☐ None ☐ Sheet ☐ Rill ☐ Gully/Mass	☐ None ☐ Sheet ☐ Rill ☐ Gully/Mass	☐ None ☐ Sheet ☐ Rill ☐ Gully/Mass	☐ None ☐ Sheet ☐ Rill ☐ Gully/Mass
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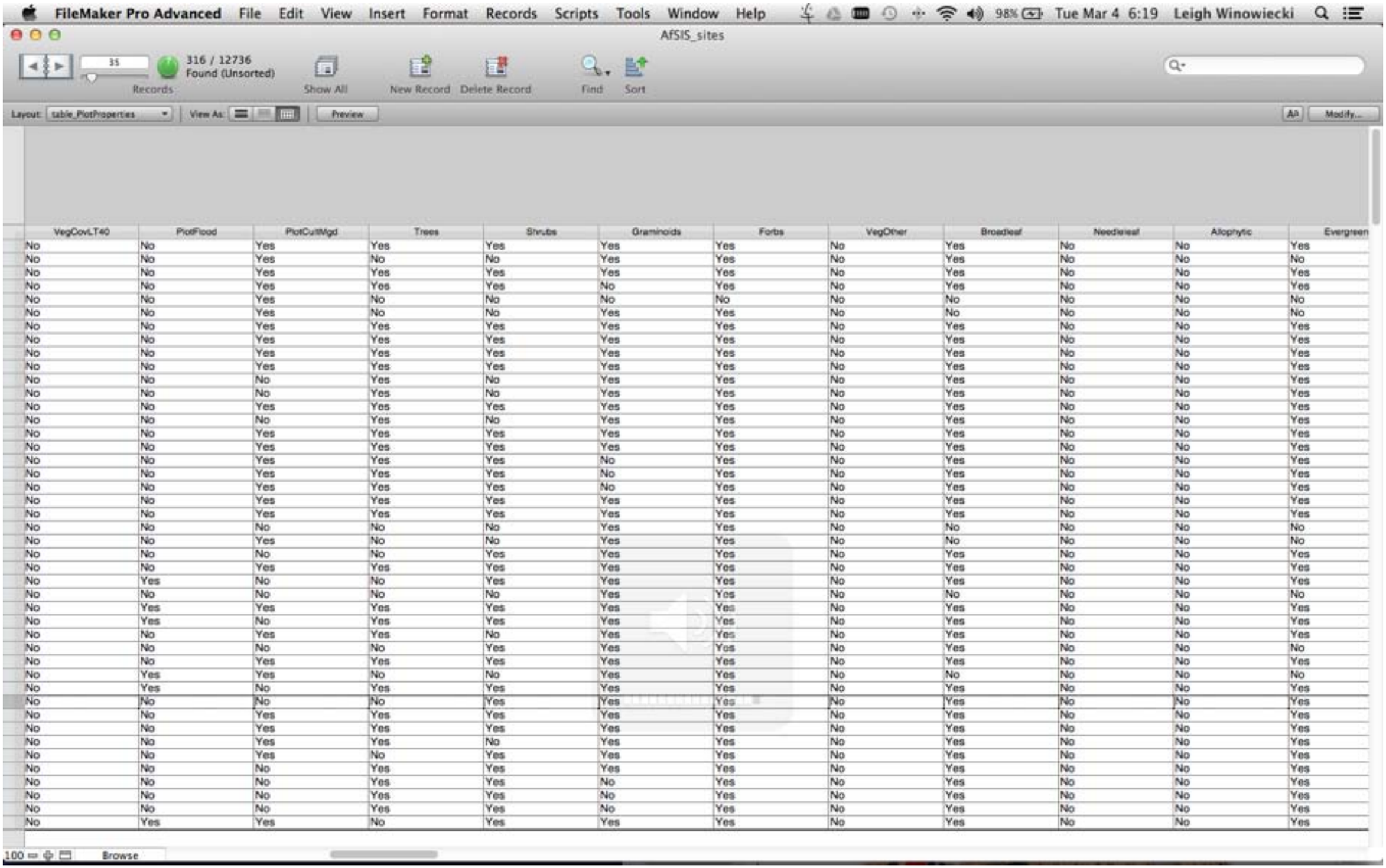
Notes:					

LDSF Database-FileMaker mirrored in MSQL



VegCovLT40	PlotFlood	PlotCultMgd	Trees	Shrubs	Graminoids	Forbs	VegOther	Broadleaf	Needleleaf	Allophytic	Evergreen
No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
No	No	Yes	No	No	Yes	Yes	No	Yes	No	No	No
No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
No	No	Yes	Yes	Yes	No	Yes	No	Yes	No	No	Yes
No	No	Yes	No	No	No	No	No	No	No	No	No
No	No	Yes	No	No	Yes	Yes	No	No	No	No	No
No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
No	No	No	Yes	No	Yes	Yes	No	Yes	No	No	Yes
No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
No	No	Yes	Yes	Yes	No	Yes	No	Yes	No	No	Yes
No	No	Yes	Yes	Yes	No	Yes	No	Yes	No	No	Yes
No	No	Yes	Yes	Yes	No	Yes	No	Yes	No	No	Yes
No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
No	No	No	No	No	Yes	Yes	No	No	No	No	No
No	No	Yes	No	No	Yes	Yes	No	No	No	No	No
No	No	No	No	Yes	Yes	Yes	No	Yes	No	No	Yes
No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
No	Yes	No	No	Yes	Yes	Yes	No	Yes	No	No	Yes
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No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
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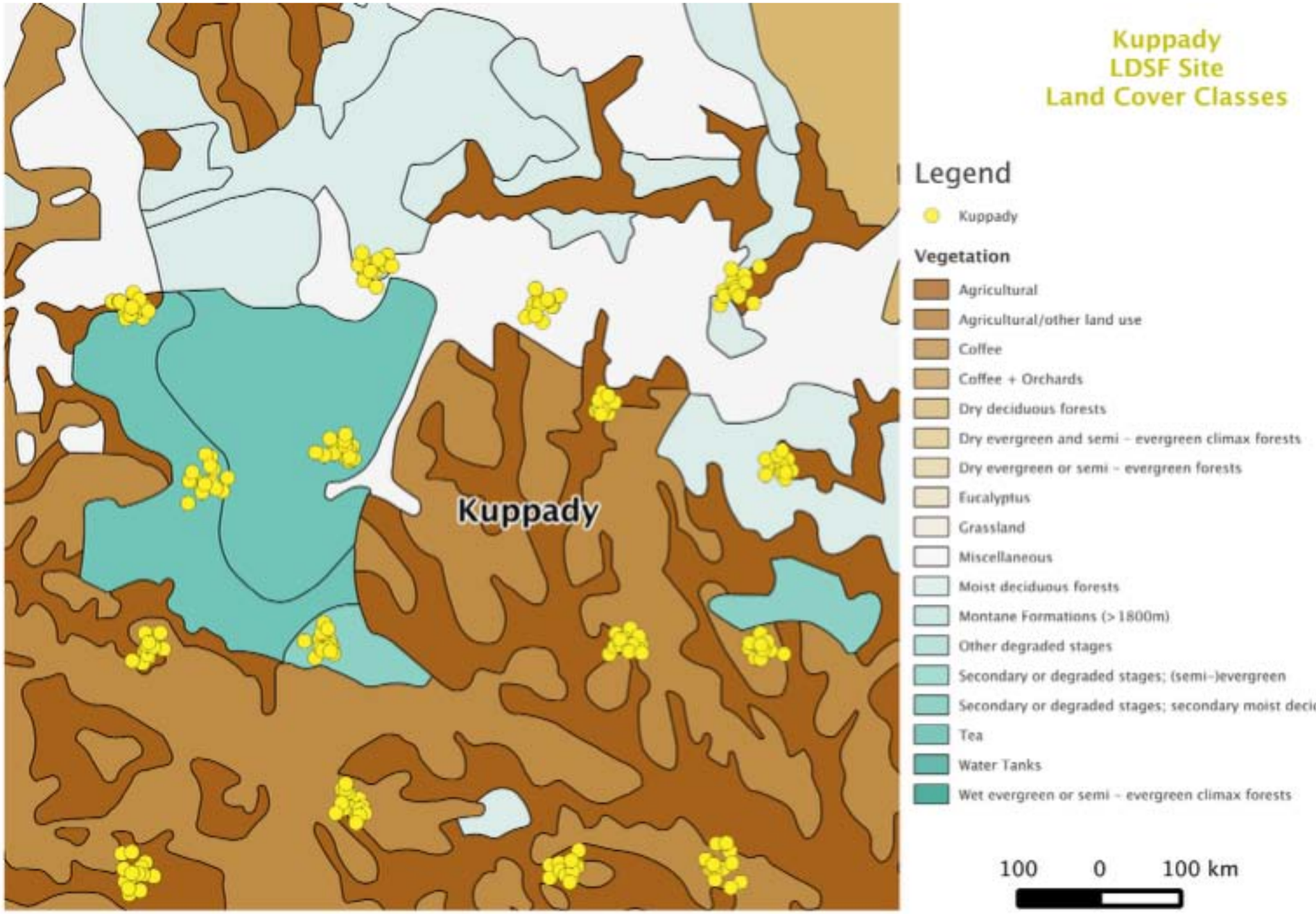
No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
No	No	Yes	Yes	No	Yes	Yes	No	Yes	No	No	Yes
No	No	Yes	No	Yes	Yes	Yes	No	Yes	No	No	Yes
No	No	No	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
No	No	No	Yes	Yes	No	Yes	No	Yes	No	No	Yes
No	No	No	Yes	Yes	No	Yes	No	Yes	No	No	Yes
No	No	No	Yes	Yes	No	Yes	No	Yes	No	No	Yes
No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	No	Yes

