Characterization of Humid-Forest and Savanna Ecoregions of West and Central Africa using Satellite Sensor Data of Three Eras

Characterization of Eco Regions in Africa (CERA)

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Project web page:
http://www.geology.yale.edu/~smith/africa_project.html
http://www.yale.edu/ceo/

Characterization of Eco Regions in Africa (CERA)

Eco Regions of study

1. Sudan savanna (LGP: < 150 days);
2. Northern Guinea savanna (LGP: 151-180 days);
3. Southern Guinea savanna (LGP: 151-210 days);
4. Derived savanna (LGP : 211-270 days);
5. Degraded forest (LGP: > 270 days);
6. Forest margin (LGP: > 270 days); and
7. Primary forest (LGP: > 270 days).

LGP = length of growing period

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OBJECTIVES

The following Objectives will be achieved using satellite sensor data of 3 eras:

1. Agroforest characterization and carbon credits;
2. Regrowth dynamics or agricultural fallow systems;
3. Study major weeds and grasses (Chromolenea odorata and Imperata cylindrica);
4. Forest fragmentation and dynamics (e.g., logging, slash and burn, regrowth, species composition);
5. Land cover transformations over decades;
6. Degradation levels of natural environments: Characterize and evaluate; and
7. Carbon budgets for above ground biomass.

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OBJECTIVES

Specific Issues of focus:

1. Agricultural fallow systems and Regrowth dynamics;
2. Degradation levels of natural environments: Characterize and evaluate;
3. Agricultural intensification and related components (croplands, rangelands, and useful trees);
4. Land cover change dynamics over decades;
5. Agroforest characterization and carbon credits;
6. Forest and savanna fragmentation and dynamics (e.g., logging, slash and burn, regrowth, species composition);

Final goal ……Carbon budgets from above ground biomass…….in distinct ecoregions.

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Satellite Sensor Data of 3 Eras

1. pre-1999 era (e.g., TM, MSS, JERS SAR);
2. Earth Observing System (EOS) era (e.g., ETM+, ASTER, IKONOS-2); and
- New Millennium Program era (e.g., Hyperion, ALI).

Note: Plus hyperspectral data from hand held or platform mounted spectroradiometer data.

Hyperspatial (e.g., IKONOS) and Hyperspectral (e.g., Hyperion) data open a New Era in remote sensing. How does the data from these sensors compare with sensors of previous eras?

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Ground Truth Data

data gathered at each 30 by 30 meter (or 15 by 15 meter) plots include

- Species: tree, shrub, grass, weed species
- dbh of tress and shrubs of > 10 cm. Diameter
- Tree height
- Land cover classes and their percentage
- Land use
- Spectroradiometer data in 350 to 2500 nanometers (for regrowth fallows, grasses, weeds, shrubs, agricultural crops)
- Photos (digital and slide)
- GPS location
- Note: Total of 677 plots. 332 plots from Nigeria and Benin (year 2000); 67 plots from Cameroon (year 2000); 76 plots from Central African Republic (year 2000); 202 plots from Cameroon (year 1995)

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Datasets

1. Satellite sensor data from 3 eras;
2. Hyperspectral data from spectroradiometer;
- Ground truth data from field surveys;

Note: Specific focus on hyperspatial data from IKONOS.

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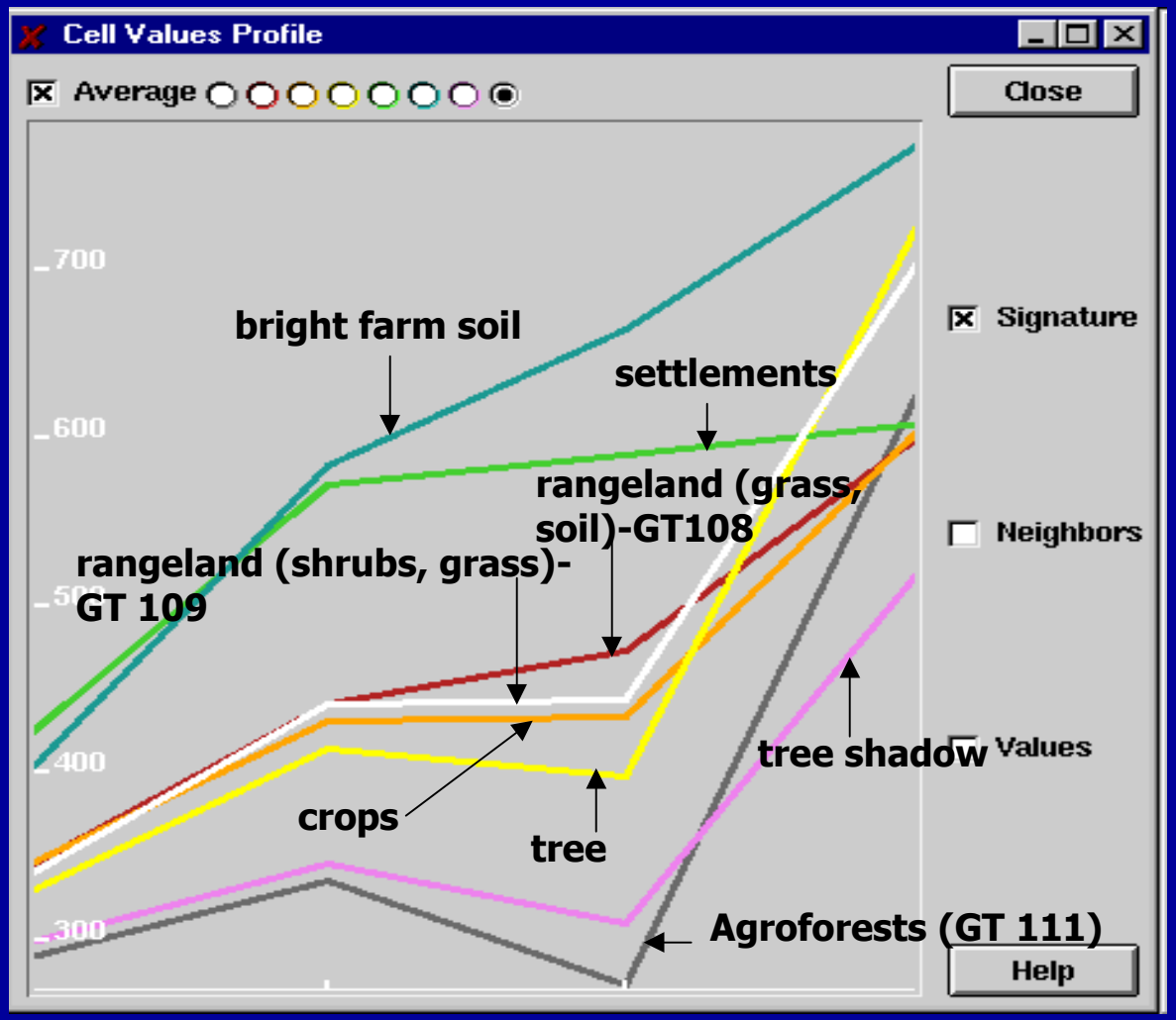
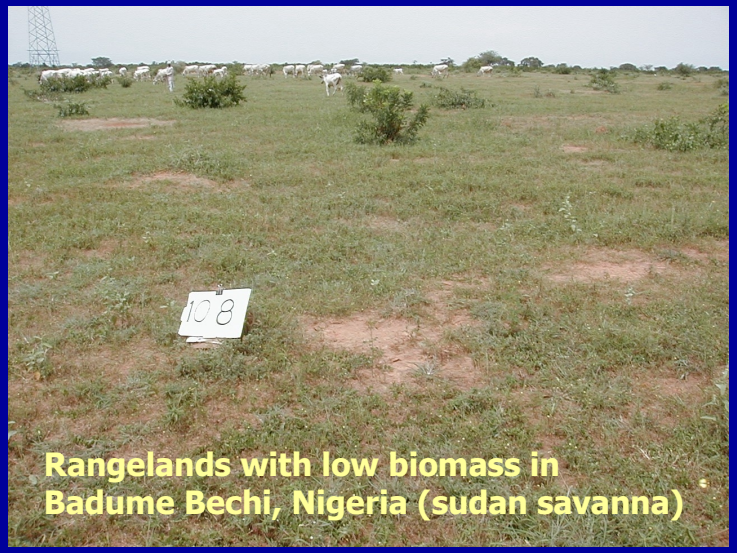
Spectral Profile of Distinct Classes in an IKONOS Image

