



Remote Sensing and Monitoring the Land Surface for Sustainable Development: Desertification, Carbon Sequestration, and Sustainable Interventions

Larry L. Tieszen¹ and G. Gray Tappan²

Center for Earth Resources Observation and Science (EROS)
Space Tools and Solutions for Monitoring the Atmosphere in Support of
Sustainable Development

Austrian Academy of Sciences, Institute for Space Research

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¹ U.S. Geological Survey

² SAIC, Contractor to the USGS (work performed under USGS Contract 03CRCN001)

Remote Sensing and Monitoring

Presentation Outline

1. Introduction to EROS
2. Regional Centers and Continental Capacity Building
3. Land Cover Change and Desertification (West Africa)
4. Local Successes in Natural Resource Management

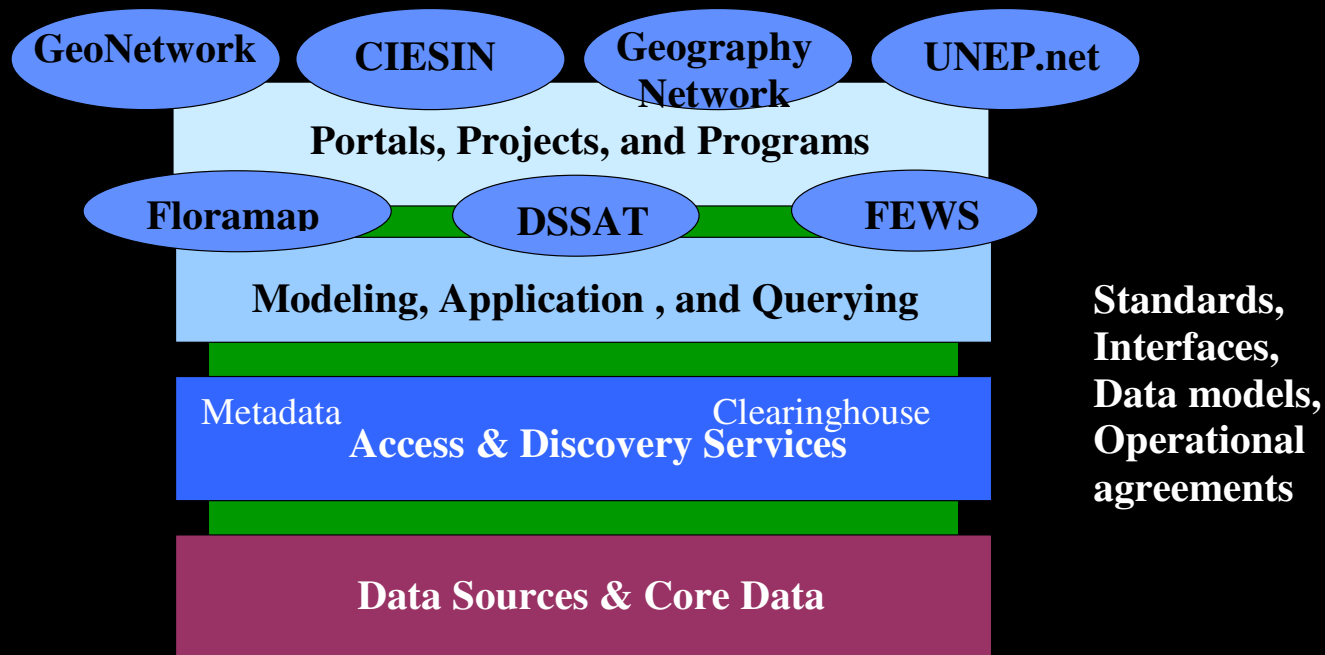
1. Introduction to EROS (Center for Earth Resources Observation and Science)

1. Landsat TM
Land Imaging Program, data are web-enabled!
2. Support **Global R & D**, Int. Treaties, Alliances, Global & Int. Science
3. Develop **Applications** for Monitoring & **Nat. Res. Mgt.**
4. Develop **World Leadership in Land Cover Applications of Remote Sensing** *Dynamic Monitoring of Ecosystem Processes (model pixel performance with archive/near-real-time input)*
5. Support **Climate Change Adaptation and Mitigation**
6. Disseminate & **Apply Transforming Technologies**, e.g., Implement **Internet Map Serving Systems, EMIS, EIS-A**
7. Achieve and Sustain **Capacity Building**

2. Regional Centers and Continental Capacity Building = Transforming Technologies in Africa

1. The Premise:
 - We are in the midst of developing Transforming Technologies
 - Potential to support significant sustainable development
2. The Hope.....:
3. The Concern.....:
4. What are these Transforming Technologies?
 1. **Remote Sensing** in near real-time for development as a “Public Good,”
 2. **Integrated Georeferenced (GPS) Databases** and capabilities,
 3. **GIS tools, models, and decision aids** that are Web-based,
 4. **Facile use of the Internet for access to data, information, understanding, and commercial transactions.**
5. Some Examples: **GeoCafe, SOCSOB**

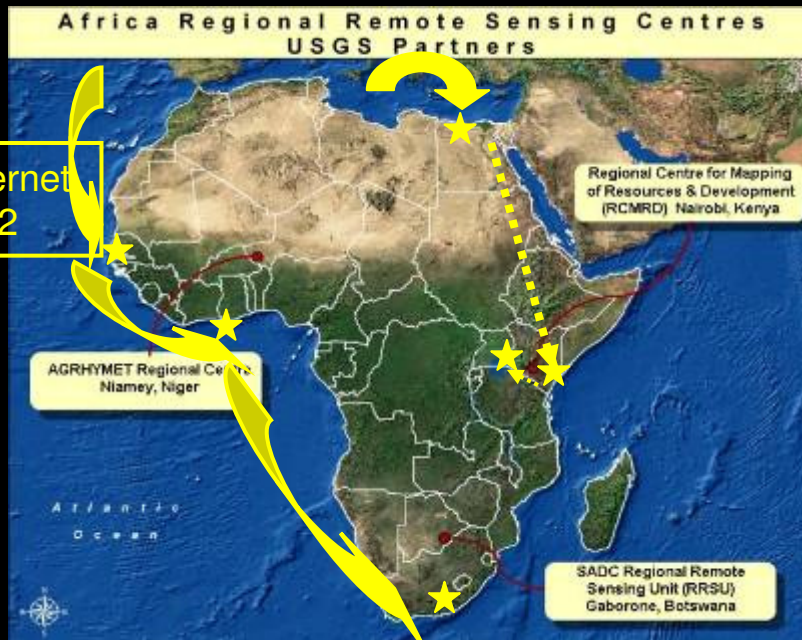
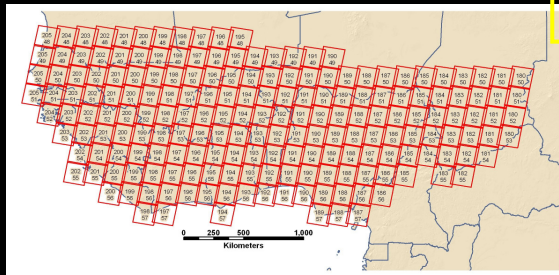
2. Regional Centers and Continental Capacity Building = Transforming Technologies in Africa



(This is “a **Browser and The Internet** accessing and producing data, information, and understanding - and supporting transactions”)

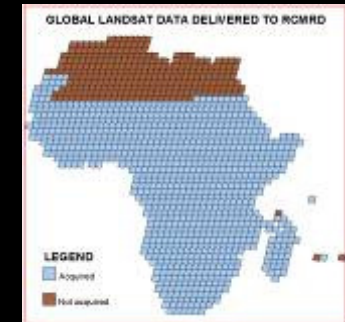
2. Regional Centers and Continental Capacity Building