Sampling a Landscape-WGSL



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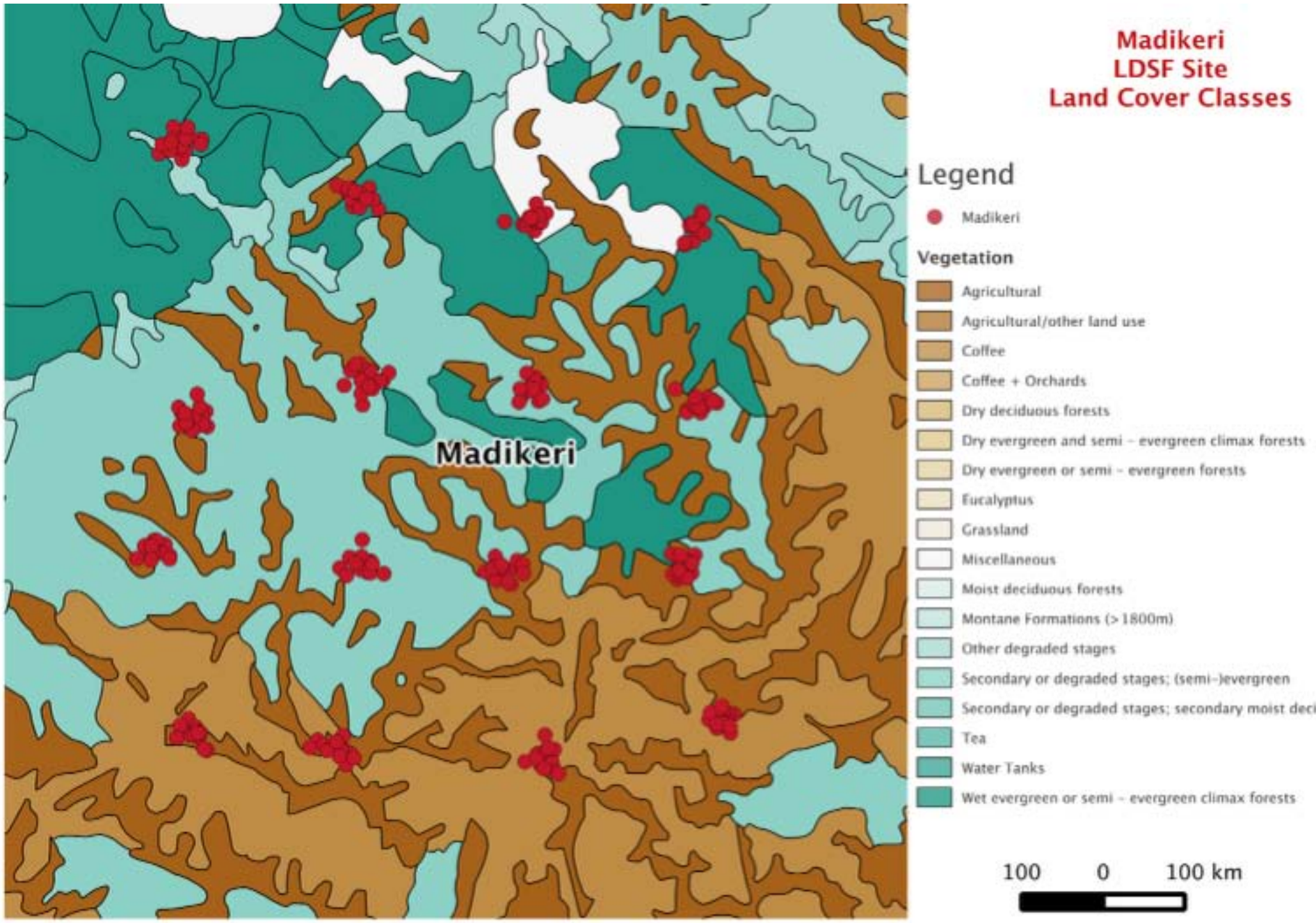

Madikeri
LDSF Site
Land Cover Classes

Legend

- Madikeri

Vegetation

- Agricultural
- Agricultural/other land use
- Coffee
- Coffee + Orchards
- Dry deciduous forests
- Dry evergreen and semi – evergreen climax forests
- Dry evergreen or semi – evergreen forests
- Eucalyptus
- Grassland
- Miscellaneous
- Moist deciduous forests
- Montane Formations (> 1800m)
- Other degraded stages
- Secondary or degraded stages; (semi-)evergreen
- Secondary or degraded stages; secondary moist decid. forests
- Tea
- Water Tanks
- Wet evergreen or semi – evergreen climax forests

100 0 100 km

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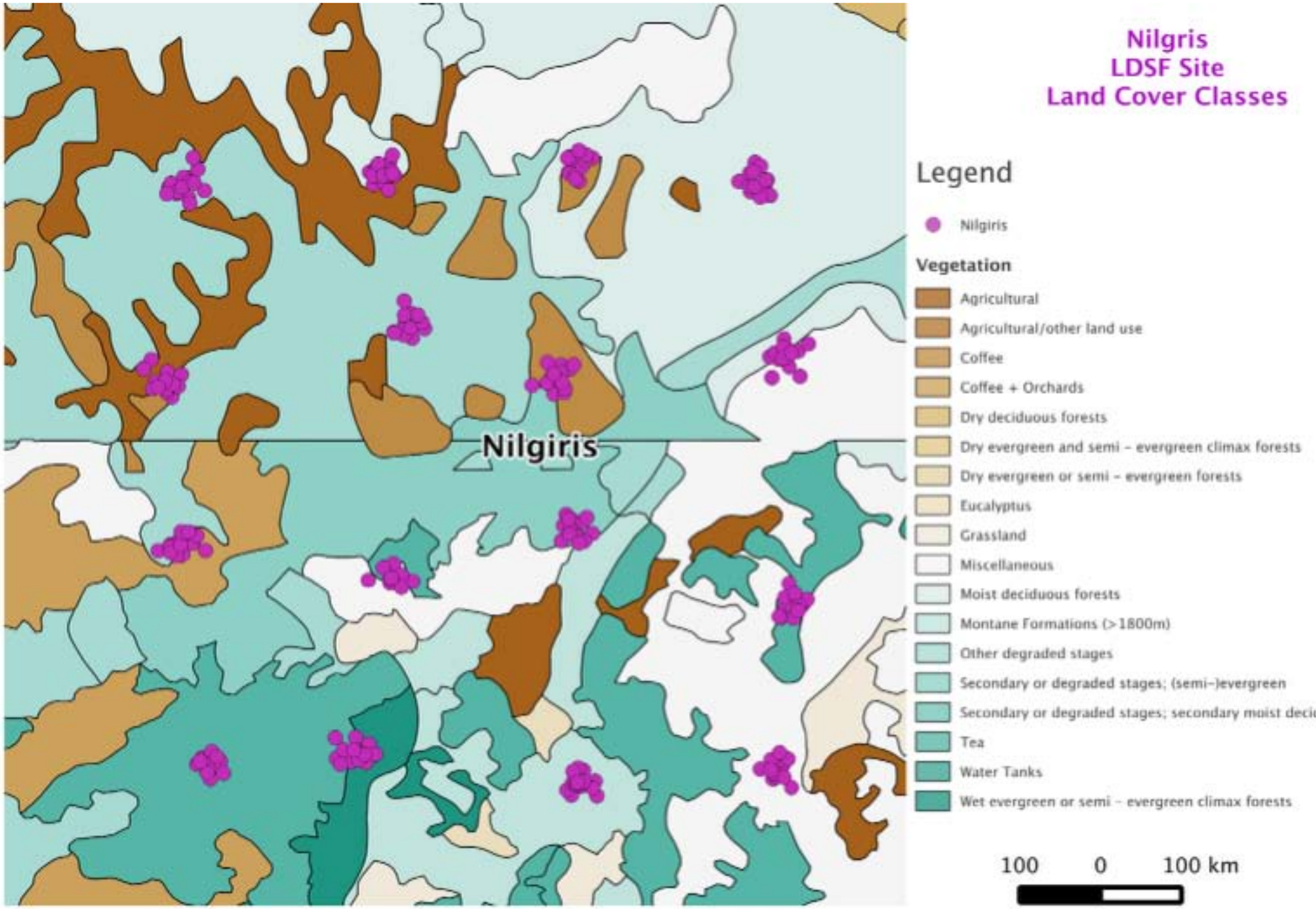
Sampling a Landscape-WGSL