Badume bechi, sudan savanna



Rangelands and Plantations

Sudan Savanna, Badume Bechi, Nigeria



Rangelands with low biomass in Badume Bechi, Nigeria (sudan savanna)

Rangelands with denser biomass in Badume Bechi, Nigeria (sudan savanna)

Cashew plantation in Badume Bechi, Nigeria (sudan savanna)

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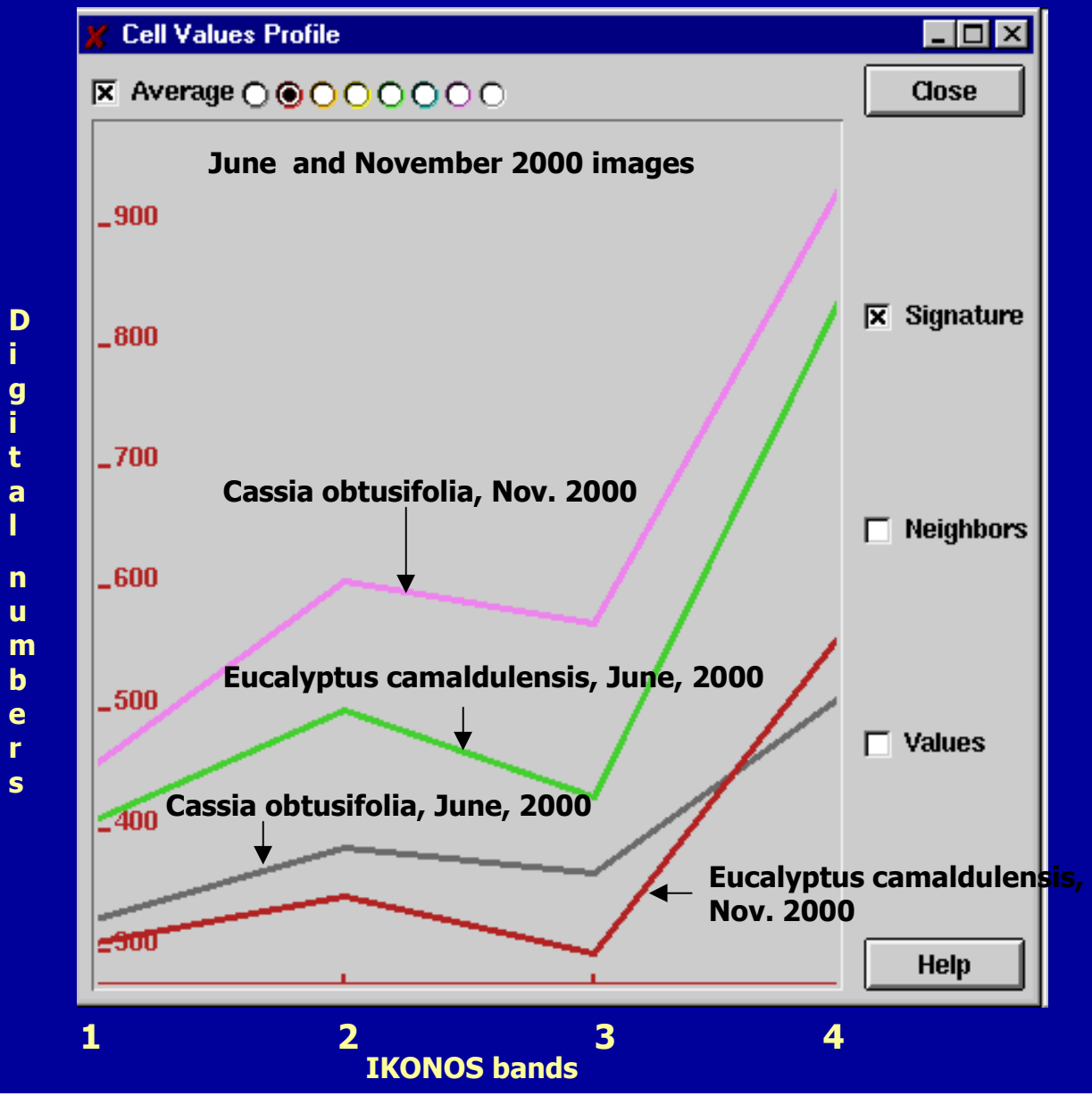
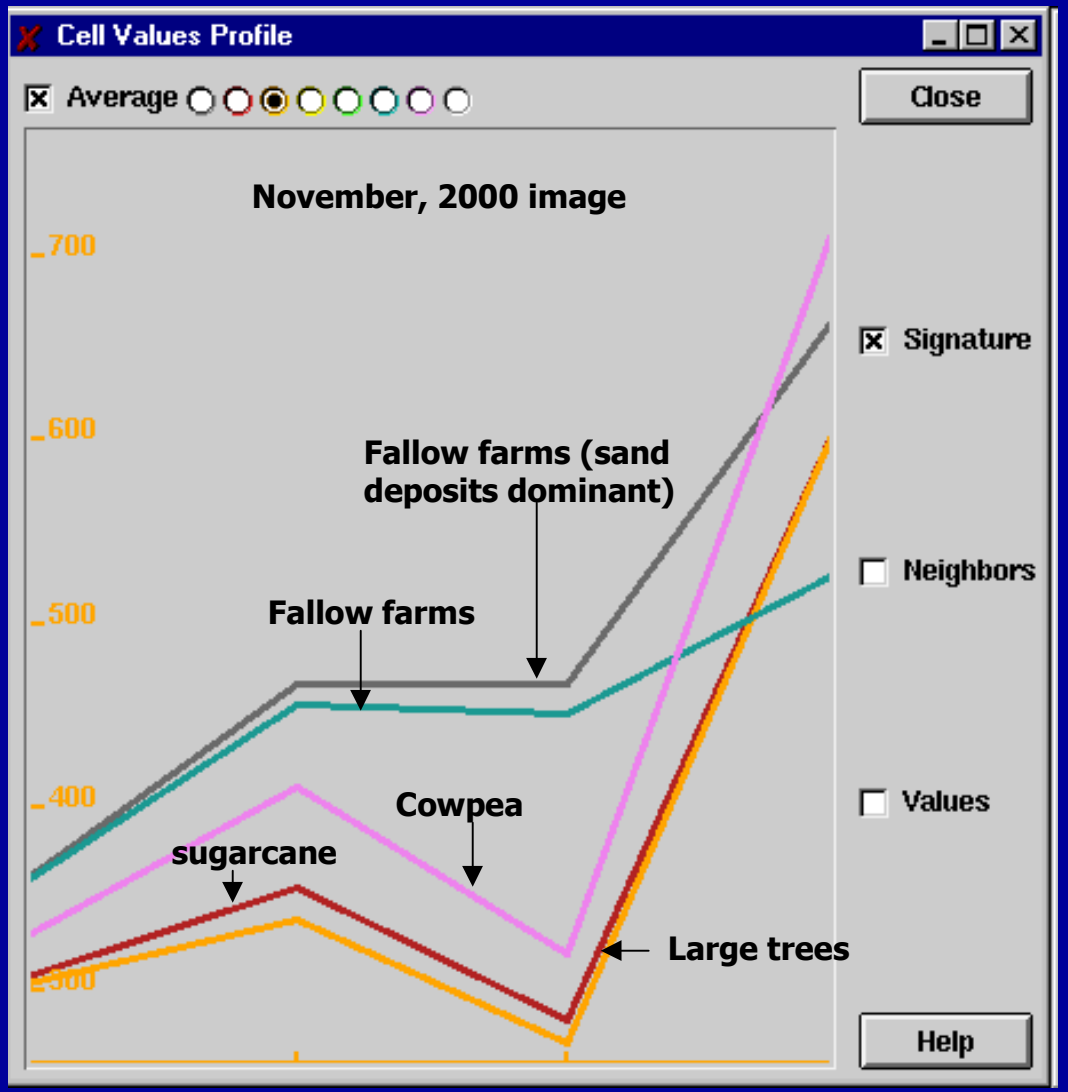
Temporal Spectral Profiles of Land Cover Classes in an IKONOS Image