AGRHYMET Regional Centre
 GeoCover (1970s, 1980s, 2000)
 + Landsat archive (EROS) +
 MODIS/ ASTER/ SRTM data

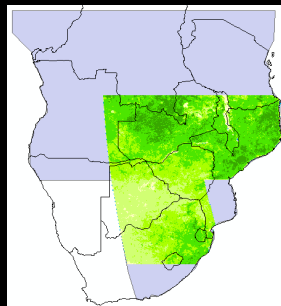
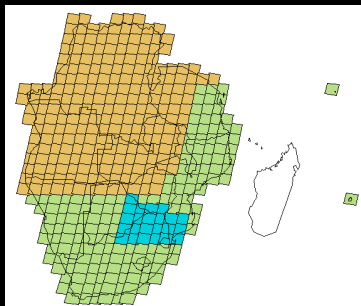


Regional Centre for Mapping of Resources for Development

Landsat 1990s



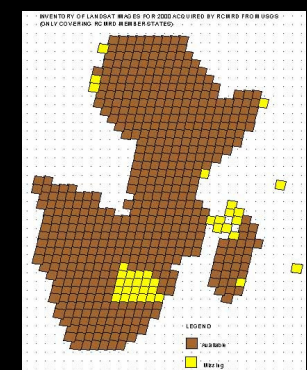
SADC Regional RS Unit
 Landsat (1970s/90s, 2000); MODIS NDVI



EROS Support to Regional Remote Sensing Centers

- collection/dissemination of RS data
- Landsat, SRTM, MODIS, ASTER
- training in applications of RS data

Landsat 2000



2. Regional Centers and Continental Capacity Building

Recommendations (specific)

1. **Secure (or nurture) government buy-in**, such that African governments provide national budgets for geo-information
2. **Institutionalize capacity building** to support proficiency in the development of RS applications and awareness of new applications
3. **Improve data availability, access, and distribution** (i.e., inexpensive or no-cost)
4. Expand and extend data and information portals
5. Develop/enhance RS capacity and RS curricula at universities and other tertiary institutions in Africa
6. **Improve access to regional and international RS communities**
7. **Improve infrastructure** for data access, analyses, and distribution – information technology, hardware, software
8. **Strengthen regional coordination**
9. Plan for future activities

2. Regional Centers and Continental Capacity Building

Special Considerations for Africa

1. The continent is large with numerous constituent countries & languages
2. There is no continental or even regional responsibility for standards
3. Internet and other communications are difficult or slow
4. Can we expedite or insure Internet 2 access?
5. Funding for centers is not secure
6. Centers and scientists are poorly networked professionally
7. Infrastructure needs to be developed
8. How do we address the needs of 3 (4 or 5) centers?
9. Can donors integrate the regional centers and network them effectively?
10. Impoverishment, climate change, AIDS, expanding populations, and political instability exacerbate development challenges
11. **Sustainability is the issue - not technology or even understanding**

Multi-Use Ecosystem Carbon Projects

(UNFCCC presentation at UNCCD-CRIC 3, Bonn)

- 1.
- 2.
- 3.
- 4.
- 5.



**Increased CO₂ Uptake
through Improved
Land Use and Management
Practices**

**Economic,
Environmental,
and Social
Benefits
for Locals**

**Benefits for
Global Climate
and
Global Society**

UN Conventions on Climate Change, Biological Diversity, and Desertification

Historical C Loss in Senegal

Senegal River Valley
6323 km²
2.8 x 10⁶ t biomass C
11.0 x 10⁶ t soil C
35-year flux -638 kg ha⁻¹yr⁻¹

SENEGAL
199823 km²
276.1 x 10⁶ t biomass C
451.0 x 10⁶ t soil C
35-year flux -418 kg ha⁻¹yr⁻¹

Northern Coast
1049 km²
2.6 x 10⁶ t biomass C
2.8 x 10⁶ t soil C
35-year flux +204 kg ha⁻¹yr⁻¹

Sylvo-Pastoral Zone
66523 km²
31.6 x 10⁶ t biomass C
142.9 x 10⁶ t soil C
35-year flux -191 kg ha⁻¹yr⁻¹

Old Groundnut Basin
25915 km²
53.7 x 10⁶ t biomass C
56.8 x 10⁶ t soil C
35-year flux -873 kg ha⁻¹yr⁻¹

So, what does this Represent in Value?

Estuaries
4095 km²
4.7 x 10⁶ t biomass C
12.6 x 10⁶ t soil C
35-year flux -292 kg ha⁻¹yr⁻¹

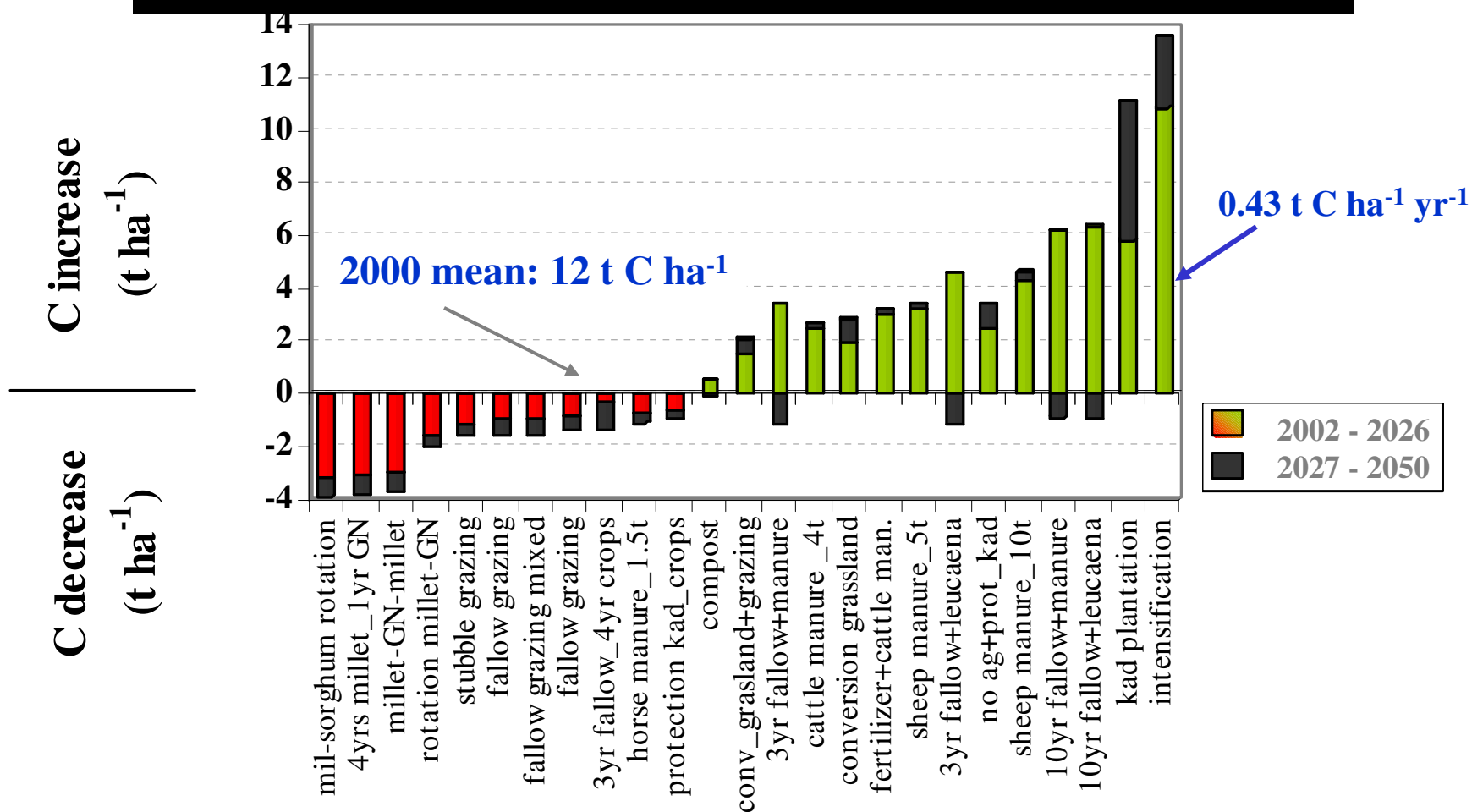
Oriental Transition Zone
56529 km²
89.3 x 10⁶ t biomass C
141.1 x 10⁶ t soil C
35-year flux -116 kg ha⁻¹yr⁻¹

