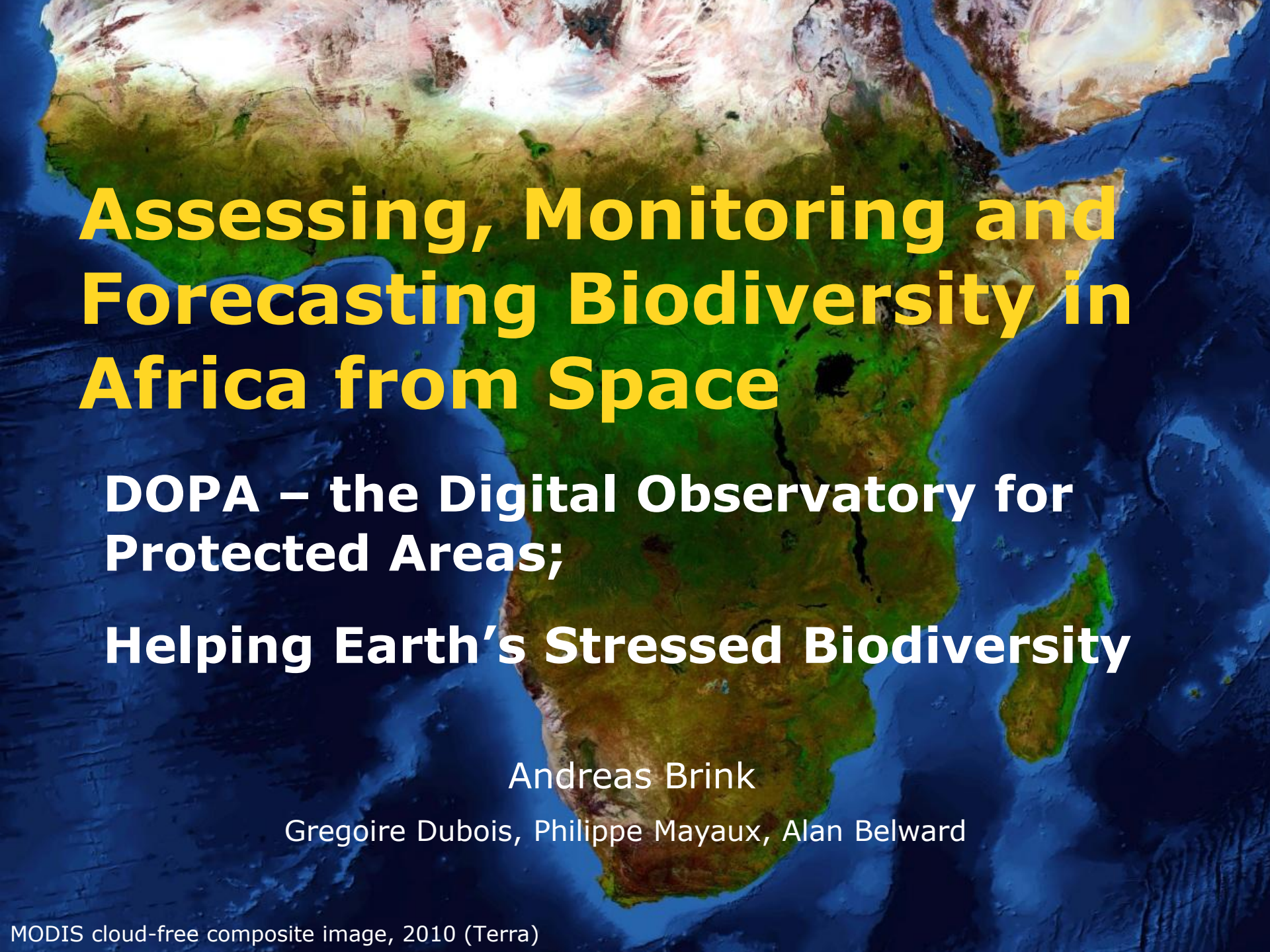


# Assessing, Monitoring and Forecasting Biodiversity in Africa from Space

## DOPA – the Digital Observatory for Protected Areas;

## Helping Earth's Stressed Biodiversity

Andreas Brink

Gregoire Dubois, Philippe Mayaux, Alan Belward

MODIS cloud-free composite image, 2010 (Terra)

European Commission

# Outline

- **the JRC**
  - The European Commission's Research-Based Policy Support Organisation
- **Biodiversity and Protected Areas**
  - Why are they important and what are the key issues and questions
- **DOPA – a toolbox for biodiversity**
  - Assessing, Monitoring and Ecological Forecasting in Protected Areas
- **Conclusions**

European Commission

# JRC – Robust science for policy making

- **As a Directorate-General of the European Commission, the JRC provides customer-driven scientific and technical support to Community policy making**

Supporting citizen's security, research on energy, environment, transport, climate change, safety of food and consumer products, security, crisis management, nuclear safety and security

European Commission

# Where does the JRC fit in the European Commission?

President Barroso

27 Commission Members

Commissioner Geoghegan-Quinn

*Research, Innovation and Science*

Joint Research Centre (JRC)

Research DG (RTD)

European Commission

# Our Structure: 7 Institutes in 5 Member States

**IRMM – Geel, Belgium**
- Institute for Reference Materials and Measurements

**ITU – Karlsruhe, Germany**
- Institute for Transuranium Elements

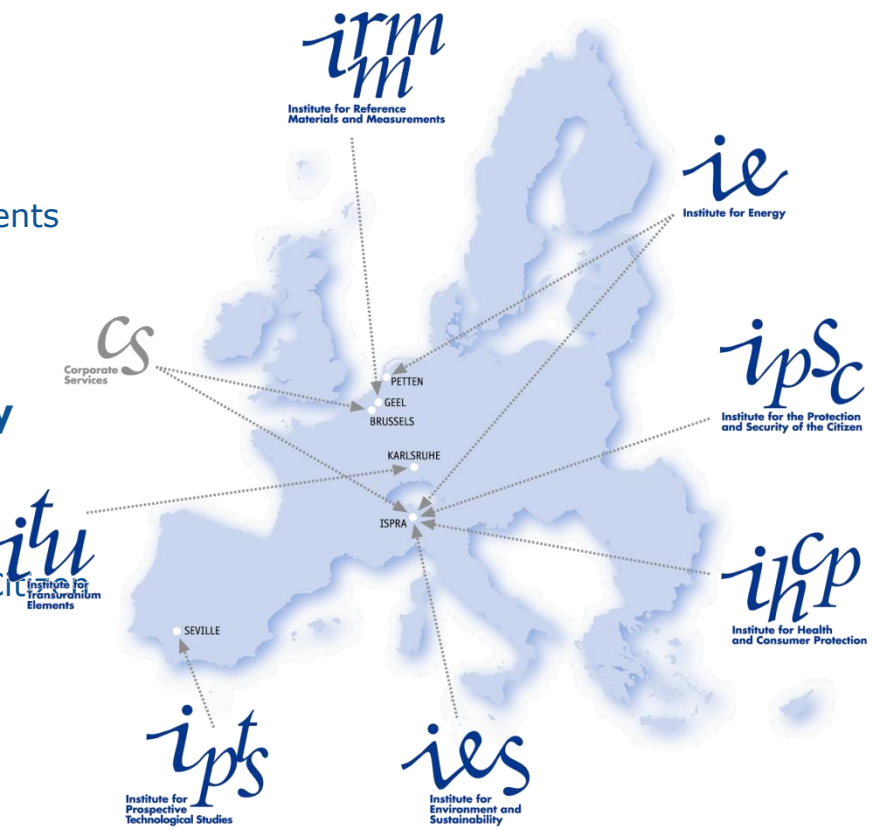
**IE – Petten, The Netherlands and Ispra, Italy**
- Institute for Energy