Danayamaka, Nigeria in N. Guinea savanna



Temporal Spectral Profiles of Agricultural Crops in an IKONOS Image

Danayamaka, Nigeria in N. Guinea savanna



Legumes, Crops, and Plantations

N. Guinea savanna, Danayamaka, Nigeria

Cassia obtusifolia (N fixation legume) in Danayamaka, Nigeria (N. Guinea savanna)

Eucalyptus camaldulensis in Danayamaka, Nigeria (N. Guinea savanna)

Corn crop in Danayamaka, Nigeria (N. Guinea savanna)

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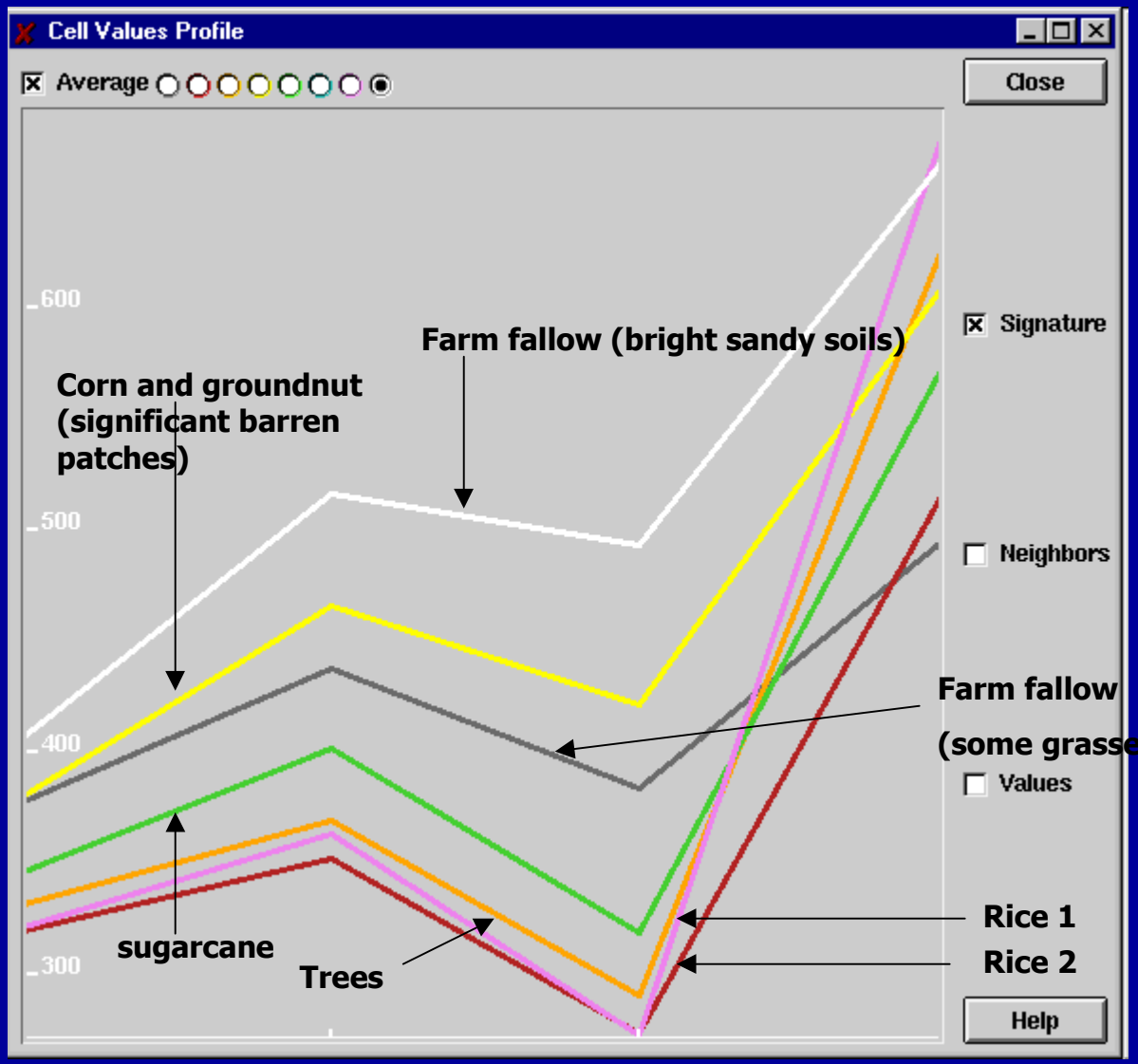
Spectral Profiles of Agricultural Crops in an IKONOS Image

Kaswan Magani, Nigeria in N. Guinea savanna



Lowland and Upland crops

N. Guinea savanna, Kaswan Magani, Nigeria

Lowland: Sugarcane crop in Kaswan magani, Nigeria (N. Guinea savanna)

Lowland: Rice crop in Kaswan Magani, Nigeria (N. Guinea savanna)

Upland: Corn crop in Kaswan Magani, Nigeria (N. Guinea savanna)