New Groundnut Basin
14849 km²
25.4 x 10⁶ t biomass C
24.6 x 10⁶ t soil C
35-year flux -924 kg ha⁻¹yr⁻¹

418	kg/ha/yr
41.8	t C/km/yr
8,352,601	t C/Senegal/yr
\$83,526,014	Senegal/yr
\$ 2,923,410,490	Senegal/35 yr

Potential Future C Levels Simulated for Numerous Management Options

Changes in soil C over 50 years (0-20 cm), t C ha⁻¹



3. Land Cover Change and Desertification

Major Environmental Concerns in West Africa

- Rainfall has declined (Sahel)
- Natural resources degrading under increasing human pressure (agricultural expansion, wood cutting, etc.)
- Land Use and Land Cover changes occurring at unprecedented rates
- Forest cover diminishing by 2.9 million ha per year (Sub-Saharan Africa)
- Biodiversity has declined (flora and fauna)

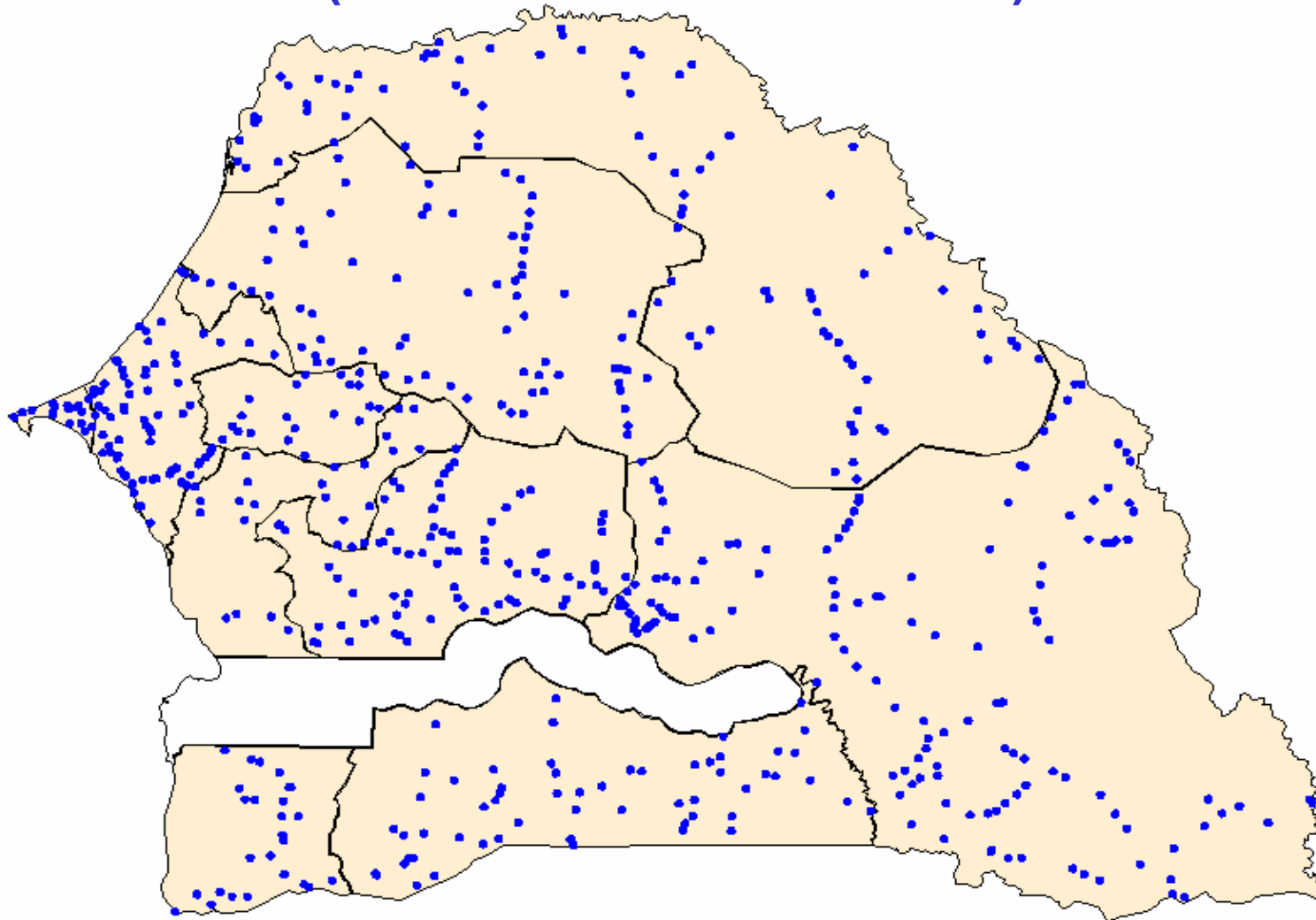


Desertification is defined as land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities.

(U.N. Convention to Combat Desertification, 1994)



Permanent Monitoring Sites in Senegal (Established in 1982-1983)



Revisit Ground Sites to Study Changes in Natural Resources



Monitoring Natural Resources in Senegal:

Human and livestock pressure (site 314)

1983



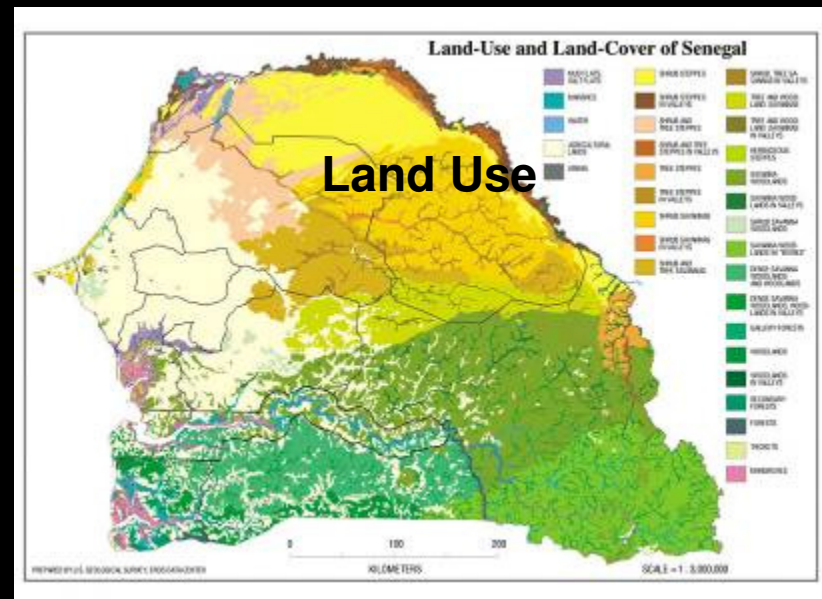
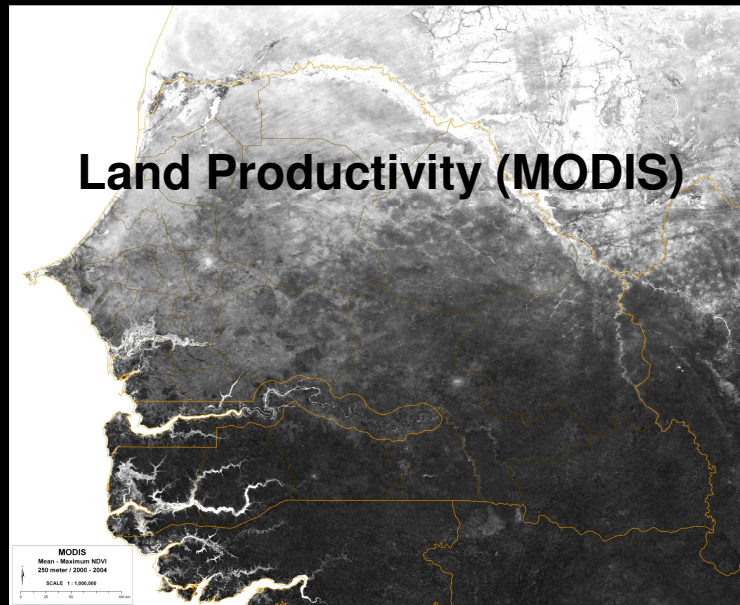
1994