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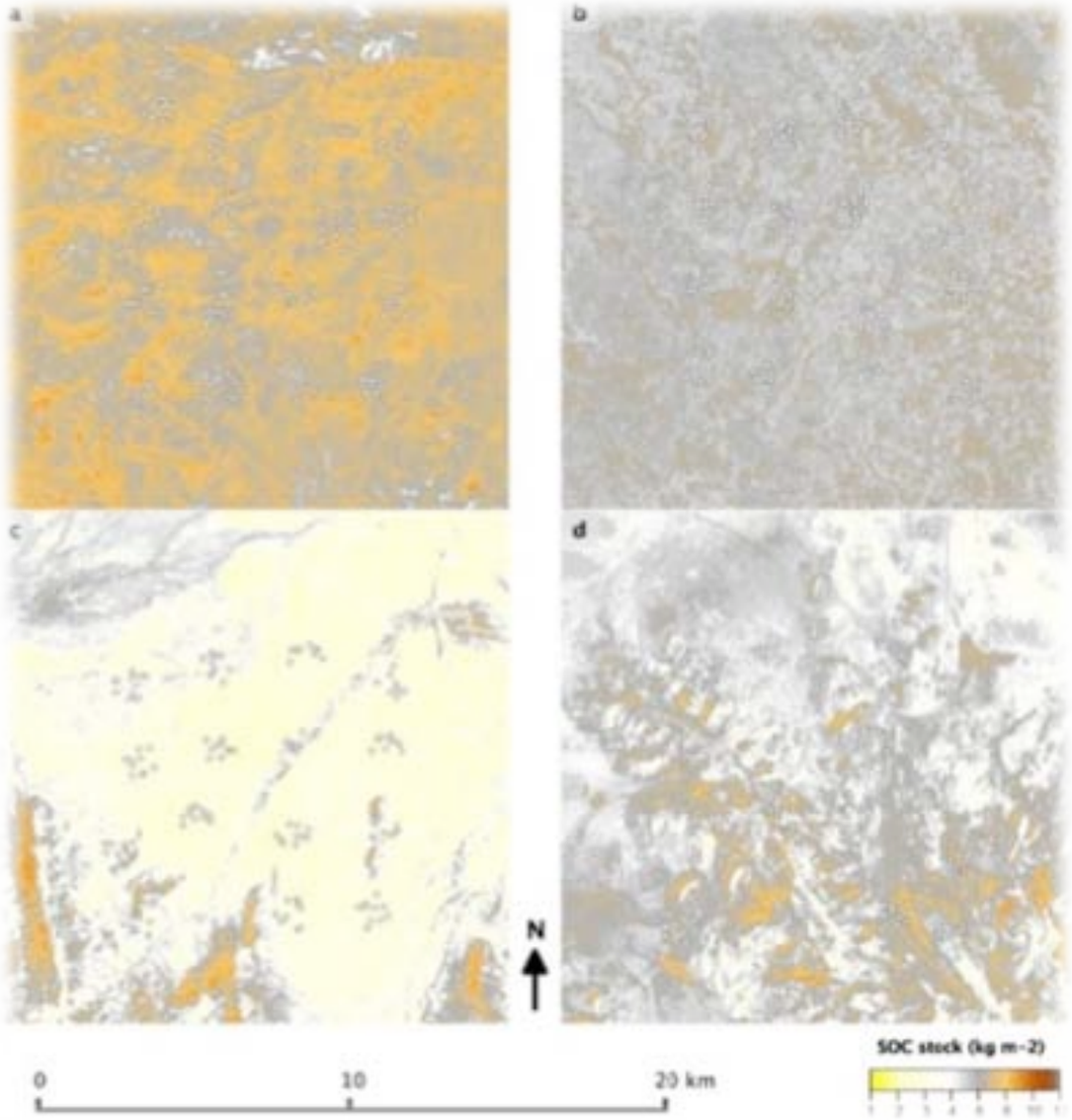
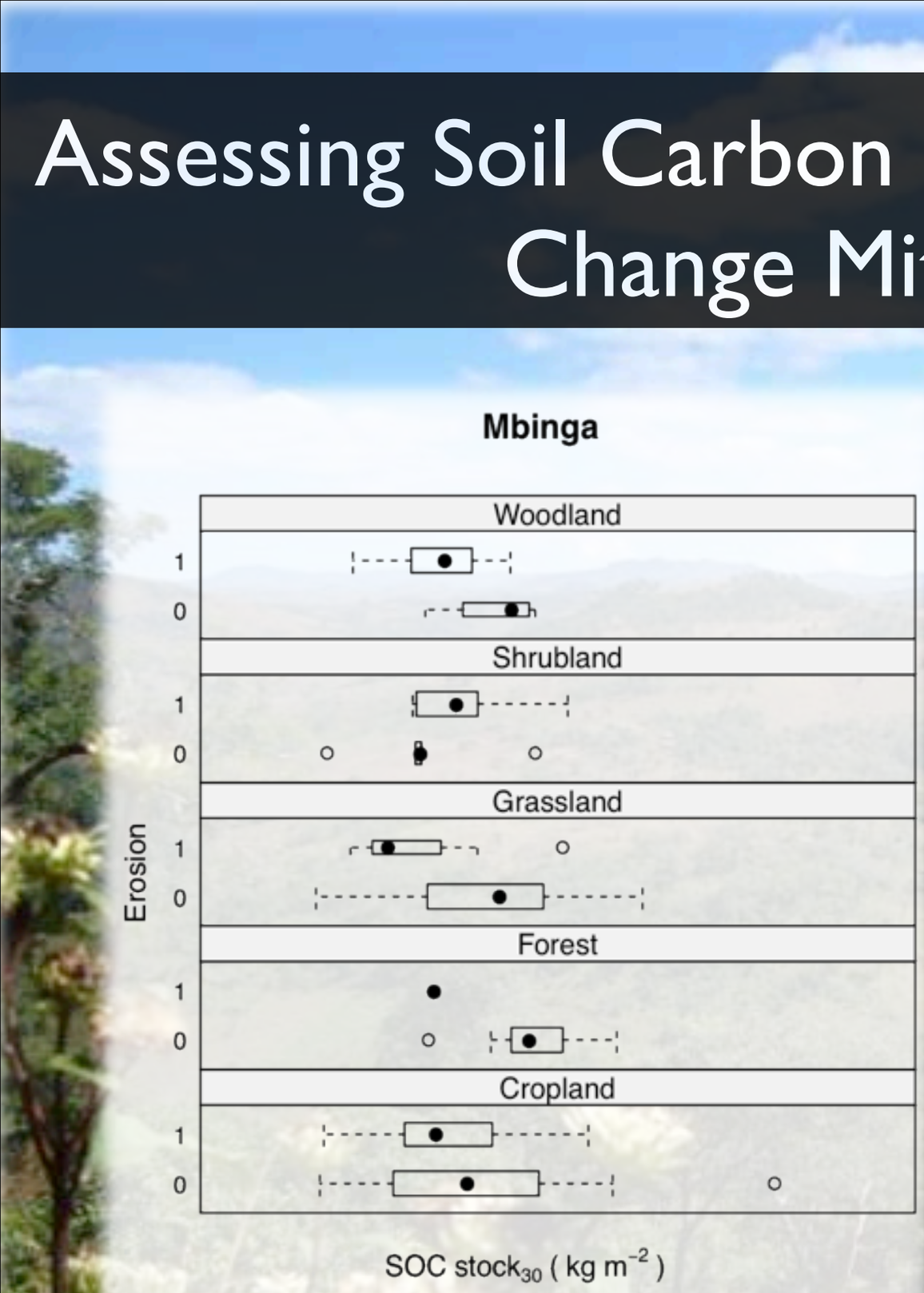
Assessing Soil Carbon Storage as Potential Climate Change Mitigation Strategy



Vågen and Winowiecki, 2013. Mapping of SOC stocks for spatially explicit assessments of climate change mitigation potential. Environmental Research Letters. 8

- Soil organic carbon is an indicator of soil health
- Contrasting sites in Tanzania, Ethiopia and Kenya to demonstrate utility of method: SOC stocks to 30 cm
- To understand landscape patterns of SOC stocks
- To target areas for SOC strategies