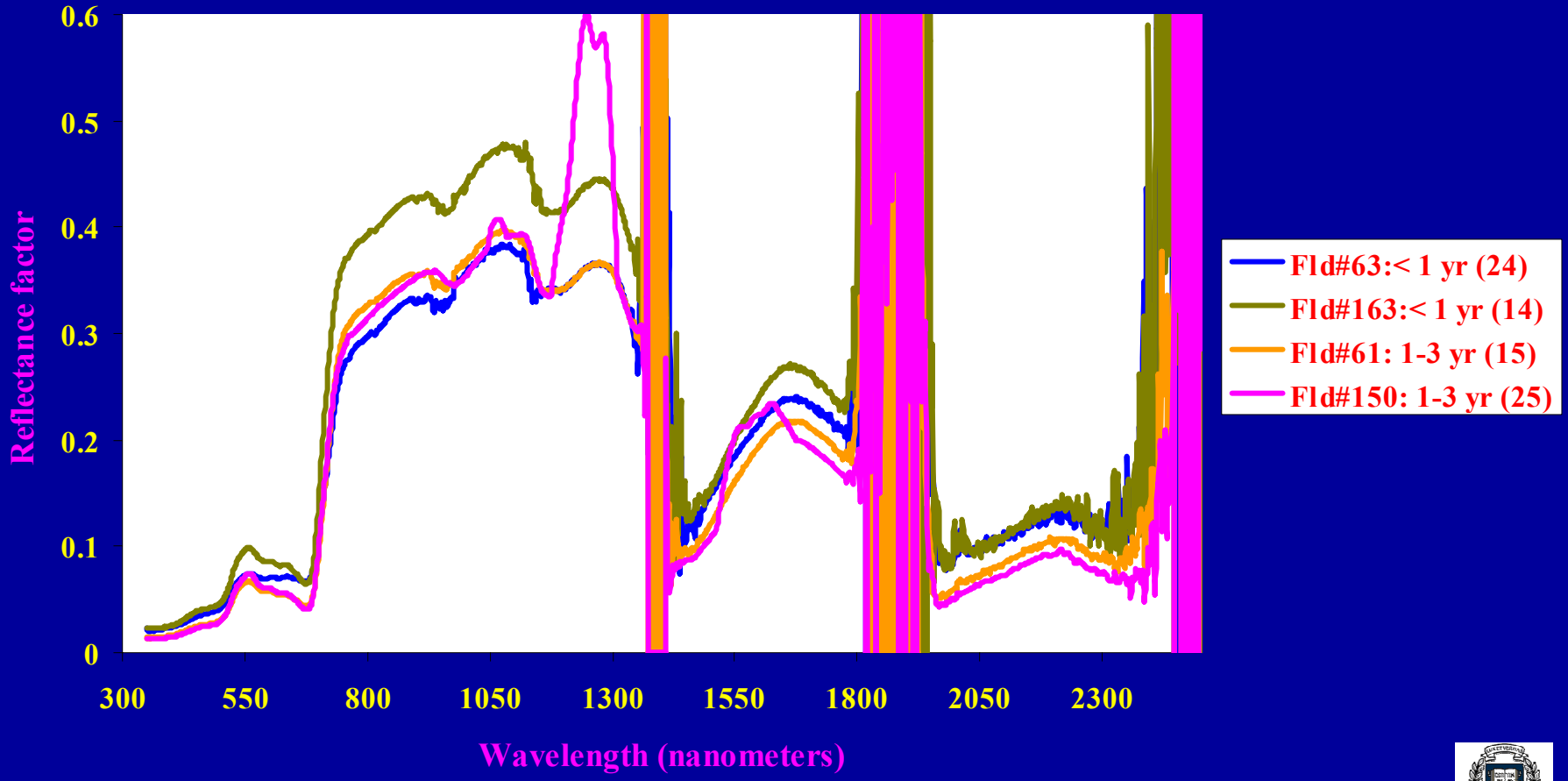
Upland: Groundnut and corn crops in Kaswan magani, Nigeria (N. Guinea savanna)

Hyperspectral Data Characteristics for Agricultural fallows

African savannas

(Northern and Southern)

Regrowth or Agricultural fallows



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Agricultural Fallows or Regrowth Dynamics

N. Guinea savanna, Kaswan Magani, Nigeria

Fld#63; < 1 yr fallow in Kaswan Magani, Nigeria (N. Guinea savanna)

Fld#61; 1-3 yr fallow in Kaswan magani, Nigeria (N. Guinea savanna)

Fld#163; < 1 yr fallow South of Niger river near Mokwa, Nigeria (S. Guinea savanna)

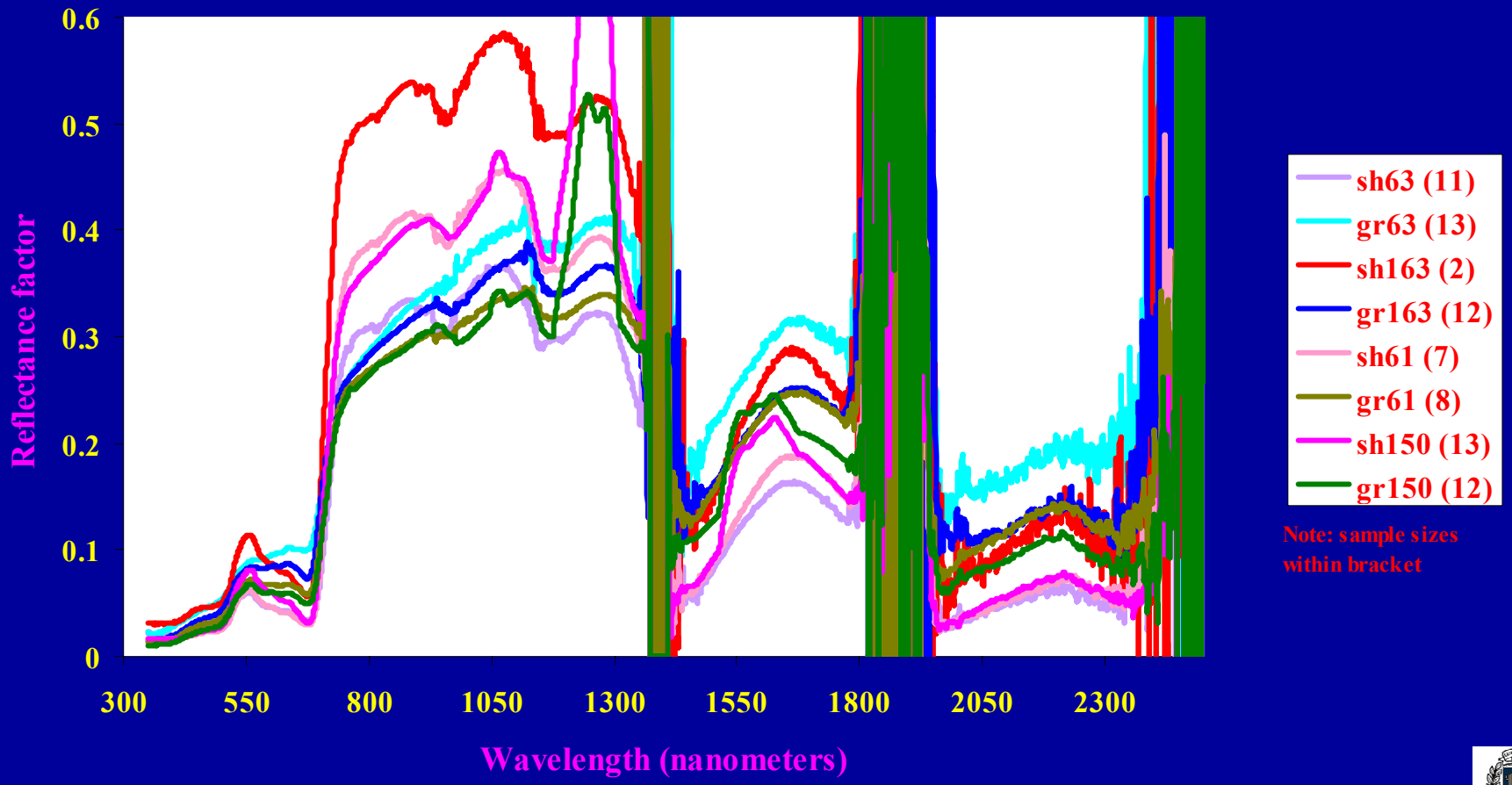
Fld#150; 1-3 yr fallow South of Niger river near Mokwa, Nigeria (S. Guinea savanna)