Remote sensing systems that we use routinely over West Africa

- Meteosat
- SeaWIFS
- MODIS
- SPOT Vegetation
- NOAA-AVHRR
- Landsat MSS, TM, and ETM+
- Corona
- ASTER
- SPOT 5
- IKONOS
- Quickbird
- Historical Aerial Photography
- Recent Aerial Photography

Tools for Assessing Land Resources



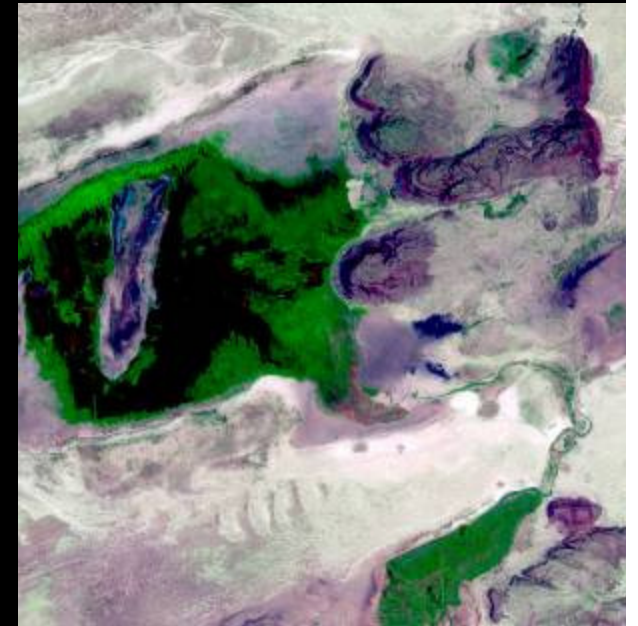
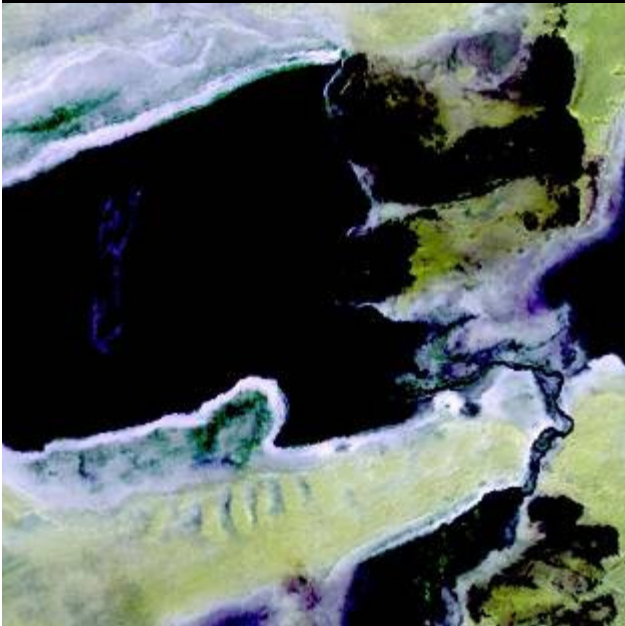
Lake Faguibine, Mali: A view through time



1972

1985

2000



26 km

West Africa LULC Trends: Goals

- Develop and Implement a West African regional LULC monitoring framework in partnership with AGRHYMET, INSAH, and national institutions
- Construct and provide a complete satellite image archive of West Africa for four periods: years 1965, 1972, 1985, and 2000
- Stratify West African landscapes by ecological regions
- Characterize and quantify LULC trends by ecoregion
- Produce LULC maps of West Africa for the periods of 1972, 1985, and 2000
- Provide information to CILSS and ECOWAS food security and natural resource management programs
- Engage decision-makers in the results of LULC trends, and involve them in running future scenarios of LULC using geographic models