**IPSC – Ispra, Italy**
- Institute for the Protection and Security of the Citizen

**IES – Ispra, Italy**
- Institute for Environment and Sustainability

**IHCP – Ispra, Italy**
- Institute for Health and Consumer Protection

**IPTS – Seville, Spain**
- Institute for Prospective Technological Studies




~ 2750 staff

~ 345 M€/y institutional budget
(+ 60 M€/y earned income)

European Commission

# Human well-being depends on ecosystem services

## Provisioning

Food production

Timber production

Mining products

Fire wood

## Supporting/Regulating

Carbon stock

Water regulation

Habitat provisioning

## Cultural

Recreation

Cultural heritage

**Well-being**

MEA, 2005

European Commission

# The value of protected areas

- **Protected areas are the cornerstones of biodiversity conservation**
  - maintain key habitats
  - provide refugia
  - ensure the maintenance of natural processes across the landscape
  - provide livelihoods for people
  - source of drinking water
  - ensure food security
  - contribute to poverty reduction and sustainable development

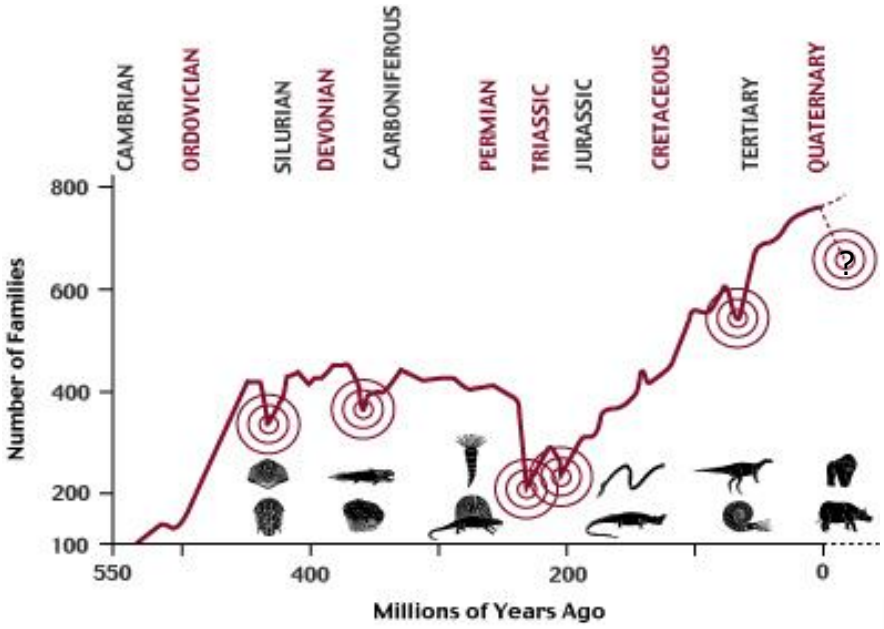


CBD, IUCN

European Commission

# Earth's changing biodiversity

- **Earth's biodiversity is not fixed**
  - Species extinctions occur without human intervention
  - The "big 5" extinction waves in geological history






Barnosky, et.al., 2011; Sepkoski and Raup, 1982

European Commission

# Earth's changing biodiversity – the sixth extinction wave?

- **Because of human activities Earth is losing biological species at unprecedented rates**
  - 60% of the world's ecosystems are degraded or used unsustainably
  - 75% of fish stocks are over-exploited or significantly depleted
  - 75% of the genetic diversity of agricultural crops has been lost worldwide since 1990
  - 13 million hectares of tropical forests are cleared each year
  - 20% of the world's tropical coral reefs have already disappeared



Barnosky, et.al., 2011; FAO; FRA, 2010; WRI, 2011

European Commission

# Earth's changing biodiversity – habitat loss

- The quality and quantity of a habitat is one of the main factors for the distribution and abundance of species
- The reduction in both quality and quantity of a habitat is therefore a key factor for species loss
- Habitat loss is identified as a main threat to 85% of all species described in IUCN's Red List



Jenkins, 2003; Scholes & Biggs, 2005; WWF, 2010

European Commission

# The global dimension

- **Rio+20 summit (2012) and the Convention for Biological Diversity (COP 2010)**
  - mainstreaming of biodiversity and ecosystem services in policies and decision-making processes
  - To at least halve and where feasible bring close to zero the rate of loss of natural habitats including forests;
  - To establish protected areas to comprise 17 % of terrestrial and inland water areas, and 10% of marine and coastal areas;
  - Through conservation and restoration, Governments will restore at least 15% of degraded areas.

European Commission

# The EU and EC dimension

- **EU biodiversity strategy to 2020: Our life insurance, our natural capital**
- **Six targets**
  - Full implementation of EU nature legislation to protect biodiversity
  - Better protection for ecosystems, and more use of green infrastructure
  - More sustainable agriculture and forestry
  - Better management of fish stocks
  - Tighter controls on invasive alien species
  - A bigger EU contribution to averting global biodiversity loss



EC COM(2011) 244 final

European Commission

# EU funding for Biodiversity - for the EU

- **LIFE is the EU's financial instrument supporting environmental and nature conservation projects throughout the EU, as well as in some candidate, acceding and neighboring countries.**
  - Since 1992, LIFE has co-financed some 3506 projects, contributing approximately €2.5 billion to the protection of the environment
  - Total budget for the period 2007-2013: €2.143 billion

European Commission

# EU funding for Biodiversity - outside EU

- **<u>Environment for development</u>: The overall objective is to assist developing countries in preventing environmental degradation, biodiversity loss and unsustainable use of natural resources while improving the resource efficiency of economic growth and reducing pollution**
  - Total budget for the period 2011-2013: €154.5 millions
  - Biological diversity: € 73.0 millions
    (including marine biological diversity, forest conservation, and desertification)
  - Forest governance/FLEGT: € 55.0 millions
  - Green economy: € 26.5 millions

European Commission

# The JRC dimension

- **Support to EC and member states**
- **Support to CBD, GEOBON**
- **Projects:**
  - EuroGEOSS, UncertWEB, Geoland2, AMESD, BIOPAMA, PacsBio
- **Remote Sensing offers a broad range of products that can contribute to monitoring progress towards these targets. Essential will be the global monitoring in and around Protected Areas**

European Commission

# Protected areas – key questions

- Are the Protected Areas really protected?
- Are the Protected Areas in the right place?
- Are they optimally connected?
- Where should new Protected Areas be located?
- Where should funds be targeted?
- How will the above change as human populations, infrastructure, economy and climate change?

European Commission

# Scientific and data borders and gaps

- **Biodiversity studies at different scales and disciplines are rich, but compartmentalized**
- **A very large number of databases are built and populated**
- **But data ownership, formats and access differ**
- **The answers to many management issues thus remain elusive – or at least incomplete**

European Commission

# The Digital Observatory for Protected Areas (DOPA) - building bridges

- **Based on remote sensing, geo-spatial and modeling techniques**
- **Web services, combining data from different owners and location to monitor past and current conditions in PAs and provide forecasts and scenarios to support management**