Hyperspectral Data Characteristics for Agricultural fallows

African savannas

(Northern and Southern)

Shrubs and grasses in Agricultural fallows



Note: sample sizes within bracket

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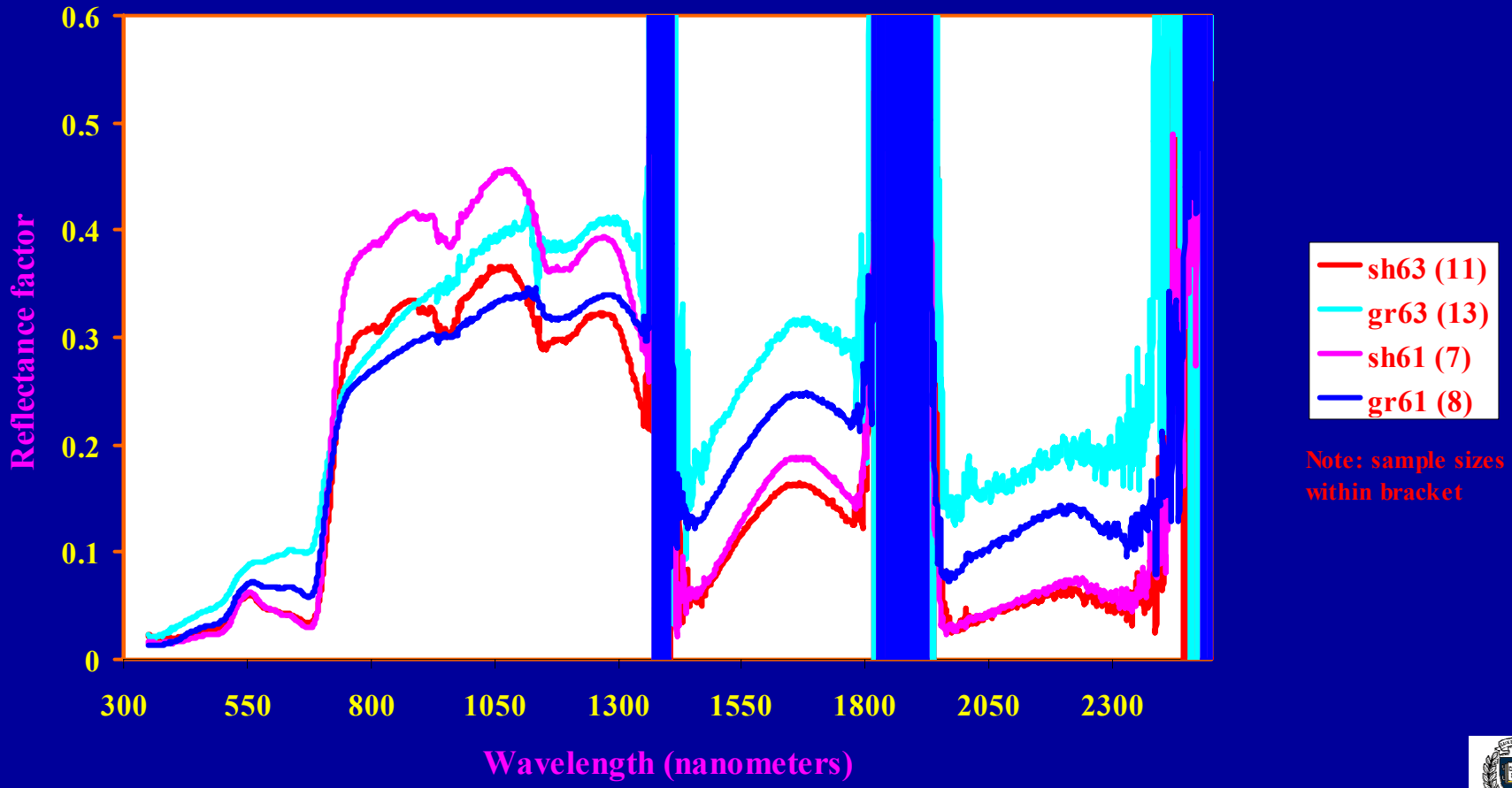
Hyperspectral Data Characteristics for Agricultural fallows

Northern Guinea savanna

Shrubs and grasses in Agricultural fallows



Note: sample sizes within bracket

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Agricultural Fallows or Regrowth Dynamics

N. Guinea savanna, Kaswan Magani, Nigeria

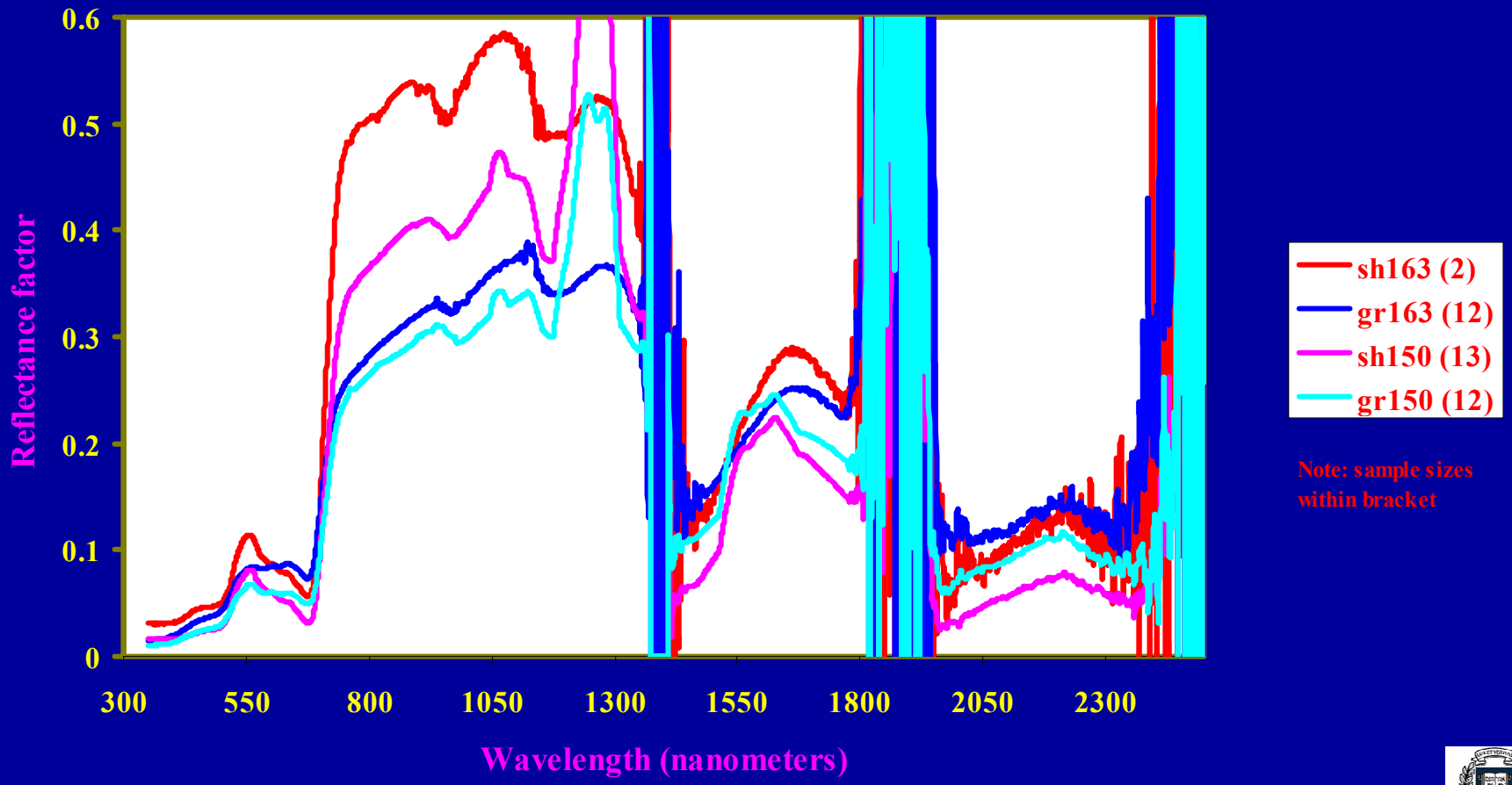
Fld#63; < 1 yr fallow in Kaswan Magani, Nigeria (N. Guinea savanna)