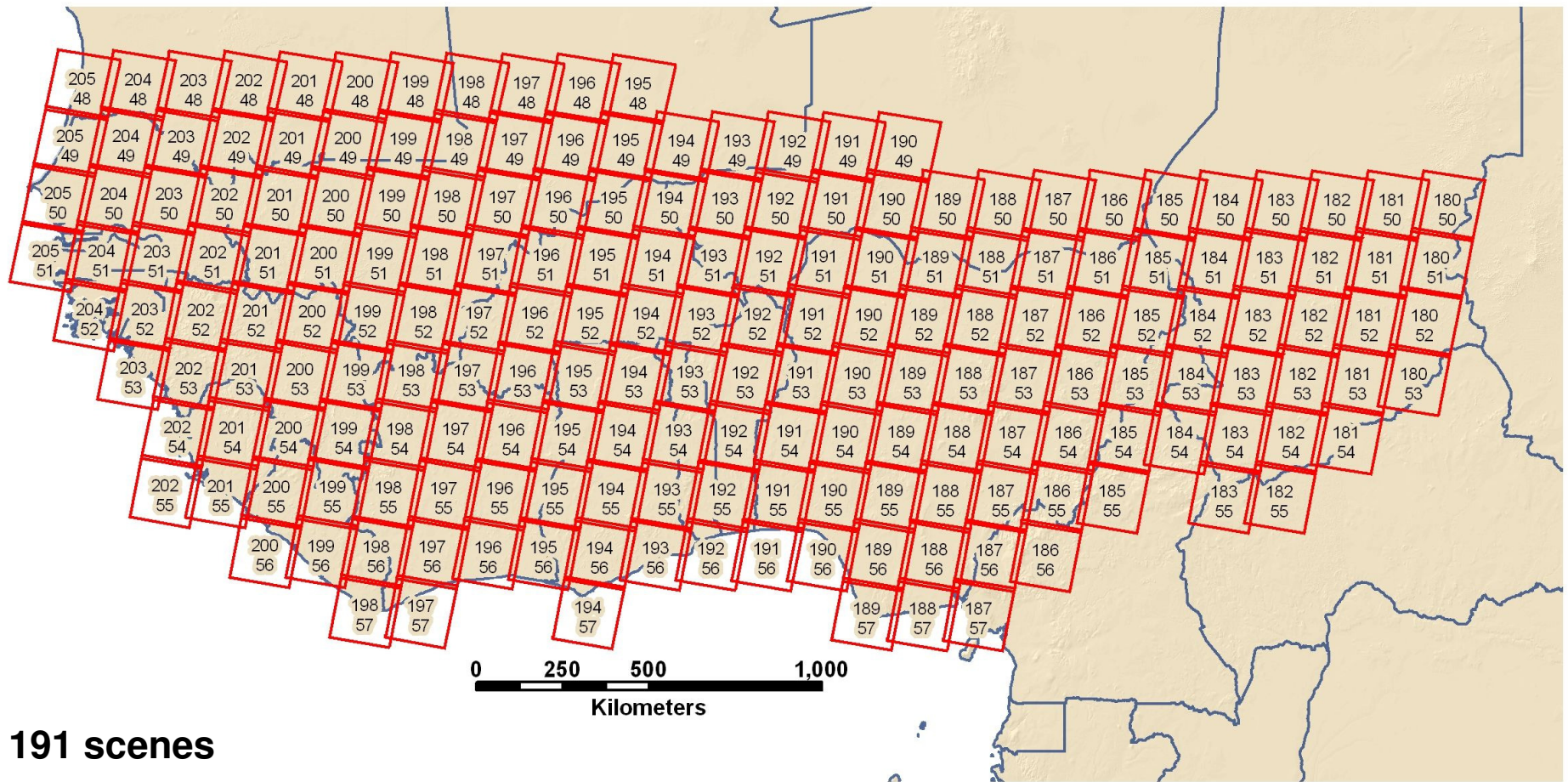
USAID
FROM THE AMERICAN PEOPLE



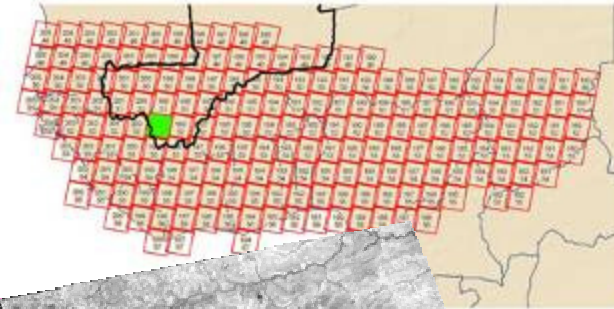
West Africa LULC Project Cooperators

- African Cooperators:
 - CILSS
 - Centre Régional AGRHYMET
 - Institut du Sahel
 - National Government Agencies
- US Cooperators:
 - U.S. Agency for International Development
 - U.S. Geological Survey

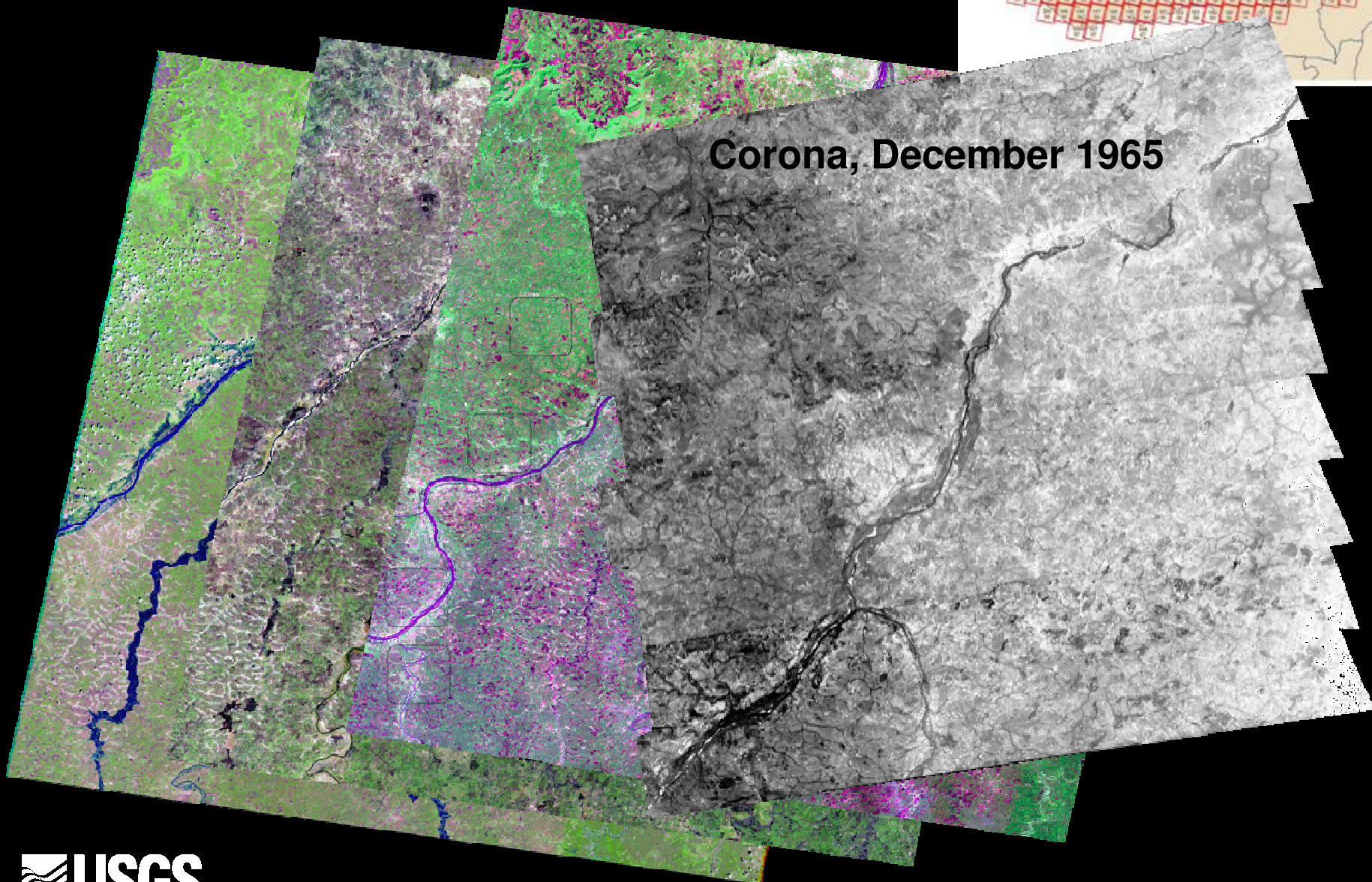
Geographic extent of the West Africa LULC Trends Project as depicted through Landsat scene coverage