UNEP WCMC JRC EUROPEAN COMMISSION GBIF BirdLife INTERNATIONAL DOPA RSPB

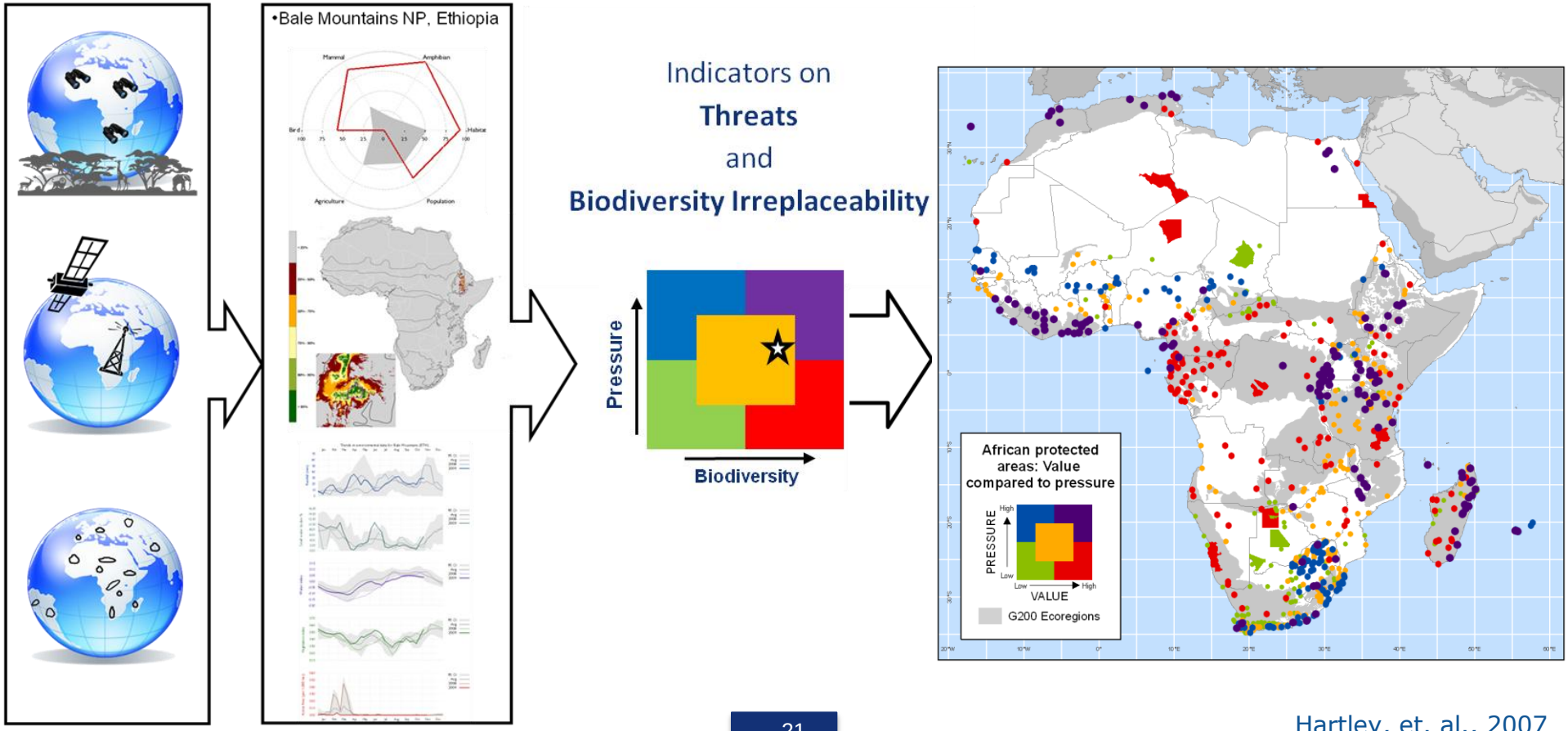
European Commission

# DOPA principles

- **DOPA integrates data and detects uncertainties and error propagation between partner web services**
- **DOPA increases the reusability of data, models and IT infrastructure**
- **DOPA captures ecological information from the ground and space**
- **DOPA automates data exchange and modeling, thus aiding repeated assessments**

European Commission

# African Protected Areas Assessment Tool (APAAT) - 2007






Hartley, et. al., 2007

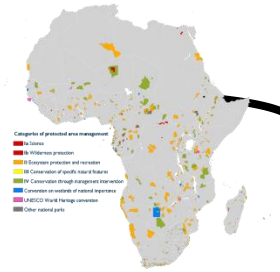
European Commission

# APAAT

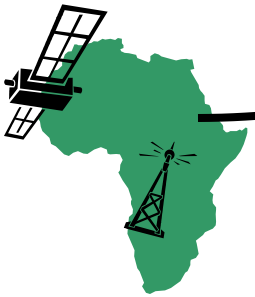
- **Analysed:**
  - 741 protected areas
  - across 50 countries
- **Used:**
  - information on 280 mammal, 381 bird and 930 amphibian species
  - wide range of climatic, environmental and socioeconomic information
- **Produced:**
  - Biodiversity indicators
  - Index for habitat irreplaceability
  - Indicator for anthropogenic pressure

European Commission

# APAAT (cont.)

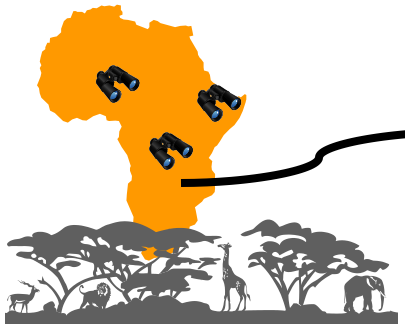


UNEP WCMC



SPOT IMAGE

1. Observations and Data Collection



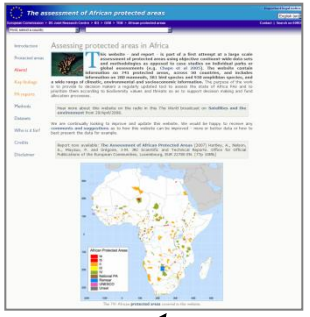
BirdLife INTERNATIONAL IUCN

2. Data Management and Quality Assurance

JRC EUROPEAN COMMISSION

3. Data integration and analysis

4. Publication



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# Limitations and lessons learnt from the APAAT experiment

- No reusability of data and models by third parties
- High maintenance costs (one big program, changes & updates complicated)
- We need to go beyond the boundaries of Protected Areas (connectivity, fragmentation, new PAs are major issues)

European Commission

# Limitations and lessons learnt from the APAAT experiment (cont.)

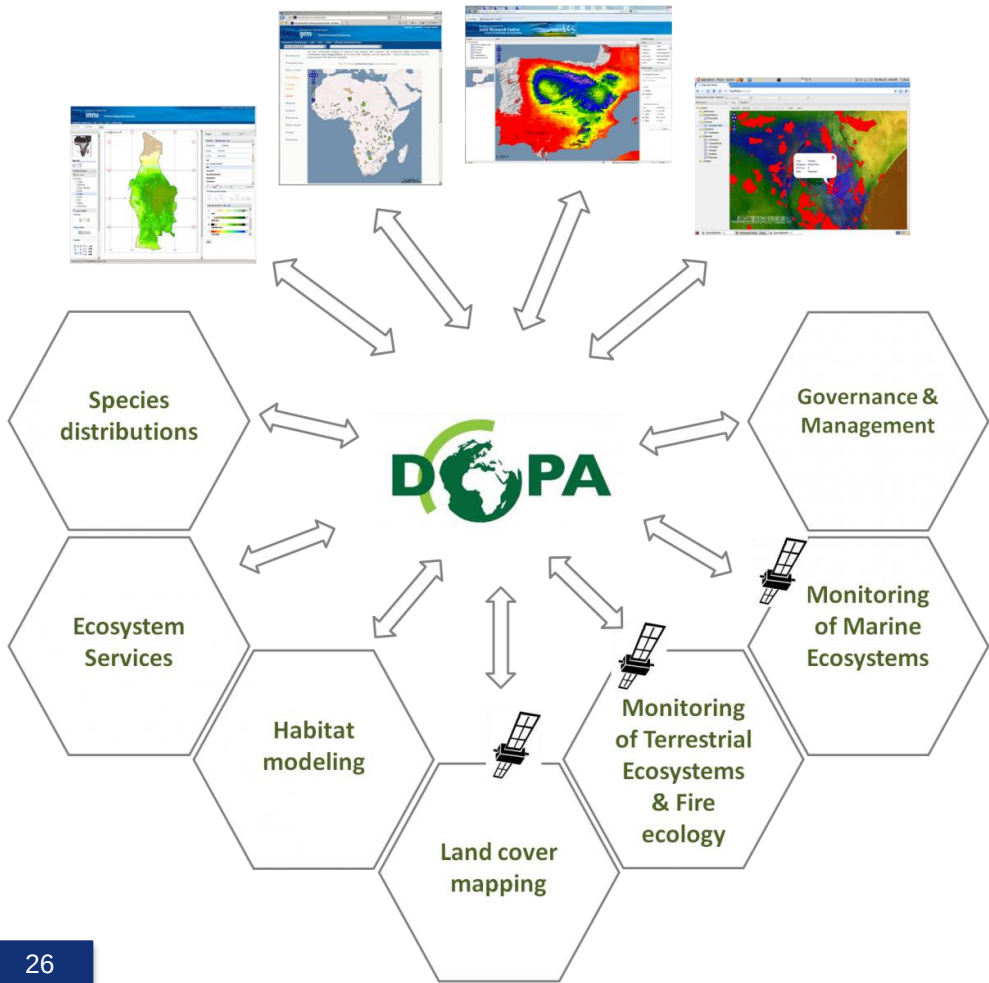
- Limited to Sub Saharan Africa. Policy issues become more and more global and there is a need for accessible global reference data and information systems
- Increase reusability of data, models and IT infrastructure for improved communication and reduced maintenance costs