Assessing Soil Carbon Storage as Potential Climate Change Mitigation Strategy

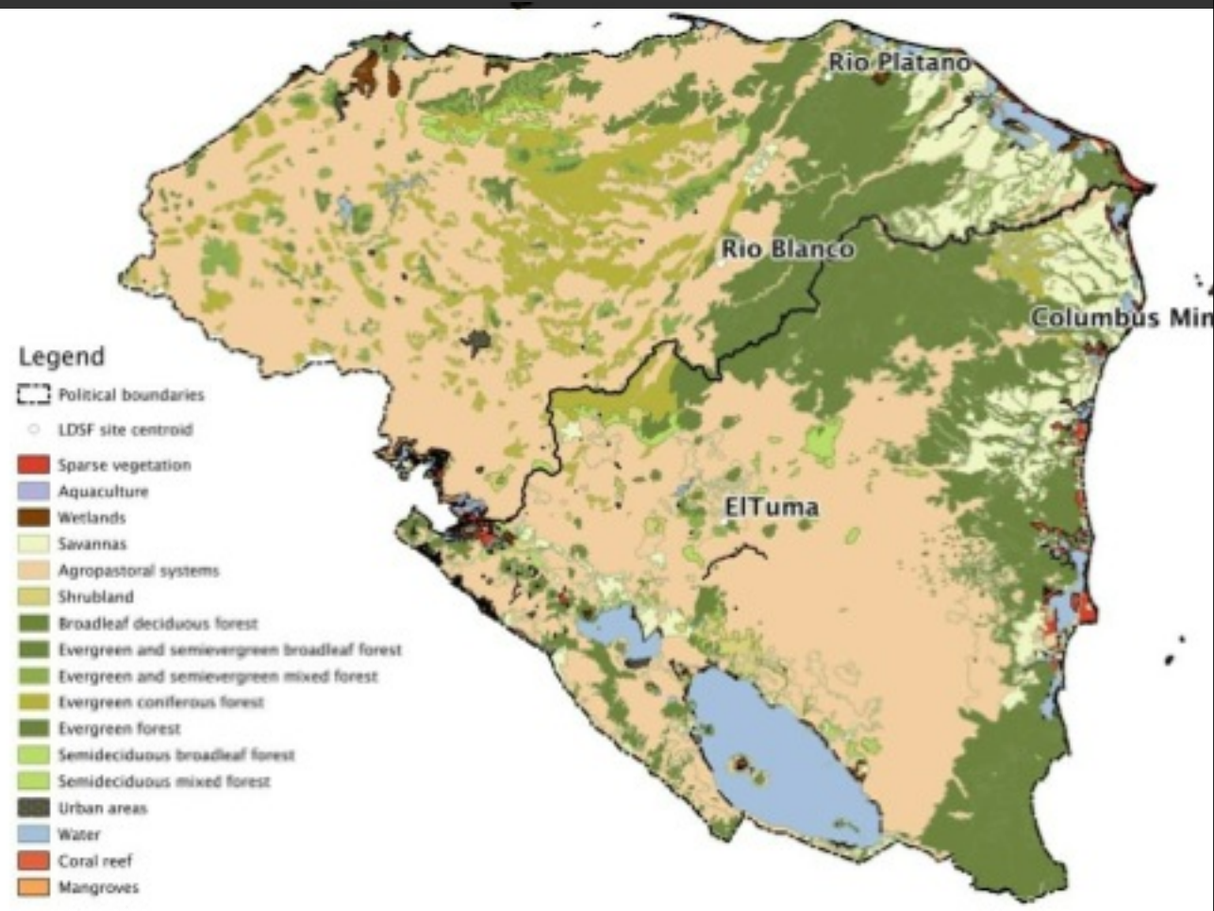


Vågen and Winowiecki, 2013. Mapping of SOC stocks for spatially explicit assessments of climate change mitigation potential. Environmental Research Letters. 8

- Climate and texture explained only 47 % of the variation
- Cross-site comparison to include land cover and land degradation
- 0.9 kg m^{-2} less C in eroded plots
- Most pronounced in Mbinga woodland/grasslands

Cross site comparisons: SL -Nicaragua & Honduras

- Two LDSF sampled in Nicaragua - 2013: Columbus Mine and El Tuma La Dahlia
- Two LDSF sampled in Honduras - 2013: Rio Platano and Rio Blanco
- Nicaragua soil samples at ICRAF lab



Working with Local Partners - CATIE, National Agricultural University (UNA) in Catacamas, Foundation of Madera Verde (FMV) in La Ceiba, Institute of Forest Conservation (ICF) in Tegulcigalpa

The Nicaragua team, led by Dr. Norvin Sepulveda and Dra. Jenny Ordonez of CATIE, will sample both LDSF sites in Nicaragua. The Honduran teams are led by Dr. Juan Carlos Flores of CATIE working together with Dr. Kenny Najera of UNA and Jaime Enrique Peralta of FMV. The UNA team will sample the Rio Blanco site near Catacamas and the FMV team will sample the remote Rio Platano site in the north. Field training was extended to students, local farmers, NGOs, CGIAR centres and others. Participants were trained in navigation with the GPS units to locate the randomly generated LDSF plots (160 per site); all aspects of the LDSF, including soil sample collection, tree and shrub measurements, erosion observations, among other variables; and electronic data entry. Preliminary data analysis was conducted on the newly collected data, including infiltration capacity curves and tree density estimates. Students from UNA will use the LDSF data for undergraduate theses.

Nicaragua team in a coffee and cacao AF plot in cluster 12 of the El Tuma landscape, about 30 km from Matagalpa.

Honduran team in the Brachiaria-dominated Rio Blanco landscape. UNA students were also included in the training!

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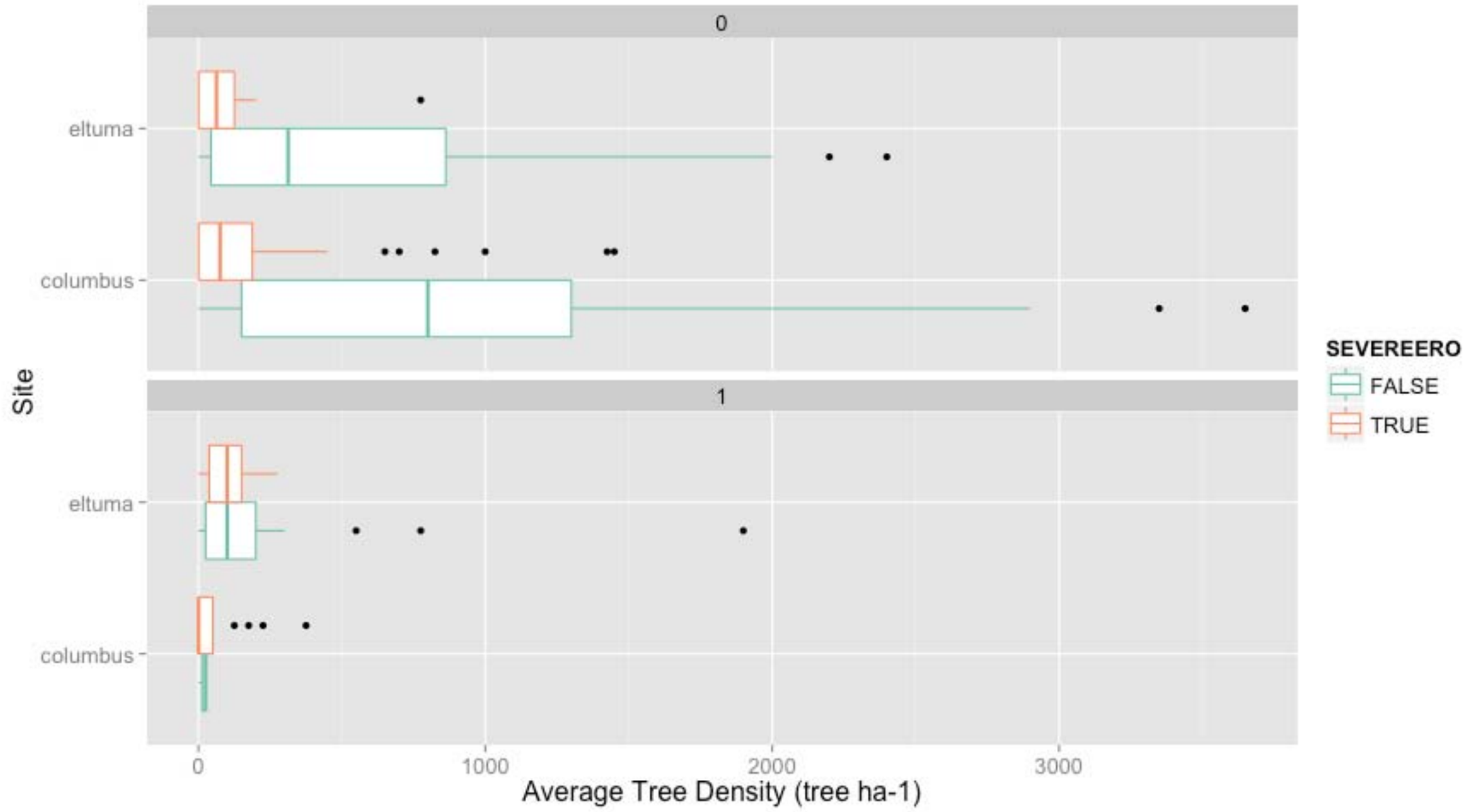
Tree Densities and Erosion Prevalence - Cultivation in El Tuma and Columbus Mine, Nicaragua



Cross site comparisons: SL - South Africa

- Two LDSF - 2013: Agincourt and Bushbuck, South Africa
- Soil samples are in the ICRAF Laboratory
- Link to Agincourt social-economic surveys

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Field training at WRF sites in Agincourt (South Africa)

Tor-G. Vågen (ICRAF)
Leigh Winowiecki (CIAT)
December, 2012

Trip Summary

Background

The University of Witwatersrand Rural Facility (WRF) is conducting several long-term studies, including health and demographic surveillance of communities in Agincourt and Bushbuckridge as part of the INDEPTH network. Building on these studies, a team from WRF led by Dr. Wayne Twine has been conducting vegetation surveys and assessments in these sites for the last two years.

Following a workshop at WRF in December 2011, it was agreed that it would be worthwhile to explore synergies between the methods used by WRF and the LDSF methodology developed at ICRAF. Dr. Leigh Winowiecki (CIAT) and Dr. Tor Vagen (ICRAF) visited WRF in March 2012 to learn more about the WRF methods and discuss possible collaboration. As a follow-up to this visit, two 10 by 10 km sites were proposed that are co-located with existing WRF vegetation plots and INDEPTH network villages.