Fld#61; 1-3 yr fallow in Kaswan Magani, Nigeria (N. Guinea savanna)

Hyperspectral Data Characteristics for Agricultural fallows

Southern Guinea Savanna

Shrubs and grasses in Agricultural fallows



Note: sample sizes within bracket

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Agricultural Fallows or Regrowth Dynamics

S. Guinea savanna, South of Niger River (Near Mokwa), Nigeria

Fld#163; < 1 yr fallow South of Niger river near Mokwa, Nigeria (S. Guinea savanna)

Fld#150; 1-3 yr fallow South of Niger river near Mokwa, Nigeria (S. Guinea savanna)

Savanna Woodlands, Agriculture, and regrowth (fallows)

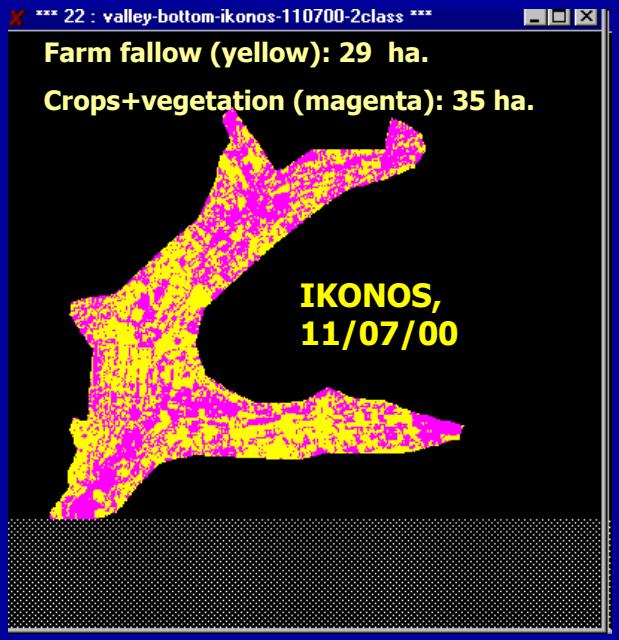
N. Guinea savanna and S. Guinea Savanna

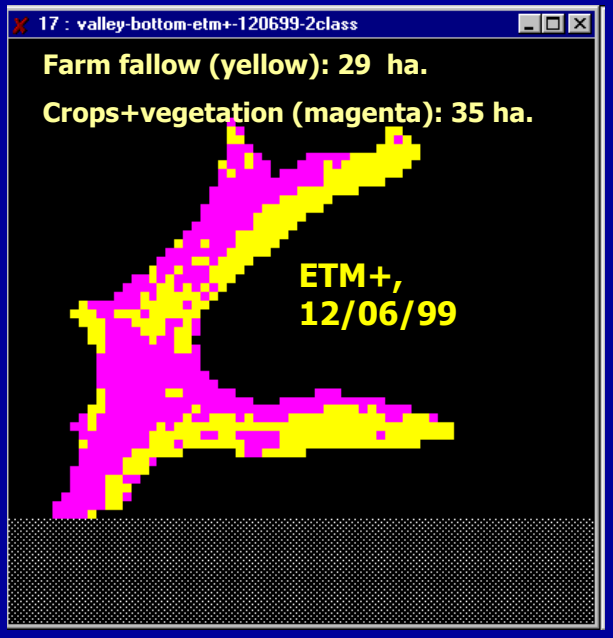
Woodland savanna near Bernin Gwari, Nigeria (N. Guinea savanna)

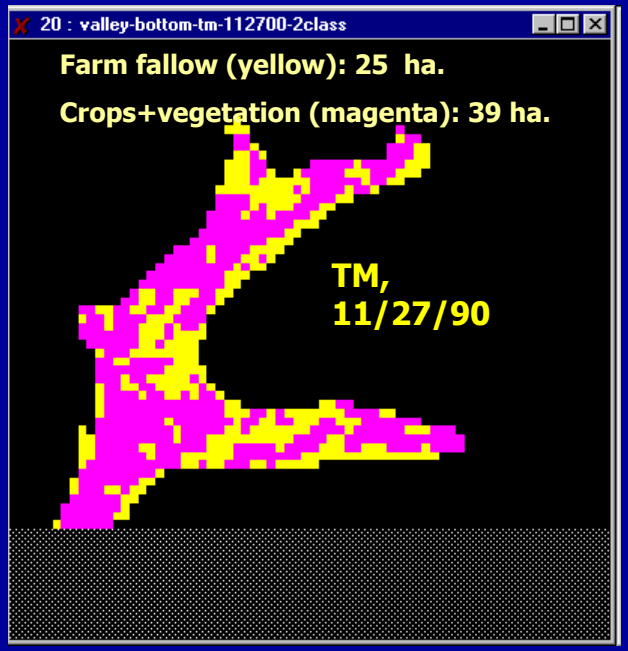
Farmlands along the corridors of major roads Near Bernin Gwari, Nigeria (N. Guinea savanna)

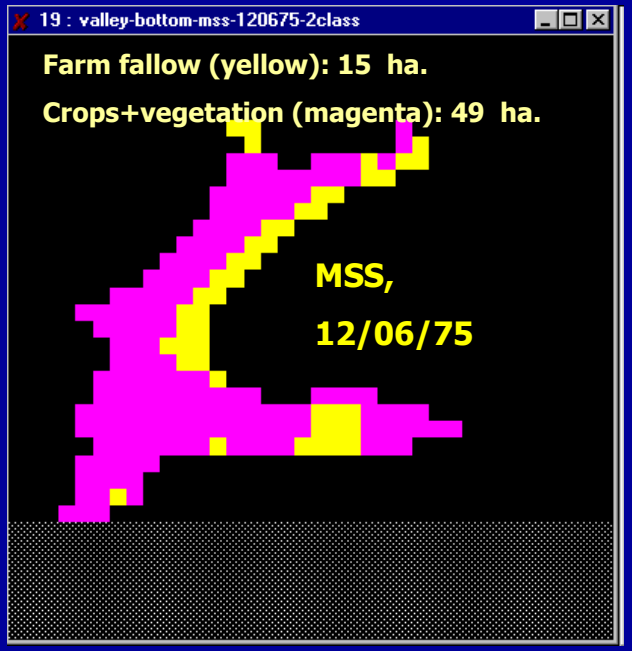
Shrubland savanna to North of Minna, Nigeria (S. Guinea savanna)