GEO BON

European Commission

# DOPA

- **DOPA is based on a set of web services to assess, monitor, and forecast biodiversity at the global scale**




http://dopa.jrc.ec.europa.eu/

European Commission

# DOPA data flow

Protected Areas

UNEP WCMC

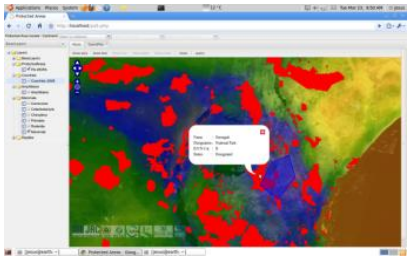
Habitats

JRC EUROPEAN COMMISSION

Species

GBIF BirdLife INTERNATIONAL RSPB

DOPA



Ecological Monitoring & Forecasting

European Commission

## IT developments

Species Analyst

Protected Areas Governance

Ecosystem Services

DOPA

Marine Ecosystem Monitoring

Habitat modeling

Land Cover Change

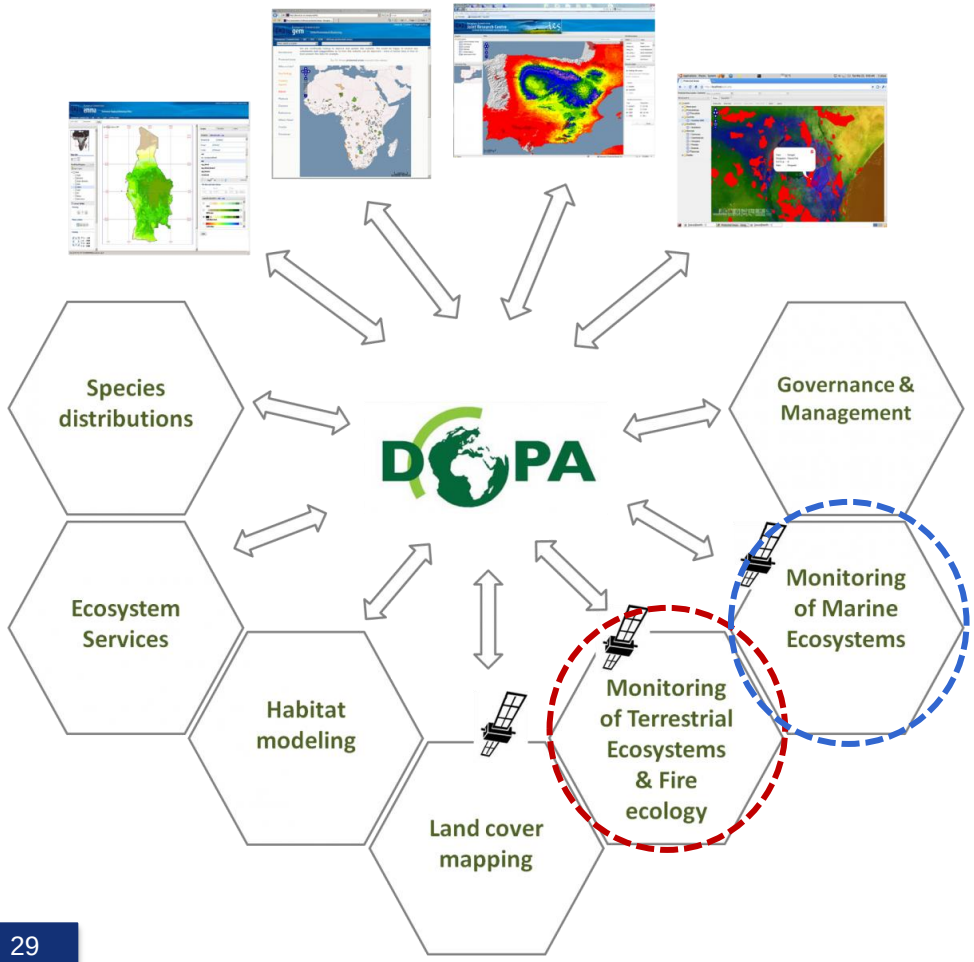
Terrestrial Ecosystems Monitoring

European Commission

# DOPA components (1)

- **eStation**
  - automatic reception, processing & analysis tool of key environmental parameters derived from remotely sensed data

http://estation.jrc.ec.europa.eu/



European Commission

# eStation

- **Remote Sensing for Biodiversity**
  - Originally a stand alone product developed by JRC for processing remote sensing data
  - Adopted by AMESD program and distributed to 48 sub-Saharan African countries
  - Processing data received via Eumetcast and the Internet
  - eStation generates indicators and images from various sensors (SpotVegetation, MSG, MODIS,…)

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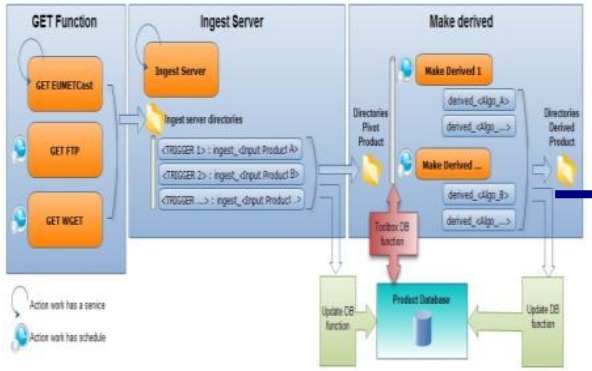
# eStation - concept

EumetCAST

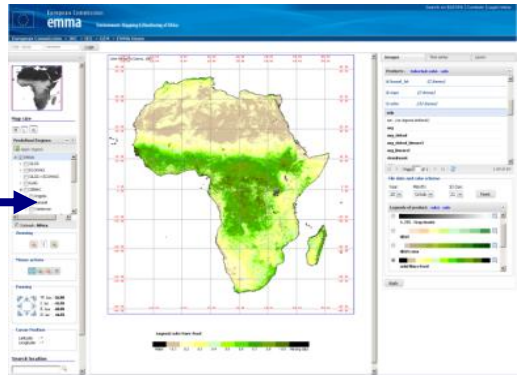
Data provider (ftp server)