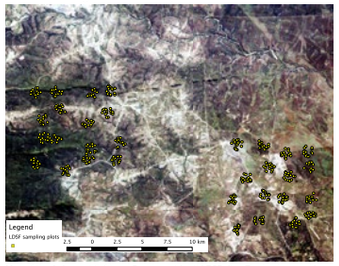
Funding was made available from CRP6 for WRF to conduct LDSF surveys of these sites, including training from CIAT/ICRAF scientists. This report is a short summary of the field training and action points following this field training.

Field training at Agincourt

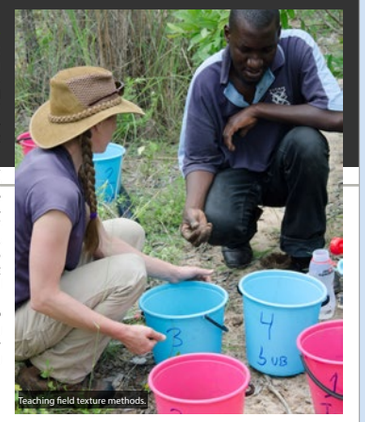
A team of scientists, Ph.D. students and field technicians from WRF were trained on the LDSF methodology during the week of December 10th, 2012. Field surveys were initiated at the Agincourt sites (map below) as part of the training.

The team was trained on vegetation survey methods following a modified version of the FAO Land Cover Classification System (LCCS), field assessments of land degradation risk factors and soil sampling (standard composite samples and cumulative soil mass).

These data will be used to conduct a comprehensive soil health assessment of the area and will be linked to both WRF vegetation surveys and INDEPTH data.



Map of the Agincourt (left) and Bushbuck (right) LDSF sites. The background is a Landsat ETM+ Image from 2009.


Teaching field texture methods.

Synergies between the LDSF and WRF vegetation monitoring methods

One of the primary objectives of this exercise was to look at synergies between the methods applied by WRF and the LDSF for monitoring of rangelands and open woodlands. The LDSF has been applied across all major climate zones in Africa as part of several initiatives, including the Africa Soil Information Service project. The framework has been shown to be very effective for landscape level assessments of soil and land health.

The WRF has implemented very detailed methods for assessment of vegetation composition, structure and trends and it is clear from this collaboration that the LDSF will benefit from incorporating additional methods based on those developed by WRF, specifically for improved assessments of grasslands and woody biomass. These methods are currently being adapted and incorporated into the LDSF framework and will be applied as part of the CRP6 sentinel landscapes initiative (see action points on the right).


The WRF and CIAT/ICRAF team.

Action points:

WRF team completes LDSF surveys in two sites (Agincourt and Bushbuck).

Order WorldView2 imagery.

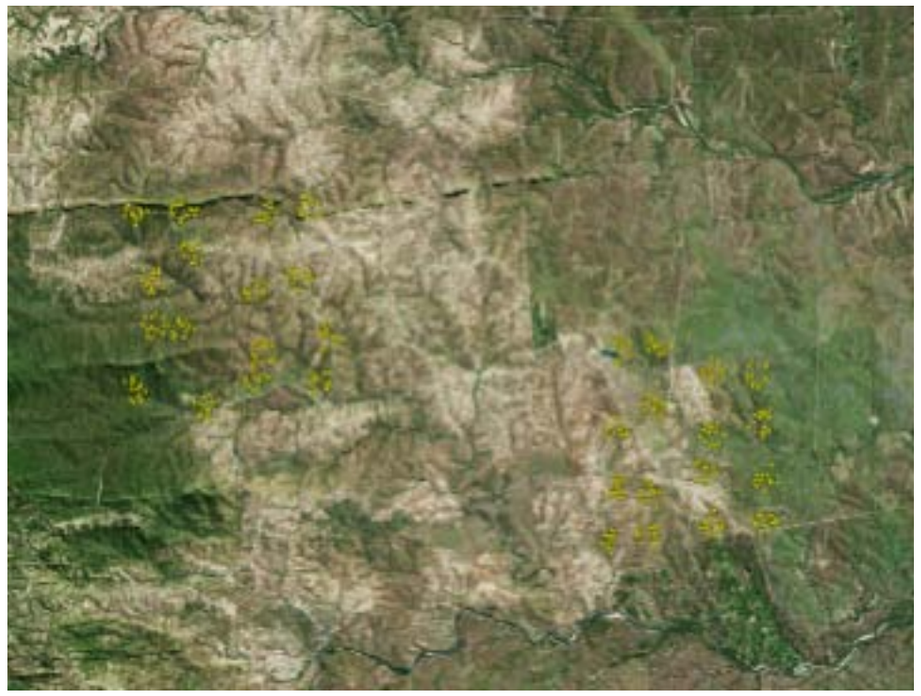
Remote sensing analysis of Landsat and WorldView2 imagery.

Development of a module for rangeland health monitoring for incorporation into the LDSF.

Development of a module for improving the assessment of woody cover and biomass in open woodlands, including "trees on farm" for incorporation into the LDSF.

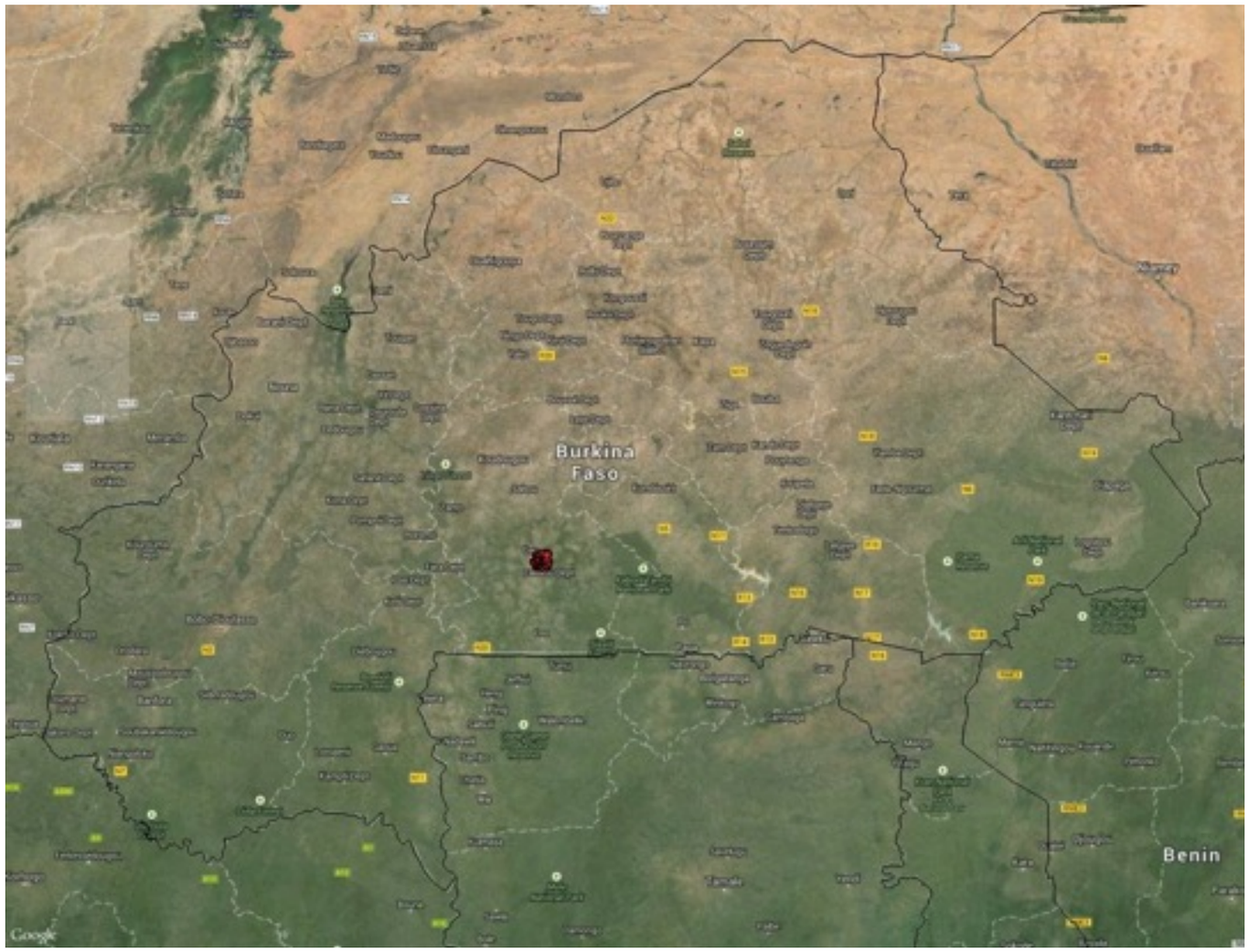
Development of a module for grass and tree biodiversity assessments for incorporation into the LDSF.

Proposal development to support a "work package" on land health assessment as part of the collaboration between ICRAF and SUCSES (Sustainability in Communal Socio-Ecological Systems).