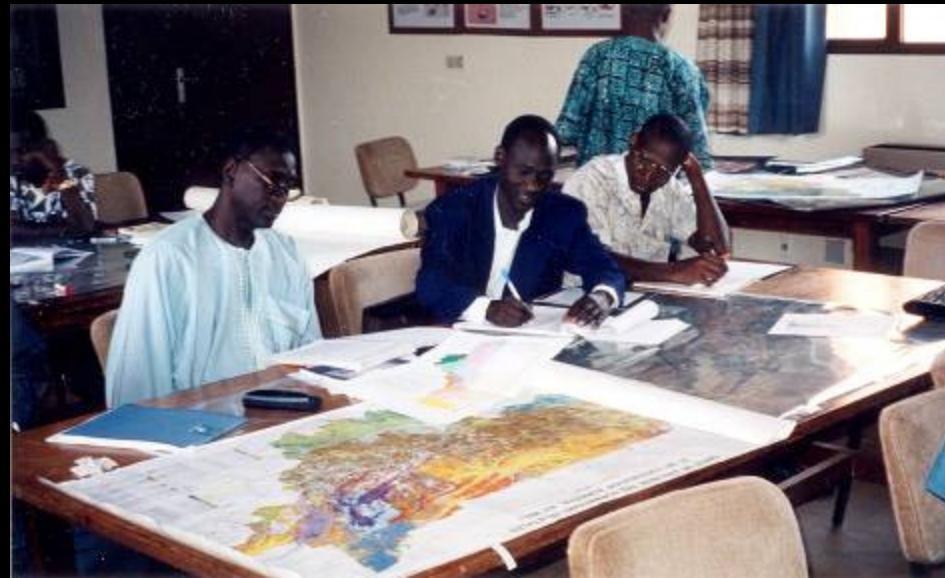
Four Periods of Image Coverage



Corona, December 1965



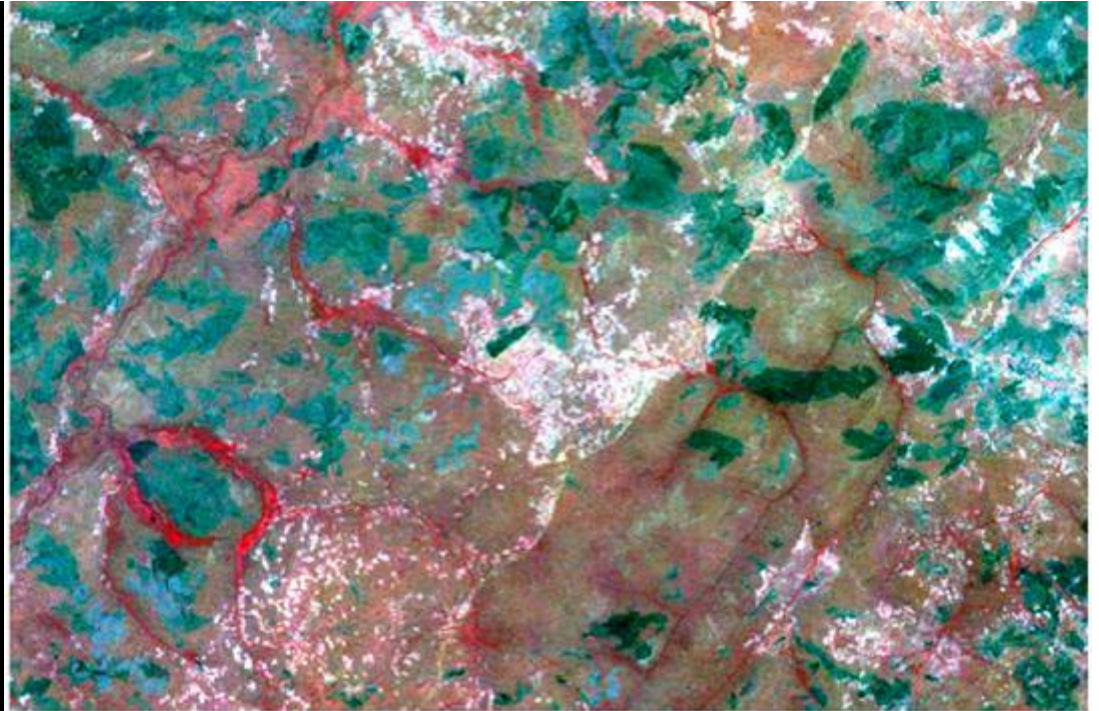
Workshop on the Stratification of Ecological Regions AGRHYMET / Niamey



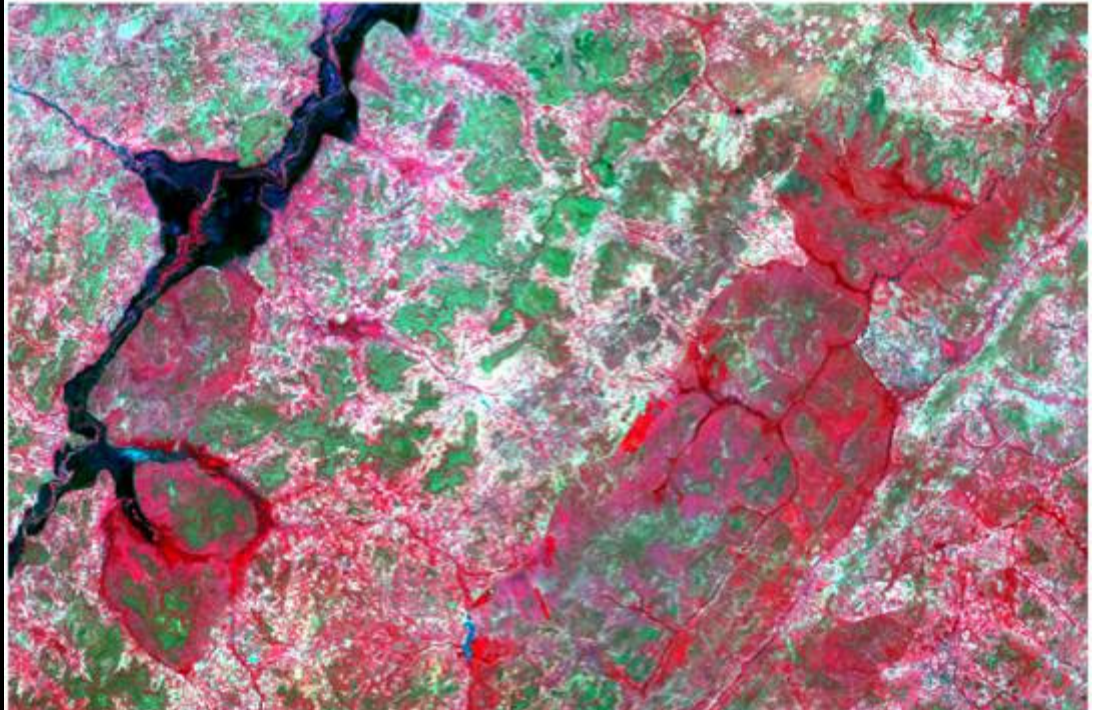
Landsat Time-Series

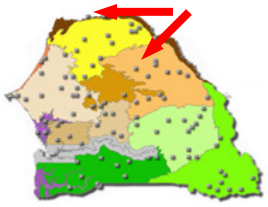
Burkina Faso: « Mare
Aux Hippopotames »