## Processing Station (PS)



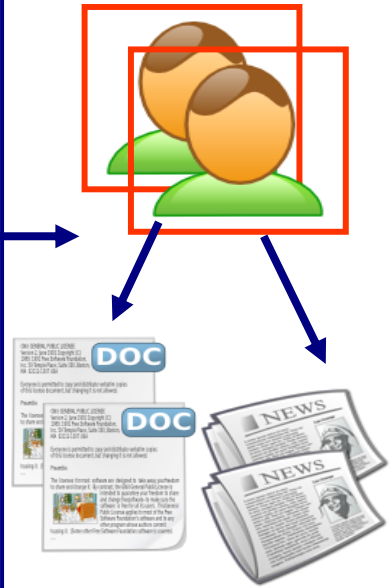

- Format Conversion
- Ad hoc indicators

## Analysis (EMMA)




- GIS tools (MapServer)

## Reporting



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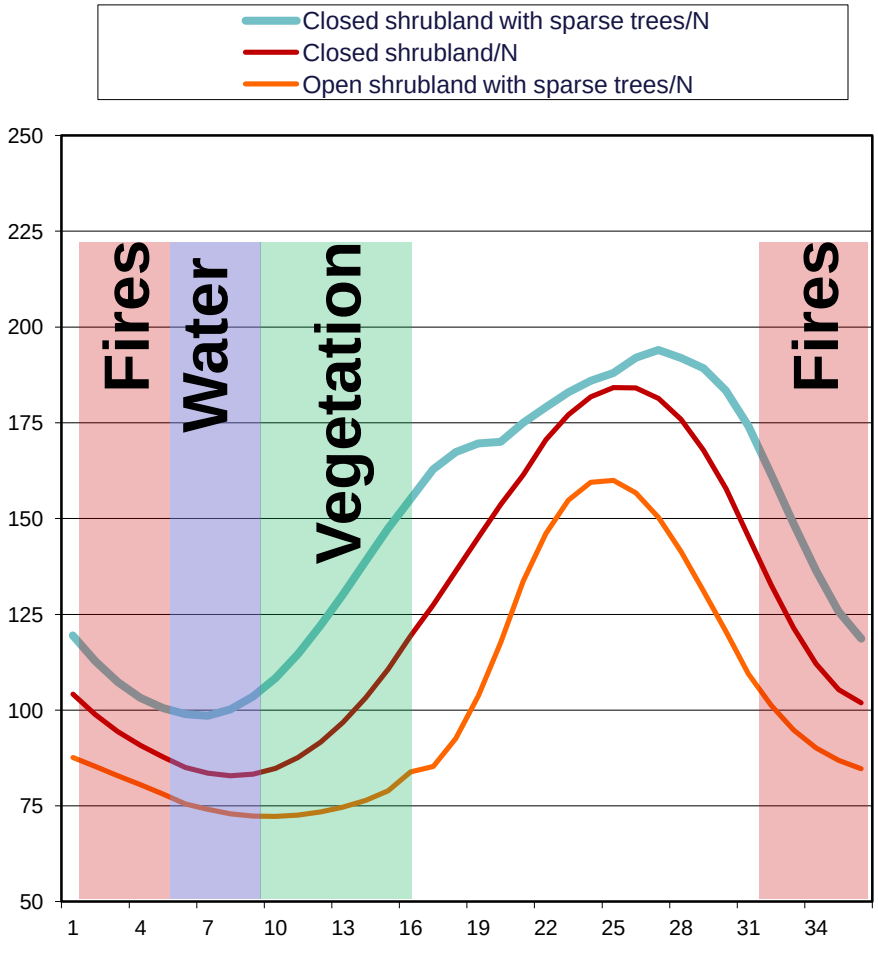
# EumetCast data and distribution

| | SPOT-VGT<br>10 days synthesis | Meteosat SG<br>15 minutes | LandSAF<br>15 minutes |
|---|---|---|---|
| **Meteo** | Albedo | AMV, CDS, CLA, CLAI, CLM, CRM, CSR, CTH, DIV, FIR, FRP, FRE, GII, HPI, IDS, MPE, MSA, OCA, OLR, SST, TH, TOZ, UTH, VOL | Albedo<br>Atmospheric fluxes<br>Land Surface Temperature |
| **Vegetation** | Dry Matter Productivity<br>NDVI = vegetation index<br>Leaf Area Index<br>Fractional Cover<br>Phenology (start, end…)<br>Vegetation Production Index | | Leaf Area Index<br>Fractional Cover<br>FaPAR |
| **Water** | Surface Water Bodies<br>NDWI = moisture index | | Evapotranspiration |
| **Fires** | Burned area | | Radiative power |

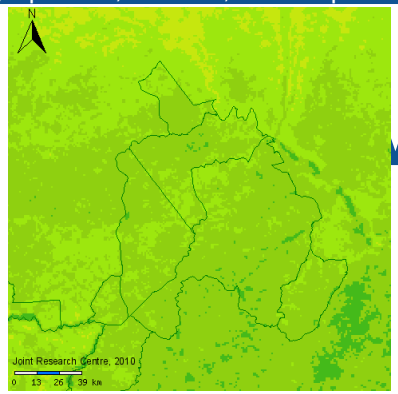
European Commission

# Application for PAs - seasonal monitoring of ecological parameters

- **Variables to monitor as limiting/driving factors for animal biodiversity**
  - Vegetation: scarcity of forage at the end of the dry season and beginning of rainy season
  - Water: scarcity at the end of dry season
  - Fires: entire dry season