Cross site comparisons: SL - Burkina Faso/WGSL

- One LDSF - 2013: Cassou, Burkina Faso
- Soil samples are being processed by WASL
- WGSL - March 2014



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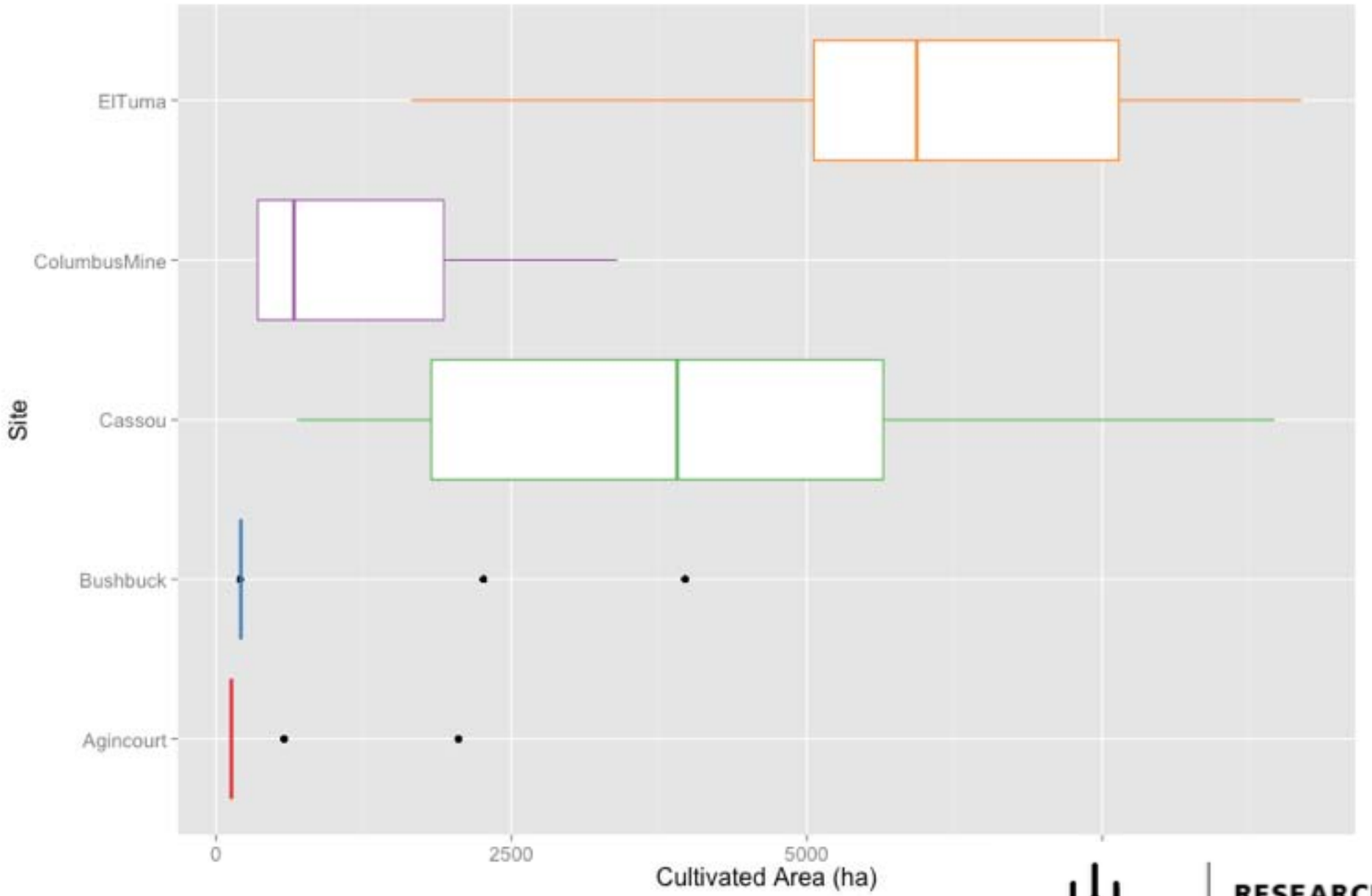
Cross site comparisons: Cultivated area within the five LDSF sites in the SL