1973



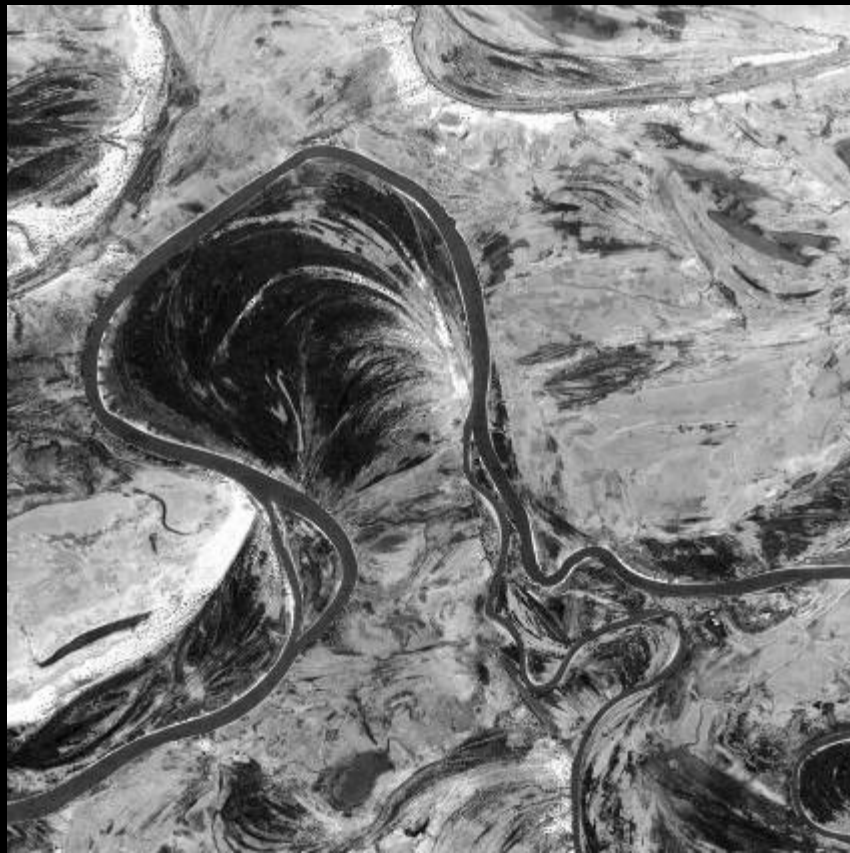
1999





Gonakié Woodlands: Middle Senegal River

Corona 1965



Landsat 1992



Riverine Woodlands of the Senegal River Valley



Preliminary Land Use/Land Cover Map, West Africa 2000

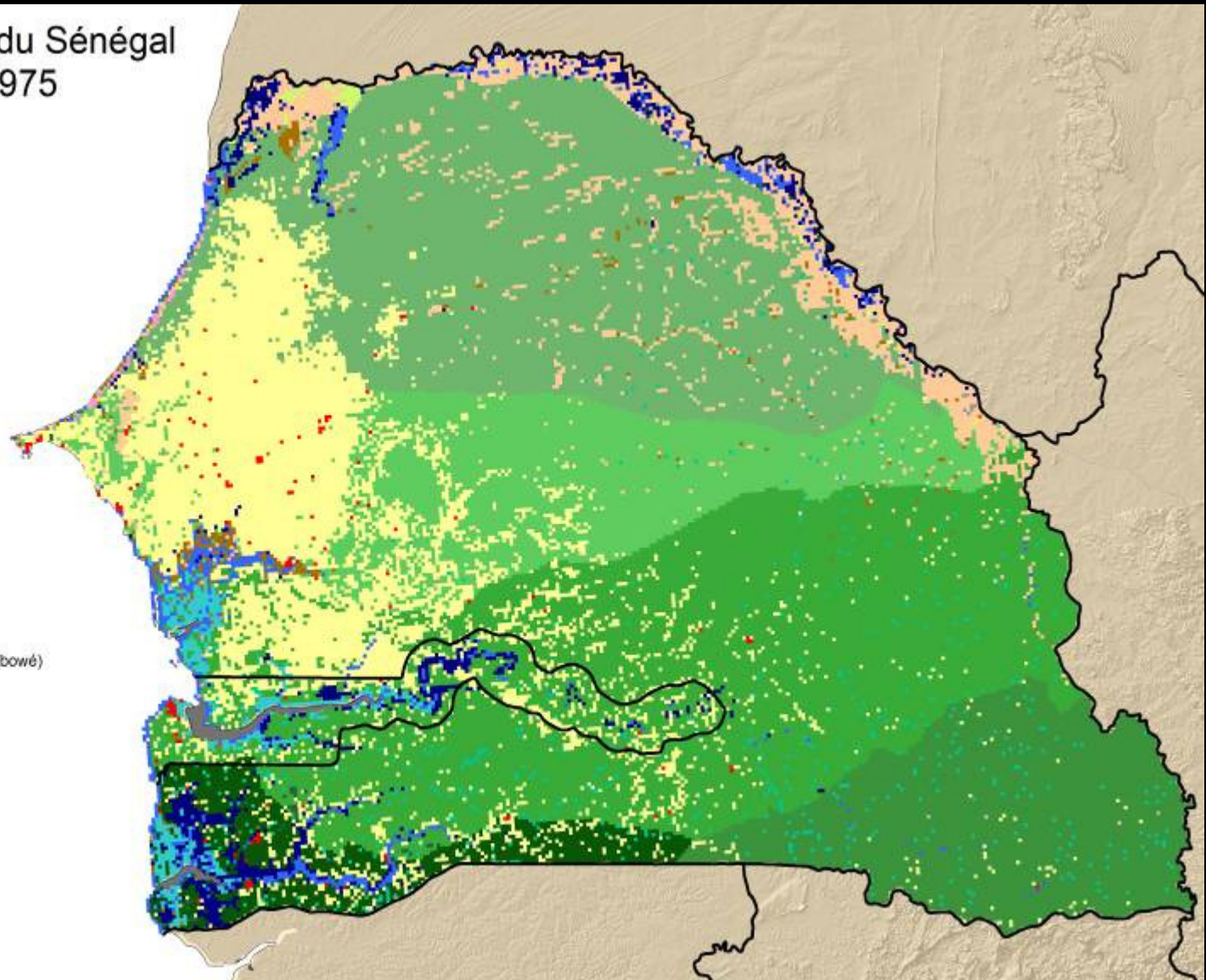


Land Use/Land Cover of Senegal and The Gambia, 1975

L'Occupation du Sol du Sénégal et de la Gambie en 1975

Résolution de 2 km

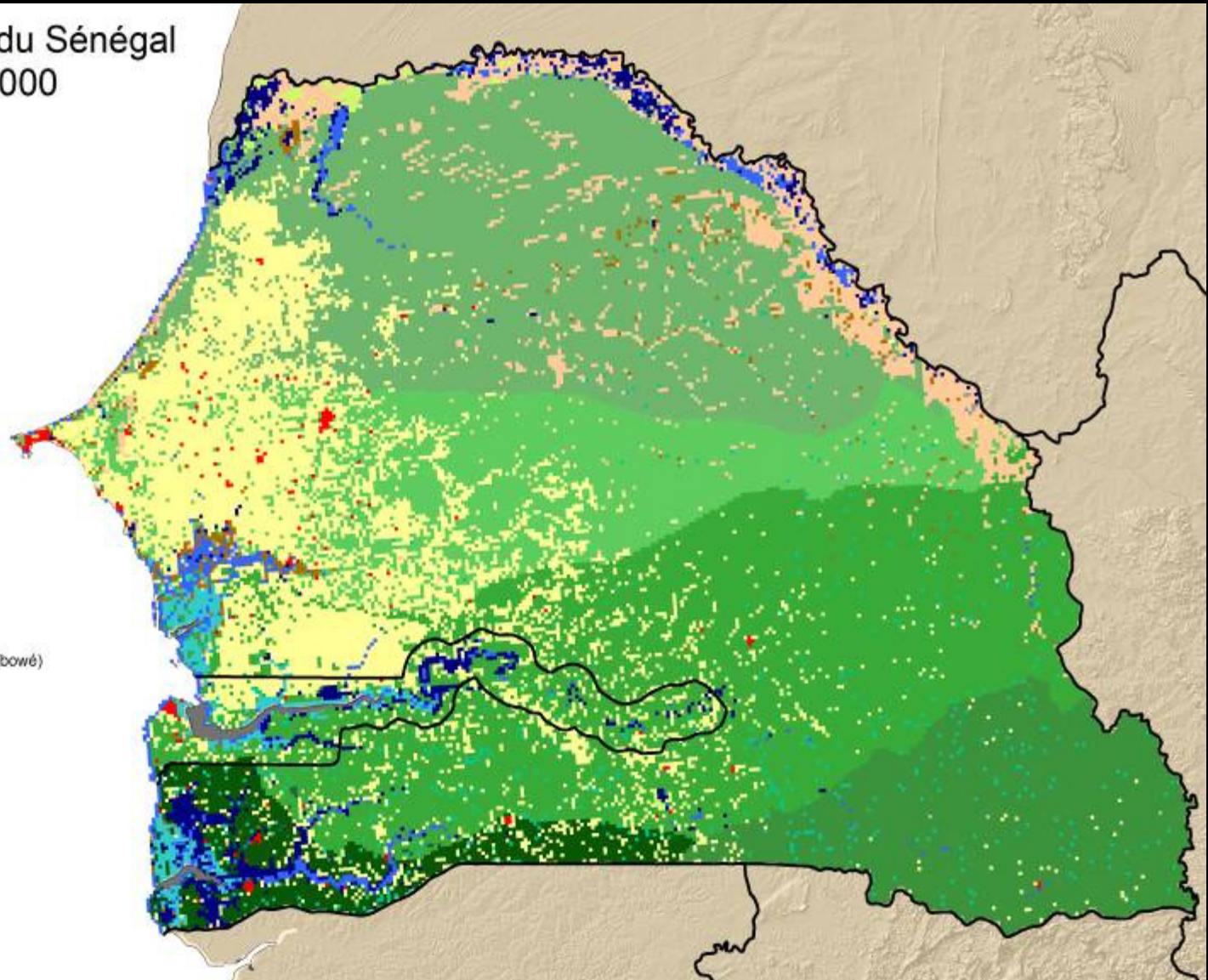
- Forêt
- Prairie marécageuse
- Steppe
- Plantation
- Mangrove
- Zone de Culture
- Plans d'eau
- Surface Sableuse
- Terrains Rocheux
- Sols Dénudés
- Habitation
- Zone de Culture Irriguée
- Forêt galerie
- Savane arbustive et arborée
- Savane arborée et savane boisée
- Savane boisée
- Savane boisée avec prairies herbacées (bowé)
- Savane boisée et forêt claire