Pettorelli, et. al., 2011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Joint Research Centre, 2010
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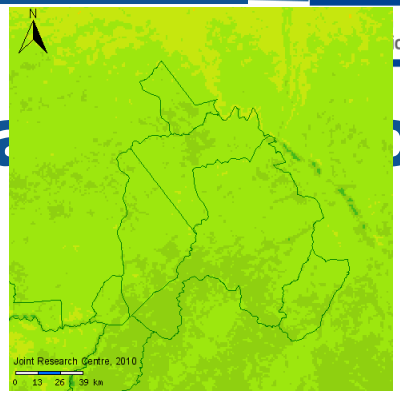
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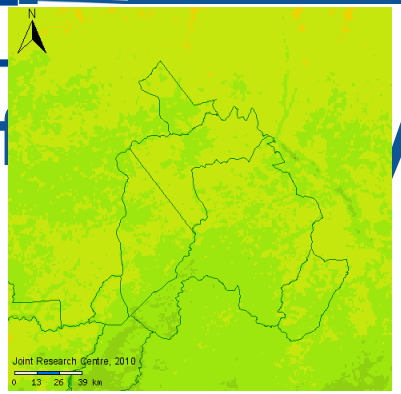
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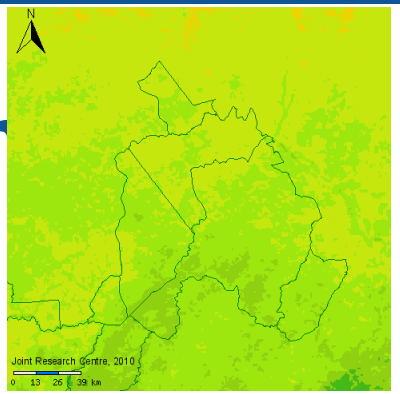
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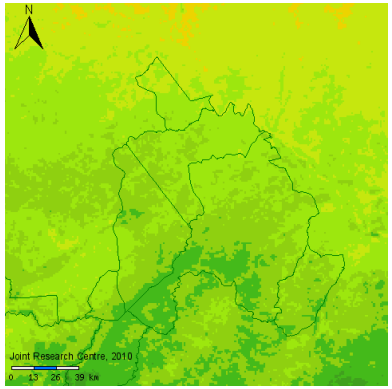
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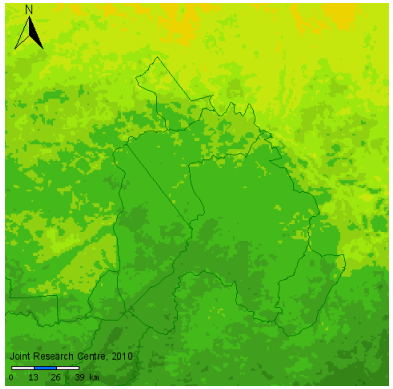
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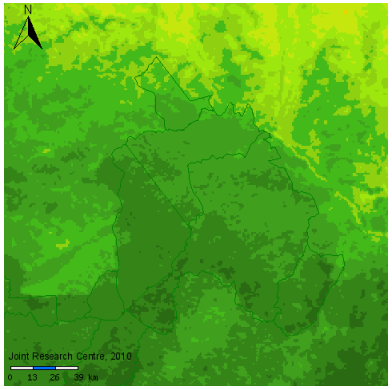
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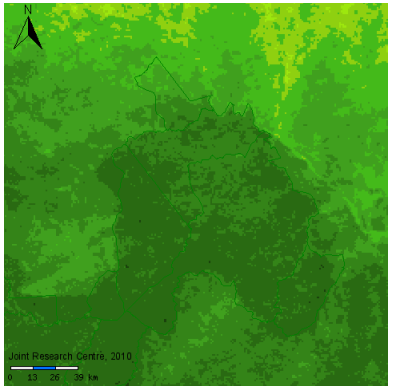
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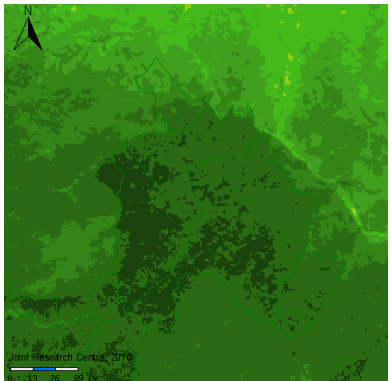
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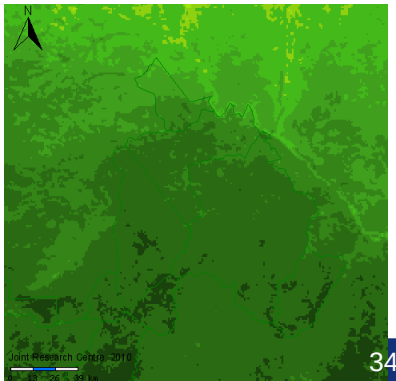
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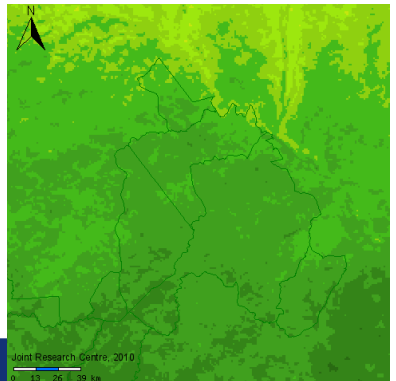
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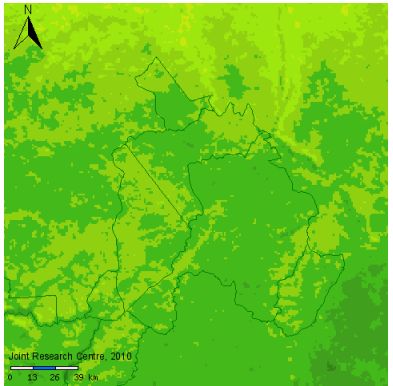
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Joint Research Centre, 2010

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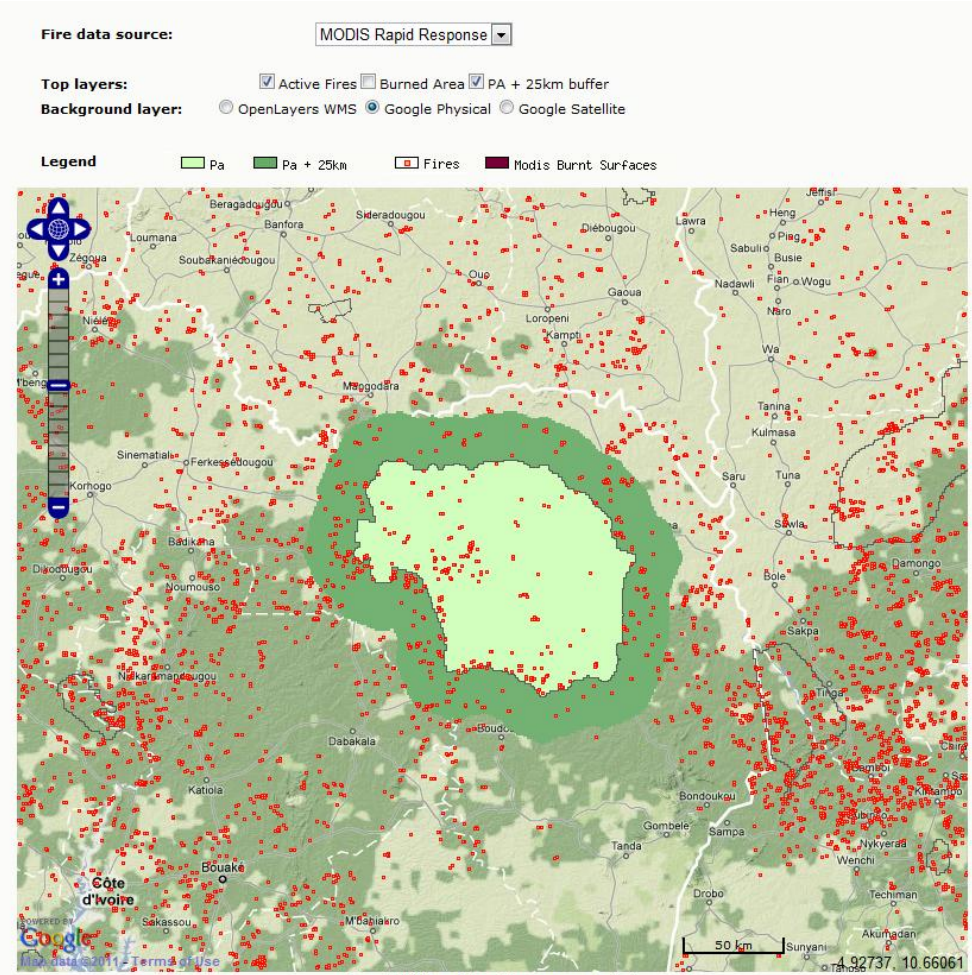
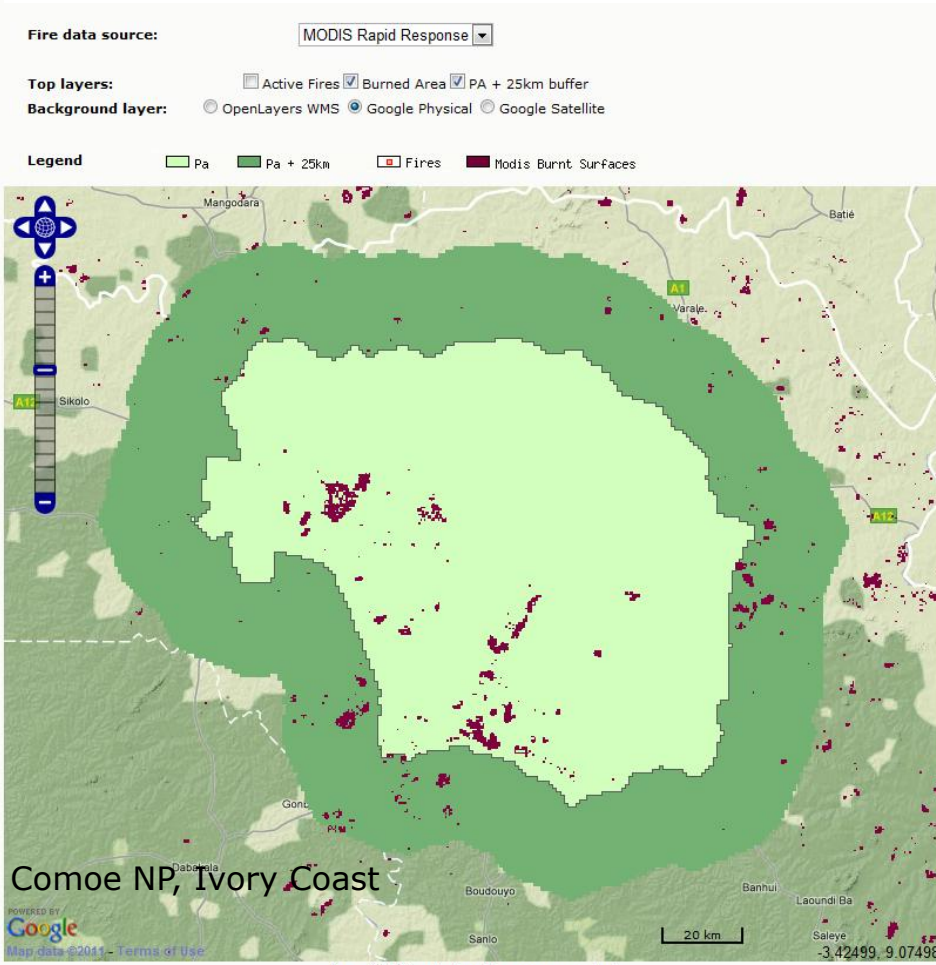
# Monitoring Fire Ecology