1-3 year fallow along major roads near Minna, Nigeria (S. Guinea savanna)









Temporal change in land use using multiple satellite sensor data over 3 decades

In a valley bottom of N. Guinea savanna

Note: detail provided by IKONOS compared to other images

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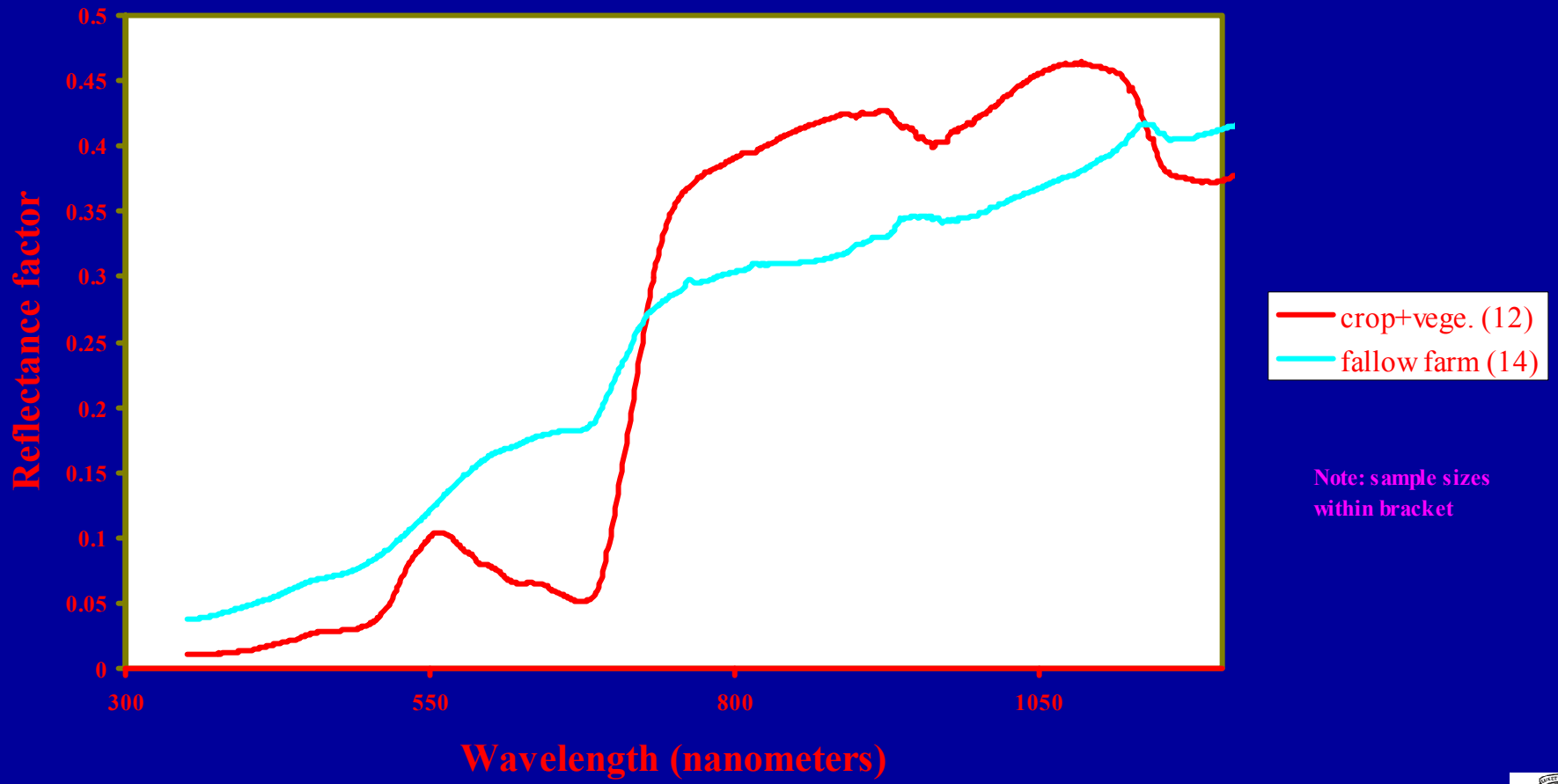
Hyperspectral Data

N. Guinea savanna, Kaswan Magani, Nigeria

Fallow farms vs. crops and natural vegetation



Note: sample sizes within bracket

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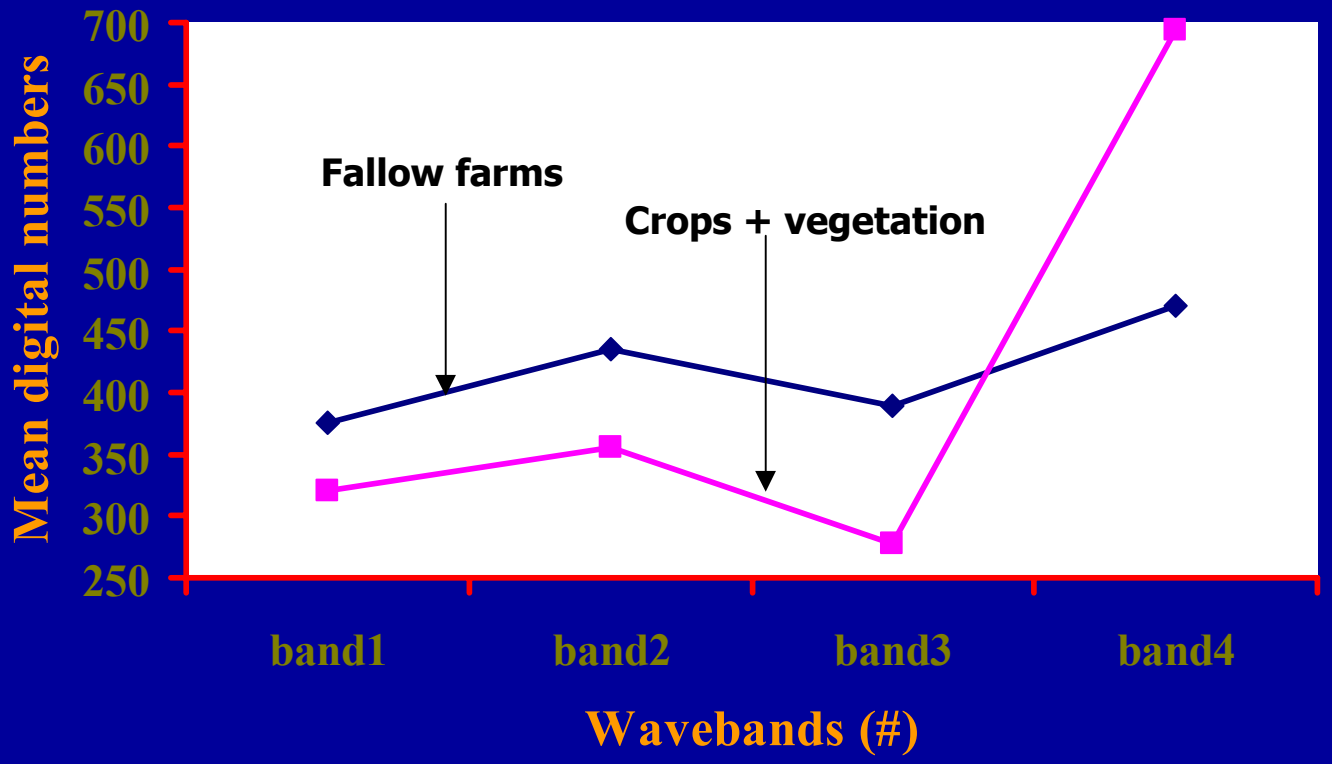
Spectral Profile from IKONOS Image