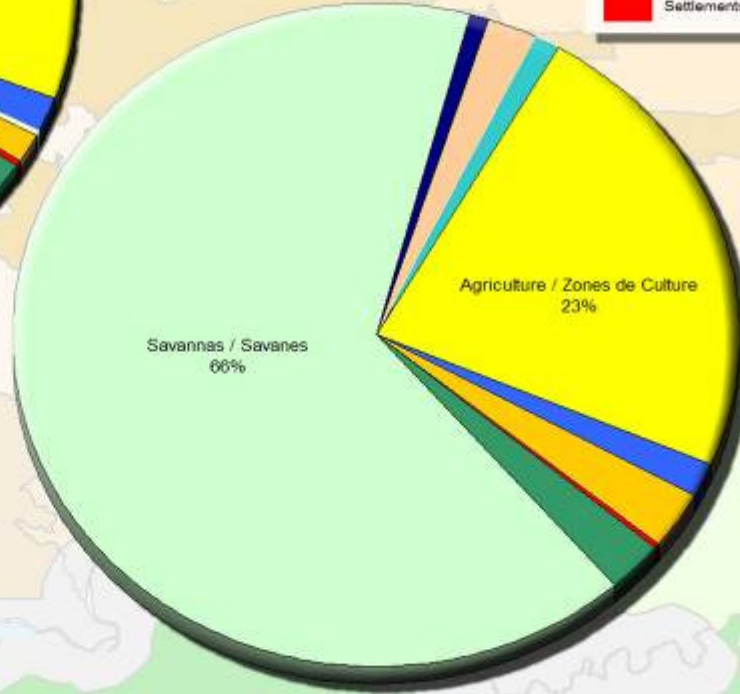
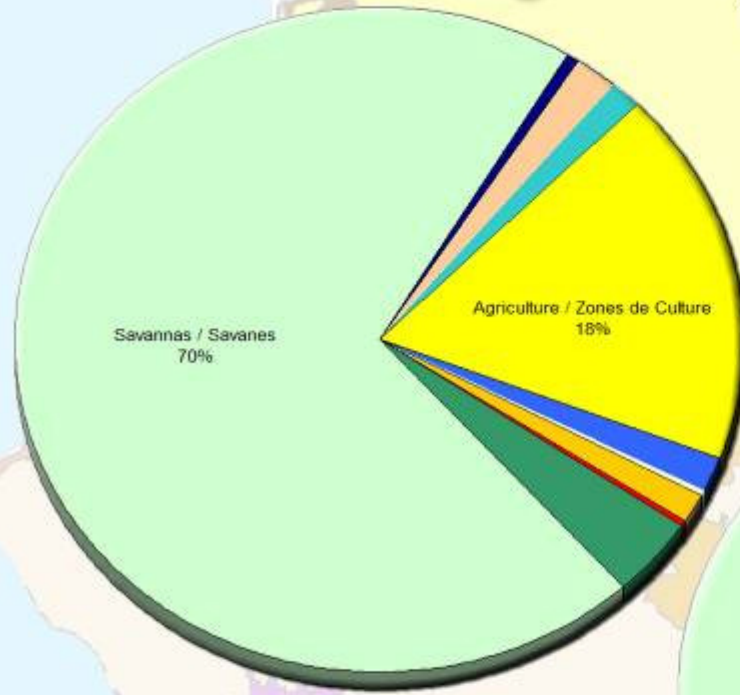
Land Use/Land Cover of Senegal and The Gambia, 2000

L'Occupation du Sol du Sénégal
et de la Gambie en 2000

Résolution de 2 km



Senegal Land Use / Land Cover Change. 1965 to 2000



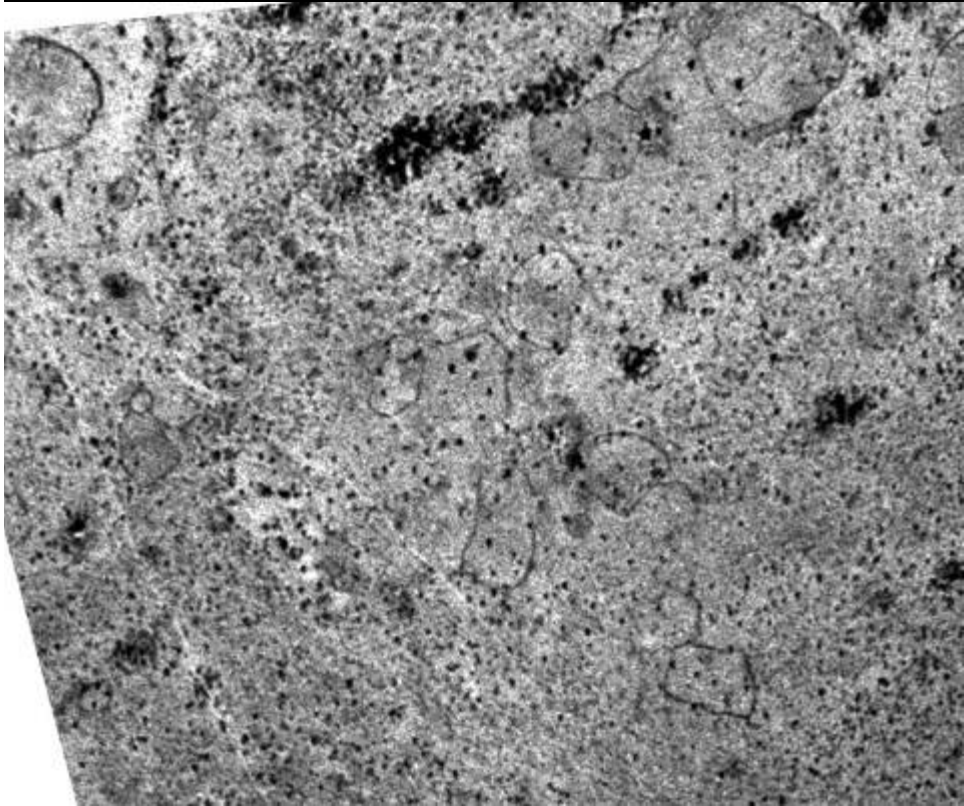
	1965	2000
Forests / Forêt	3.9%	2.3%
Savannas / Savanes	70.1%	65.7%
Wetland - Floodplain / Prairie marécageuse - Vallée	0.6%	0.7%
Steppes / Steppes	1.8%	2.3%
Mangroves / Mangroves	1.5%	1.1%
Agriculture / Zones de Culture	18.3%	23.0%
Water Bodies / Plans d'eau	1.7%	1.8%
Sandy Areas / Surfaces Sableuses	0.1%	0.1%
Bare Soils / Sols Dénudés	1.7%	2.7%
Settlements / Habitations	0.2%	0.3%

Prepared by U.S. Geological Survey, EROS Data Center
 F:\Projects\Gis\LandCoverChange\graphics



Basic Conclusions on Senegal's Land Cover Trends

- **Good news: rates of agricultural expansion into Senegal's woodlands and savannas is slower than what most official figures have claimed**
- **Rates of agricultural expansion have slowed Since the mid-1980s**
- **Bad news: Senegal's vegetation cover has significantly declined since the 1960s, both in terms of its density and its biodiversity**



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