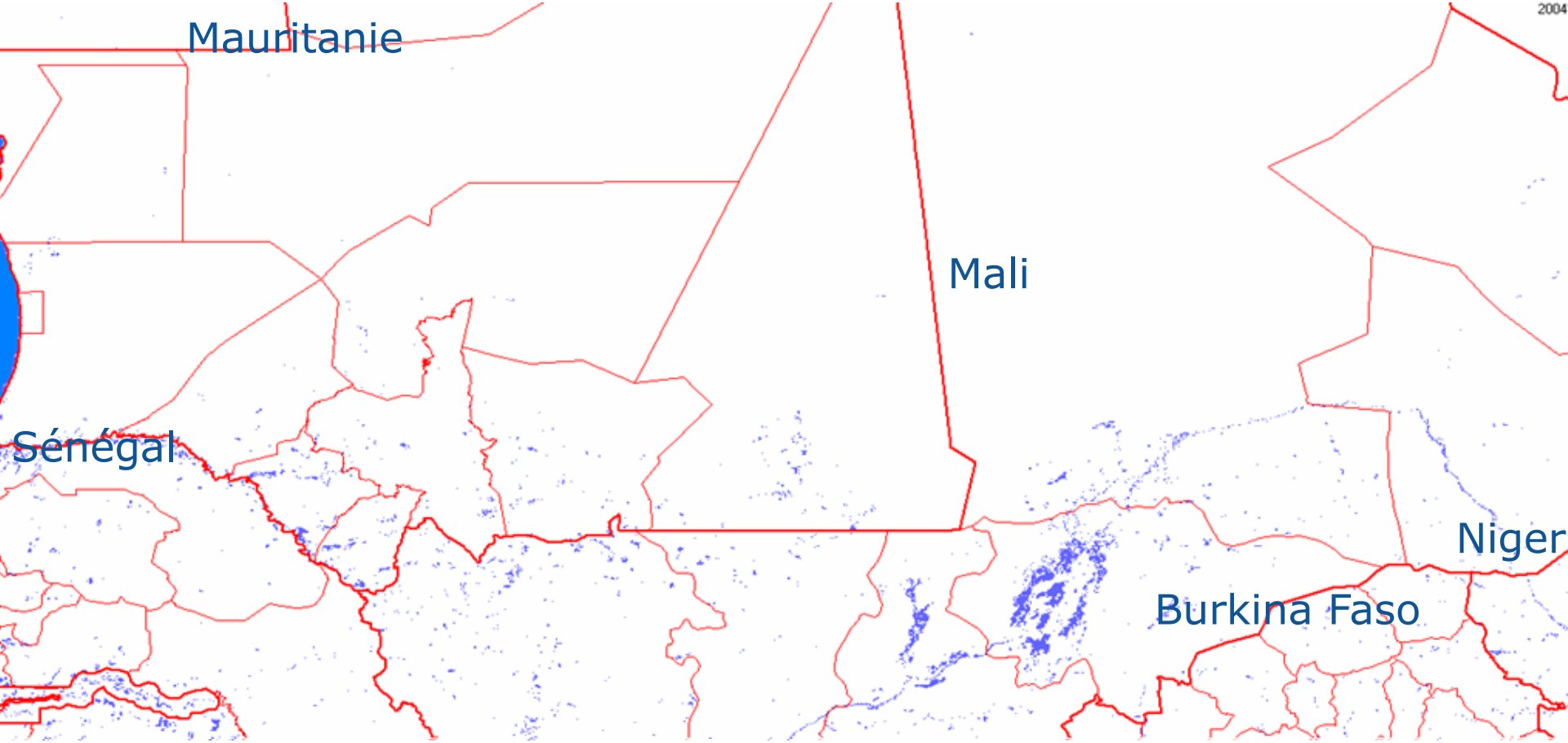



Comoe NP, Ivory Coast

European Commission

# Monitoring Water Bodies



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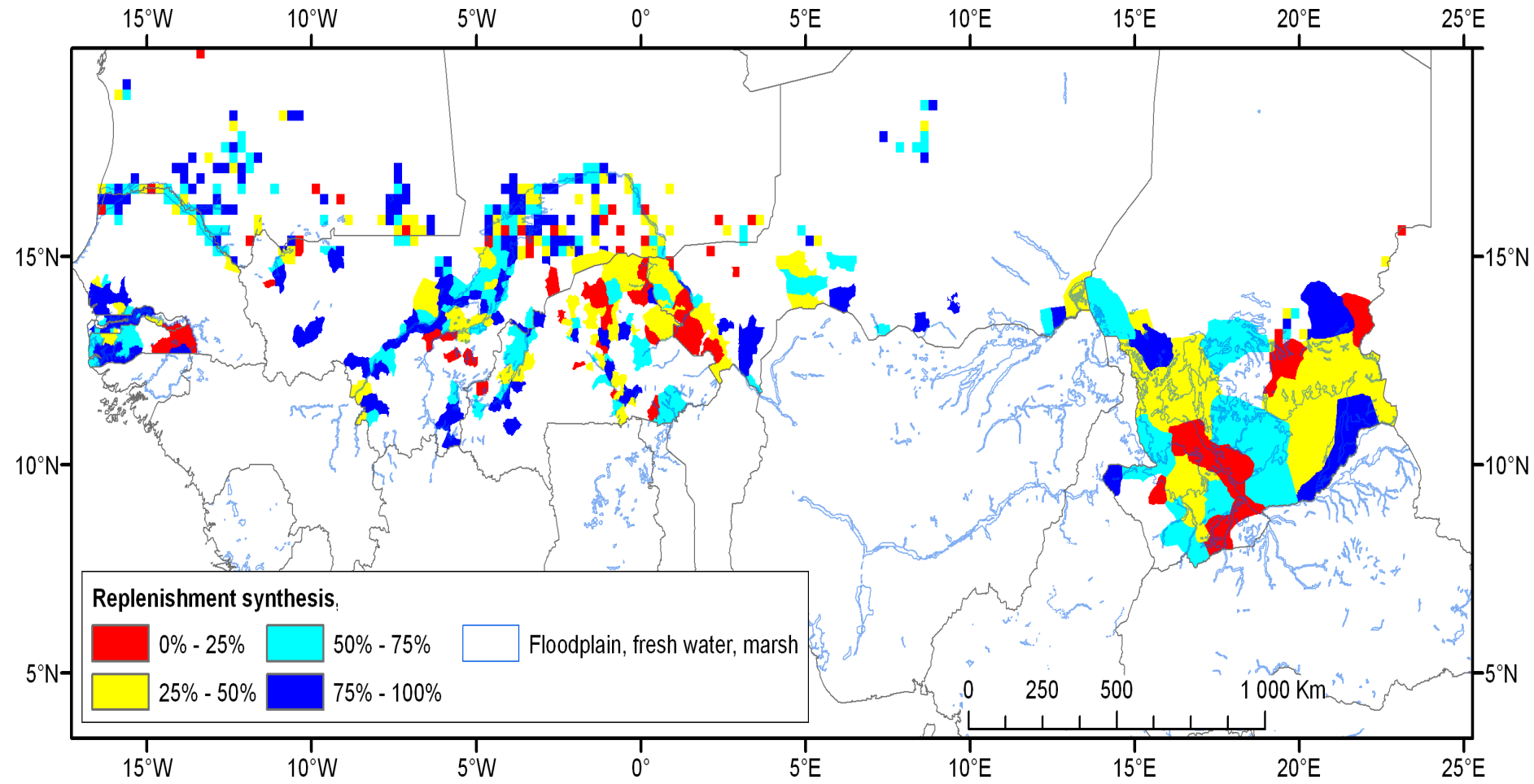
# Seasonal changes in small water bodies