N. Guinea savanna, Kaswan Magani, Nigeria

Fallow farms vs. Crops + vegetation



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Degradation of Savanna Woodlands

N. Guinea savanna and S. Guinea Savanna

Land cover along a Toposequence

S. Guinea savanna, Bida, Nigeria

Rice crop in the valley bottom

Corn crop in valley fringes

1-3 year fallow in valley fringes

Savanna shrubland in uplands

Oil Palm plantations, Agriculture, Scattered Trees, and Carbon Credits

Derived savannas, Zouzouvou, Benin

Oil palm plantation (closely spaced)

Oil palm (young) and cassava crop


Soybeans, orange trees, and a large tree


Imperata cylindrica

Oil Palm plantations, Carbon sequestration, and riparian forest

Derived savannas, Southern Benin

Oil palm plantations

Oil palm plantations with Chromolaena Odorata in under story

Oil palm plantations with Chromolaena Odorata in under story

Lowland riparian forest with bamboo

Oil palm Structure and size

1. Well spaced out Trees (9 to 10 m Apart).

2. Chromolaena Odorata weed As under canopy.

3. Very large size (few hundred Hectares)

Humid Forests

Bayanga, Central African Republic

Lowland humid forests- measuring dbh

Lowland humid forests-GPS location data

Humid Forests

Bayanga, Central African Republic

Humid forest gaps, senescing

Upland humid forests; gathering GPS

Shifting Cultivation, Forest Fragmentation, and Secondary Forests

Forest margins, Near Yaounde, Cameroon

Humid forests and Logging

Forest margins, Yaounde-Ebalowa, Cameroon


Permanently flooded swamp forest


Logging trucks near Ebalowa, Cameroon

Secondary forest

Logging roads

Primary forests and Logging

Forest margins, Yaounde-Ebalowa, Cameroon

Severe logging in primary forests

Severe logging in primary forests

Relatively intact primary forests

Logging roads

Ground Truth Teams

Nigeria, Benin, and Cameroon

Ground truth team in Nigeria

Dinner in Mokwa, Nigeria

In S. Guinea savanna, Nigeria

Ground truth team in Cameroon

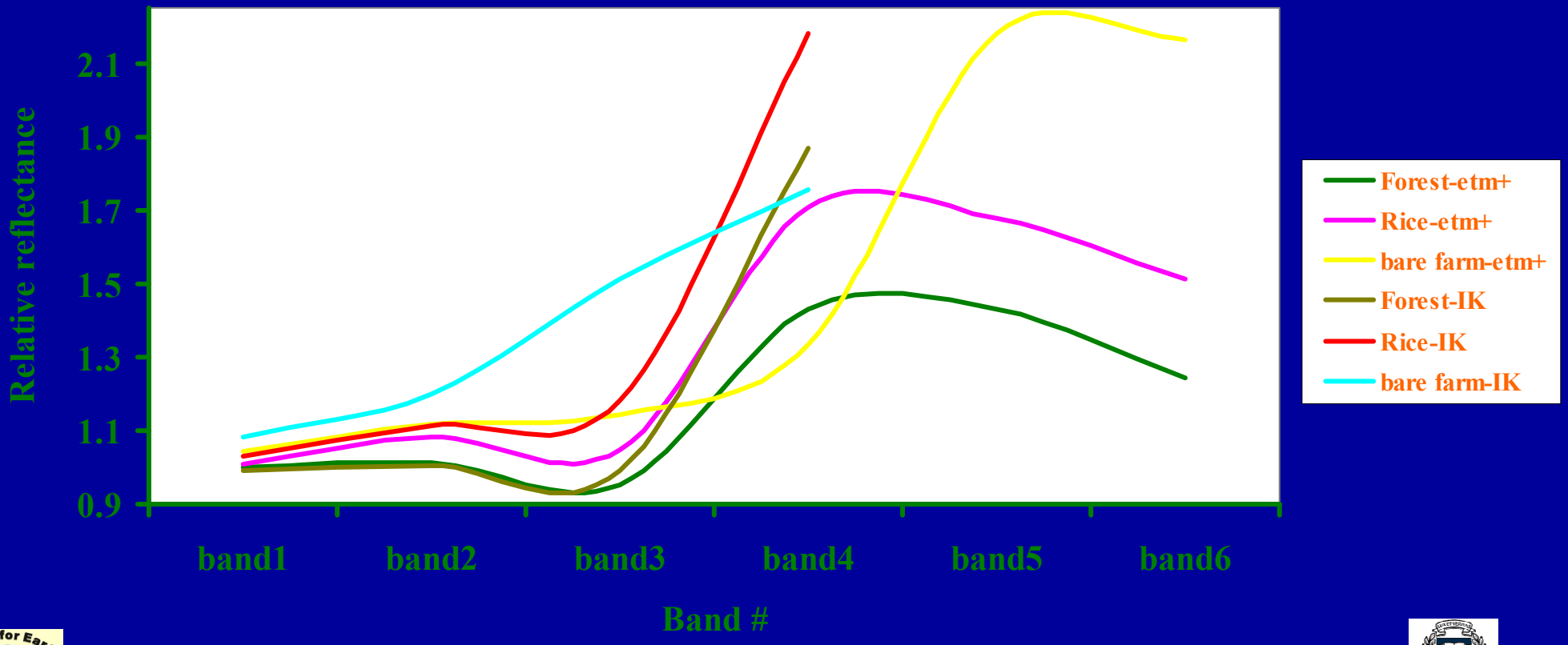
Shifting Cultivation, Forest Fragmentation, and Secondary Forests

Forest margins, Near Yaounde, Cameroon

IKONOS (Dec. 13, 2000) vs. Landsat ETM+ (Feb. 06, 2000)

Derived savanna, IITA, Ibadan, Nigeria

Magnitude of Reflectance in Wavebands for
Land Cover Types
relative to reflectance in deep water



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Concluding Thoughts

Hyperspatial IKONOS Data

- **New applications**: savanna tree density, individual trees in savannas, detail road-network including foot pathways;
- **Components of Landscape**: can be studied in great detail (e.g., biomass levels in rangelands, fallow systems like N fixation legumes, plantations like eucalyptus);
- **Agroforests and Carbon credits**: makes it feasible delineate and study agroforests (e.g., oil palm) and teak plantations for assessing biomass that could lead to determining carbon budgets;

4. **Precise within farm information**: specifically when farm sizes are small. Farm size and shape, and variability within individual farms.

…..and potential for many **New levels of Information** (e.g., what do 2 distinct types of rainforest tree crowns tell us?)…….are currently investigated.

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Concluding Thoughts

Hyperspectral (e.g., Spectroradiometer) Data

- **Agricultural fallows or regrowth dynamics**: it is possible to distinguish between various stages of regrowth fallows (e.g., < 1 year, 1-3 year) using hyperspectral data;
- **Characteristics of individual components of landscape**: spectral delineation of individual components of landscape (e.g., grasses, shrubs) shows promise;
- **Hypotheses 1**: indications are that the various levels of regrowth are best distinguished using specific narrow portions of the spectrum that need to be established;
- **Hypotheses 2**: individual components of landscape (e.g., grasses, shrubs, certain species types such as Chromolaena orodata and Imperata cylindrica) can be best characterized using high spectral resolution data.

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