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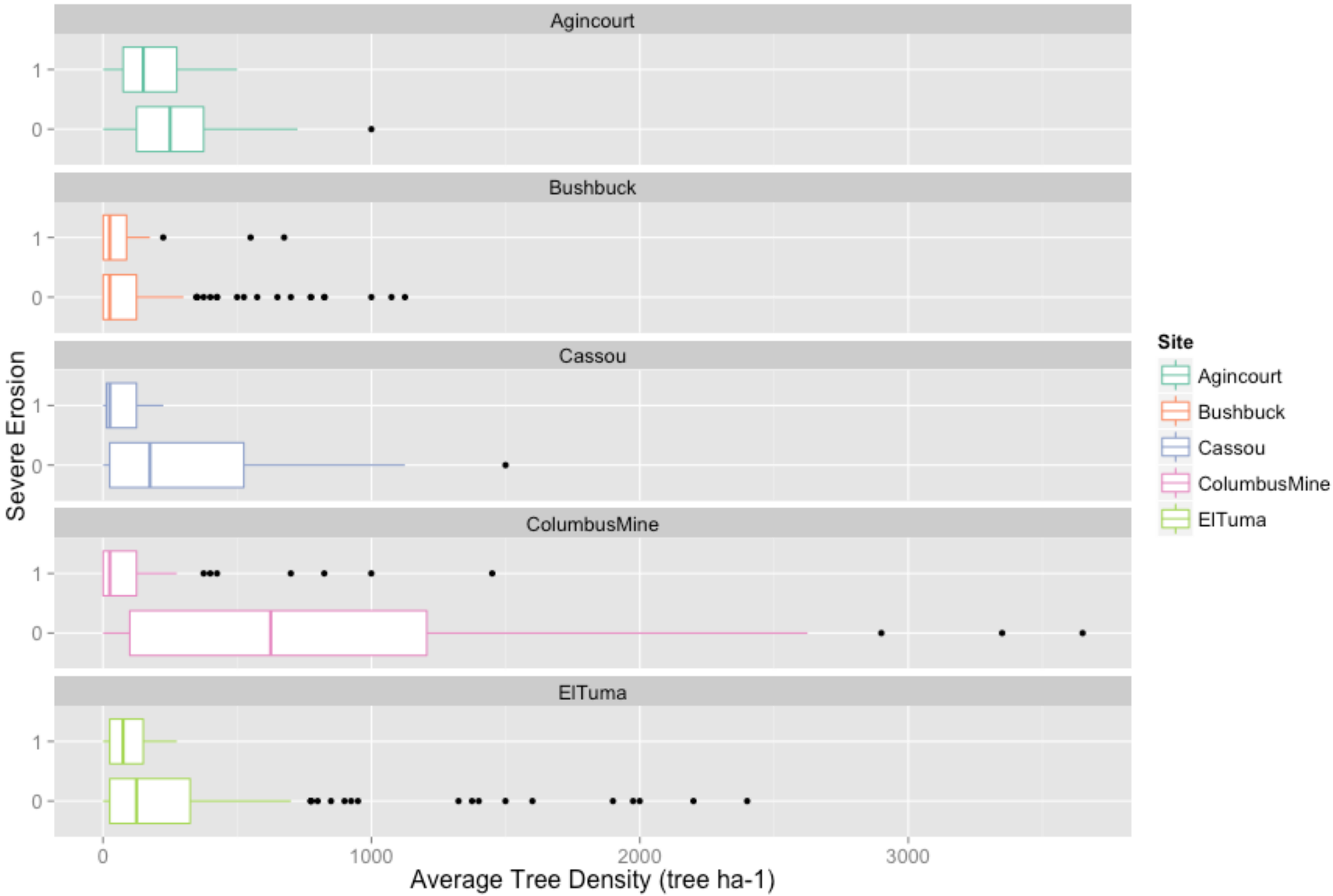
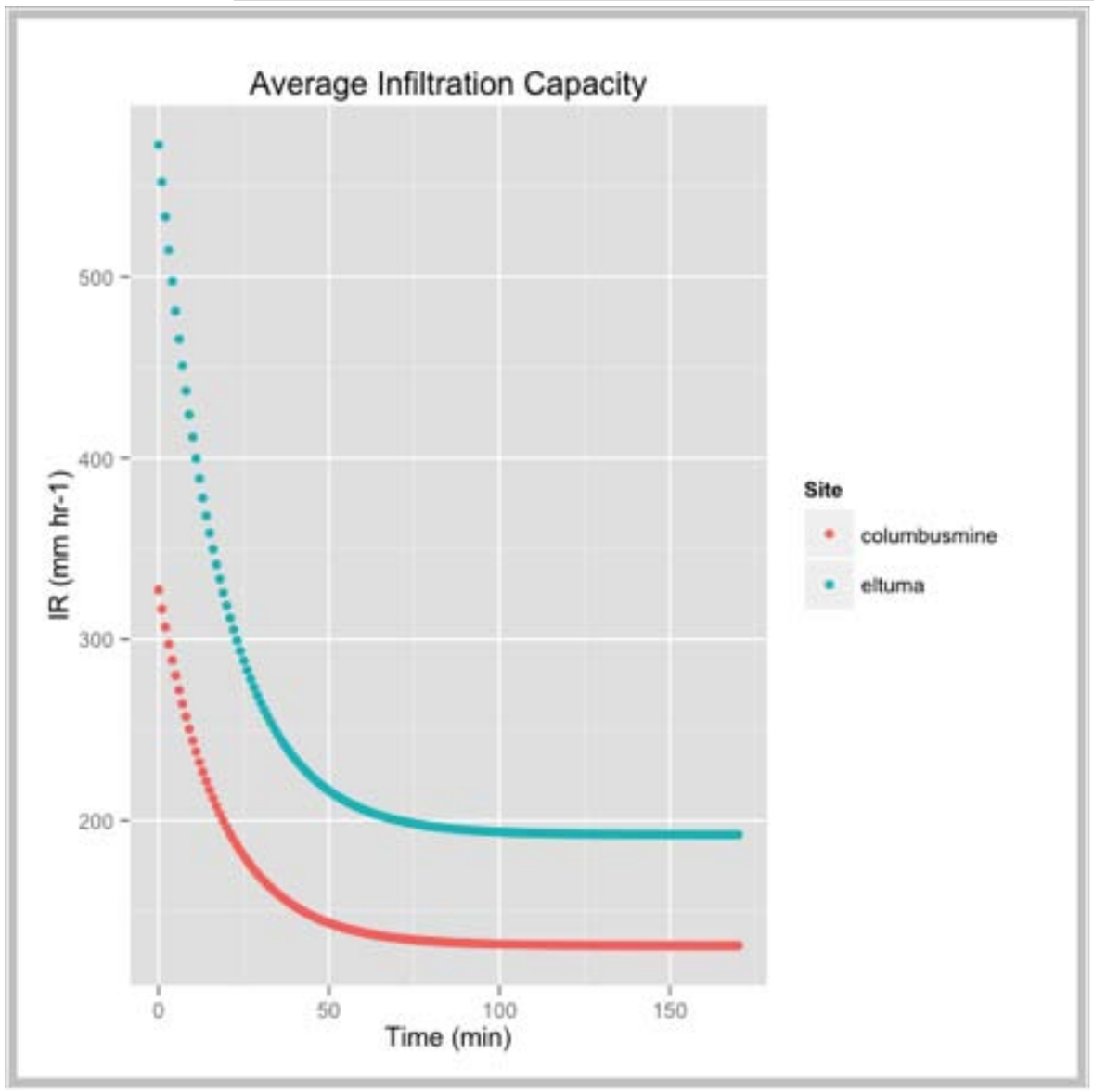
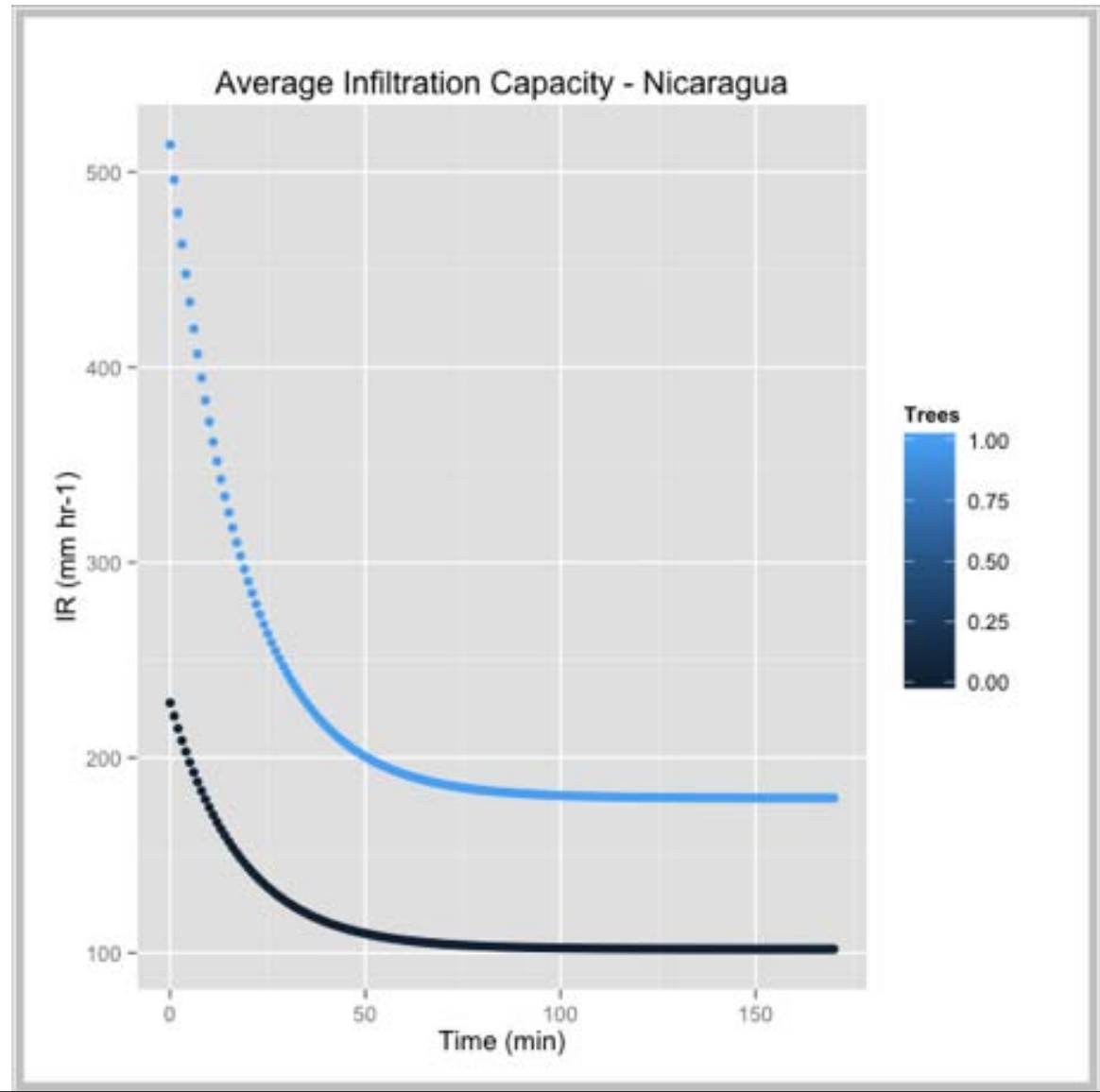
Cross site comparisons: Trees and Erosion



Nicaragua Infiltration Capacity- Effect of Trees





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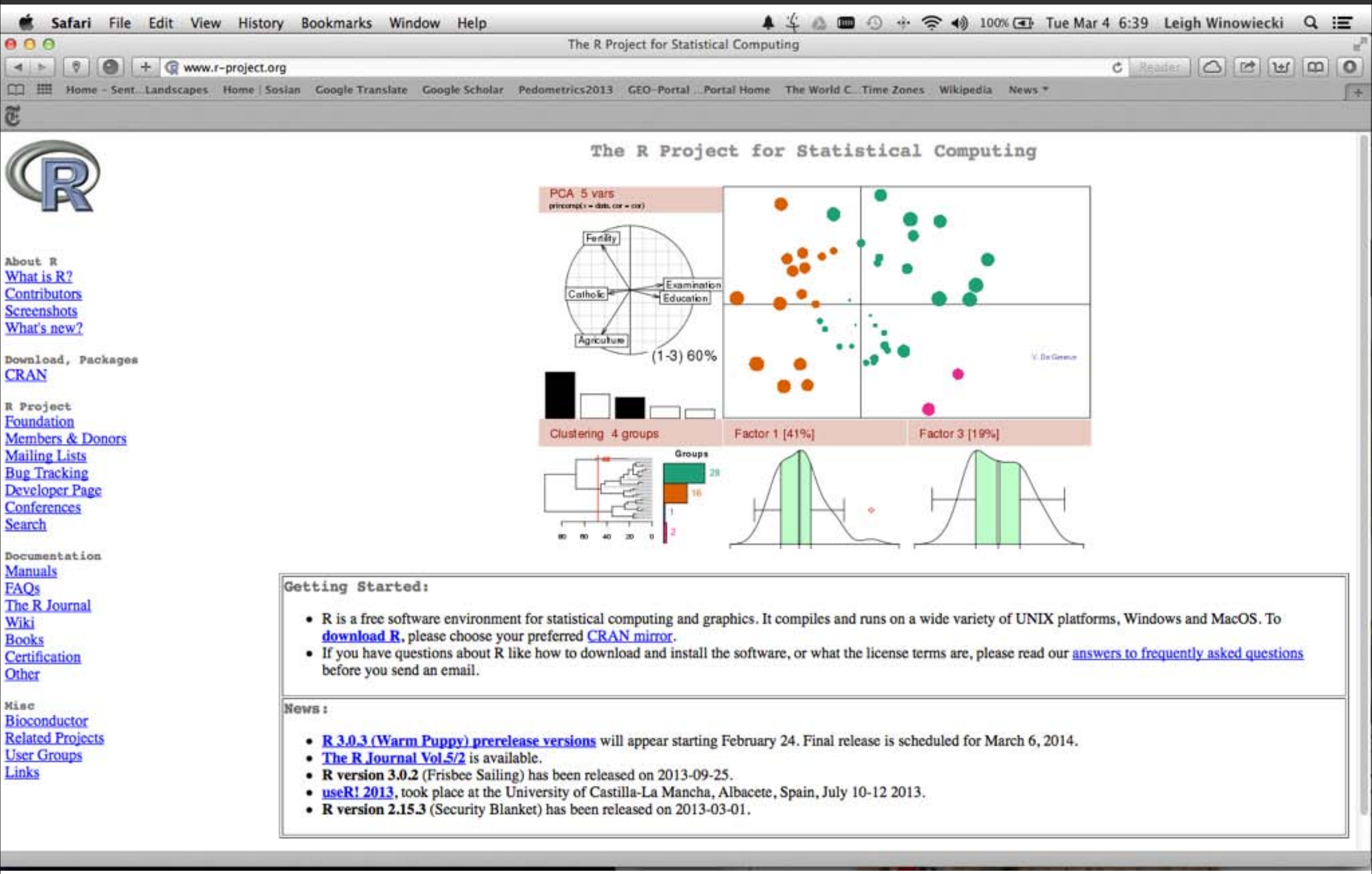
What's next…..

- Linking interdisciplinary datasets
- Understanding and linking land health with socio-economic assessments/analysis
- ..
- ….
- ..Let's open R

Let's Download R & RStudio



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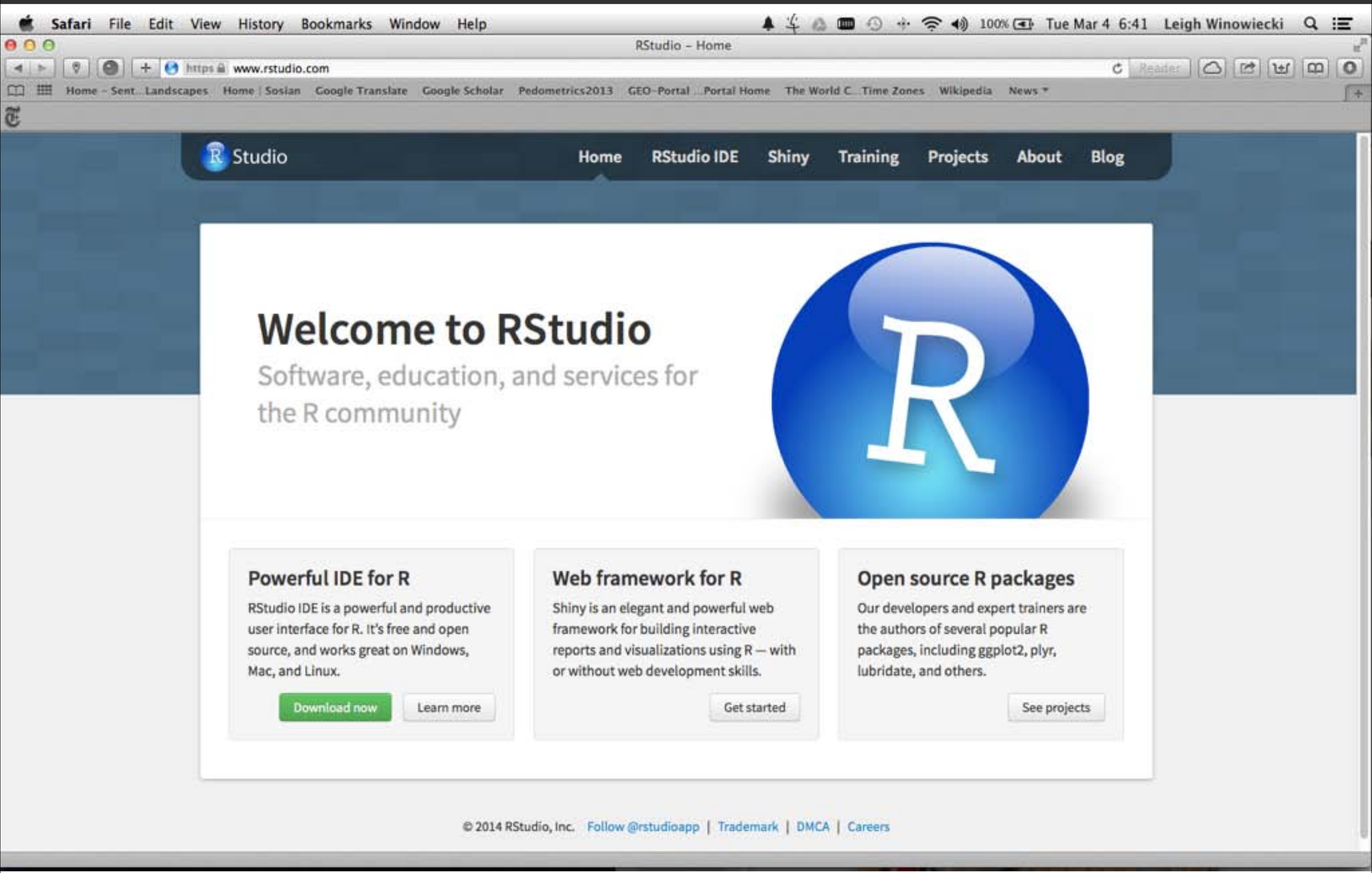
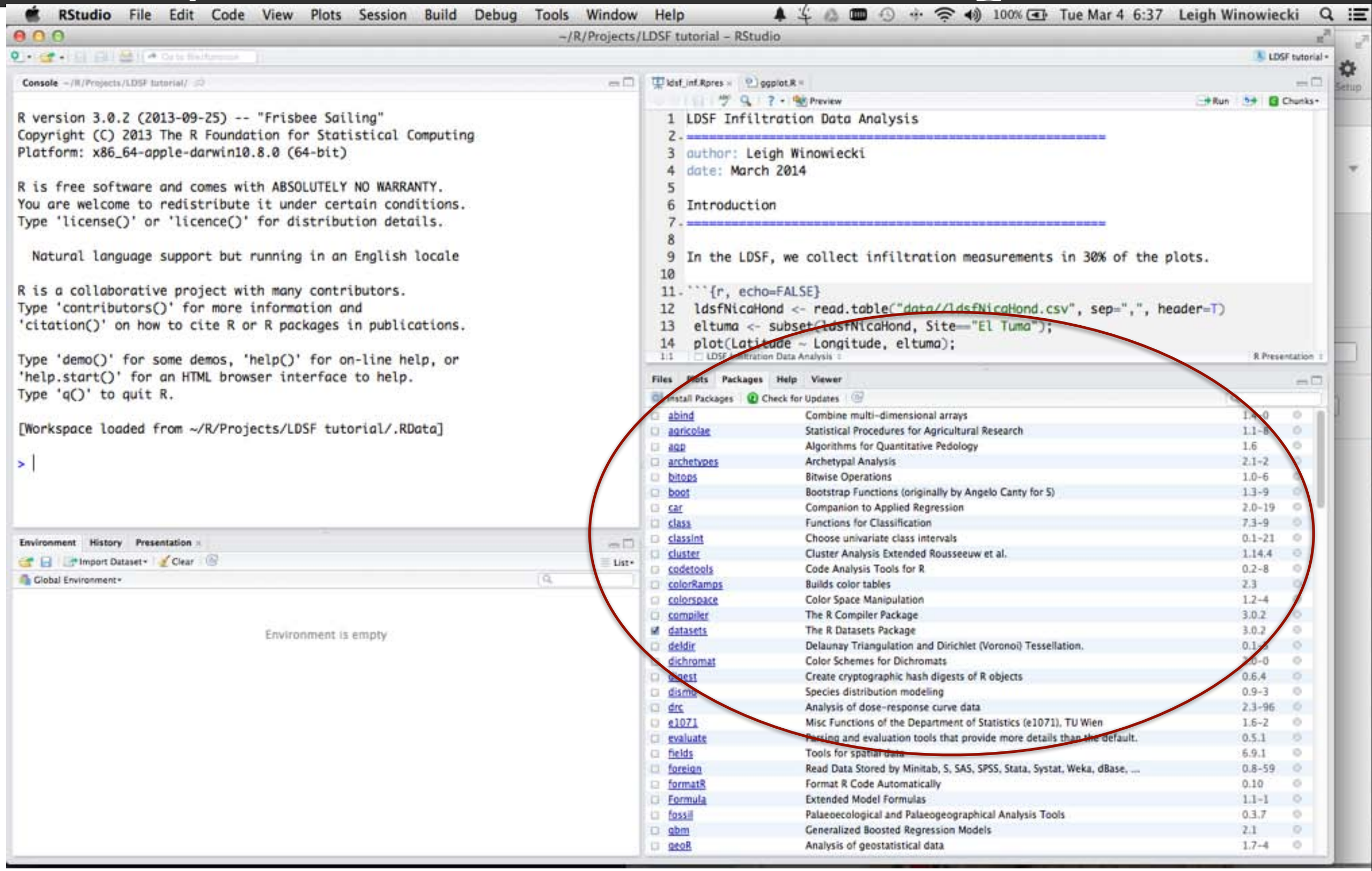


Let's Open R - RStudio - Install Packages



Install Packages

- lme4
- lattice
- ggplot2

Save the Dataset

- Save the .csv file somewhere on your computer- where you will remember!!!
- IdsfNicaSAWA

Open a New Project in R Studio!!

Project - New -

Set Working Directory

Let's explore the data


Asante!