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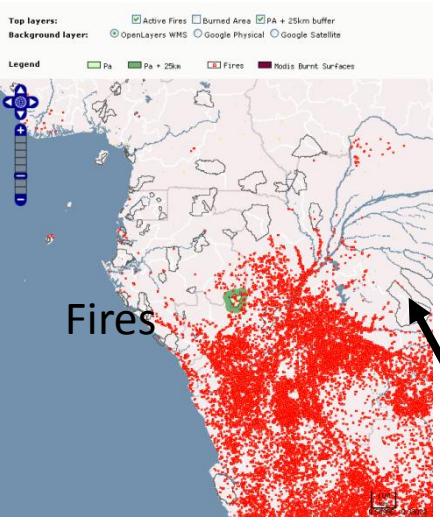
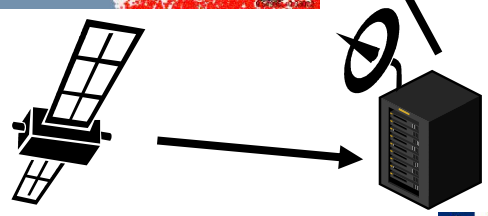
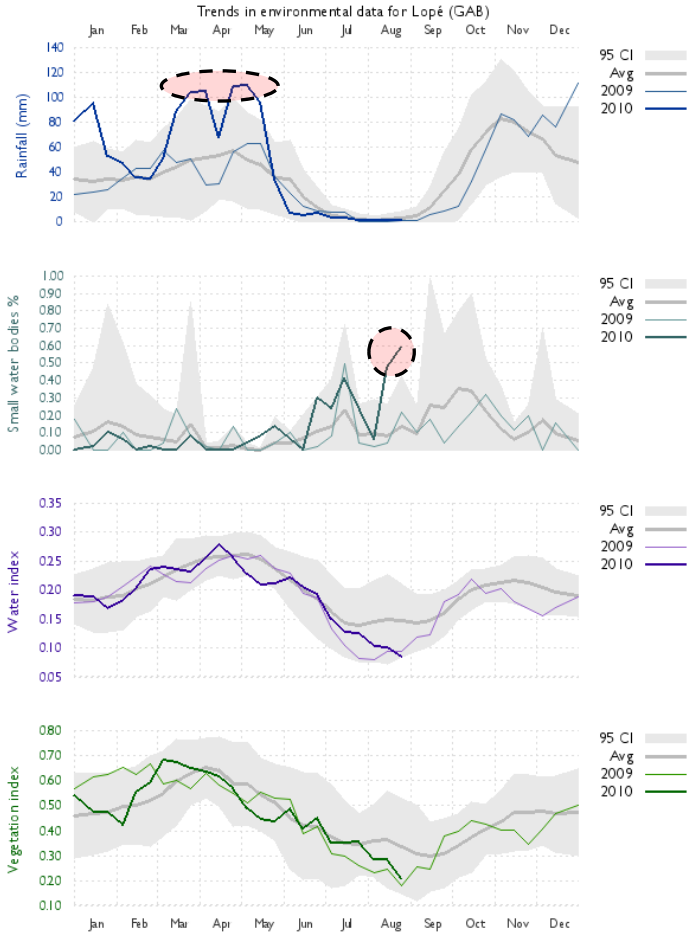
# Long term monitoring and detecting environmental anomalies





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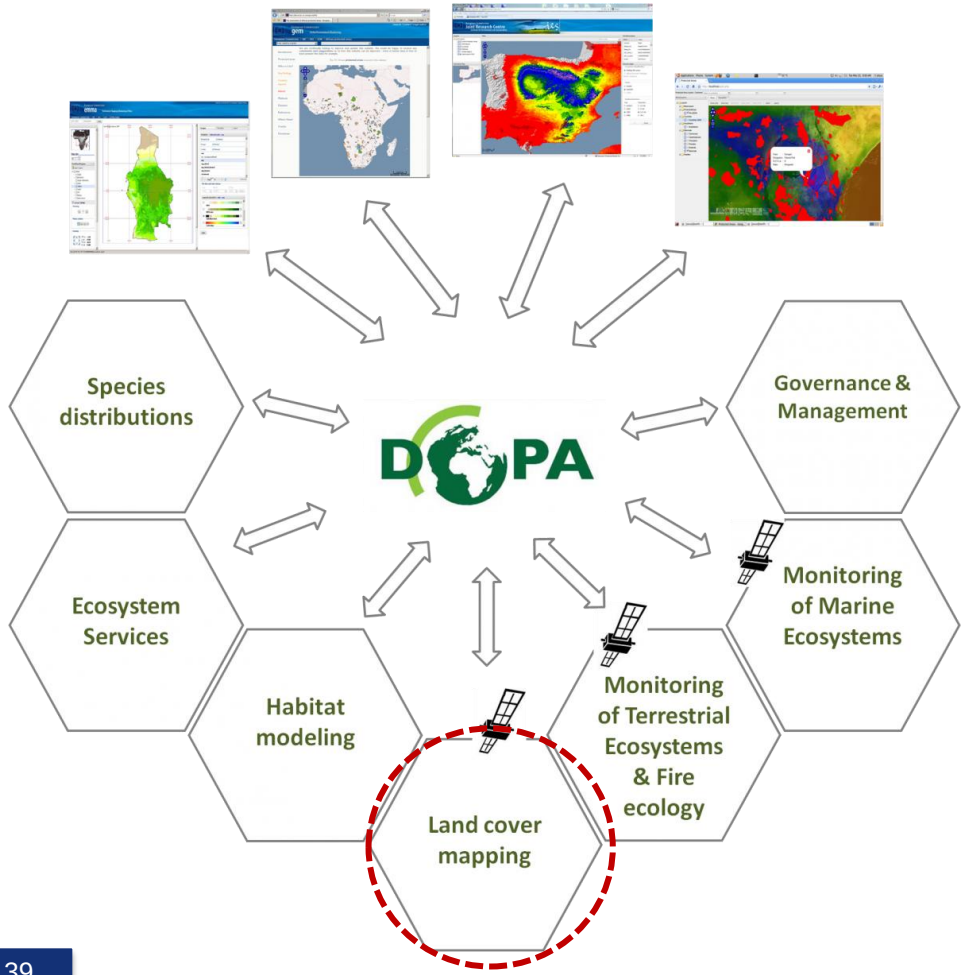
# DOPA components (2)

- **Land Cover Change**
  - Data & web based tools for facilitating the detection of changes in land cover at a regional scale and around and inside protected areas

http://landcover-change.jrc.ec.europa.eu/



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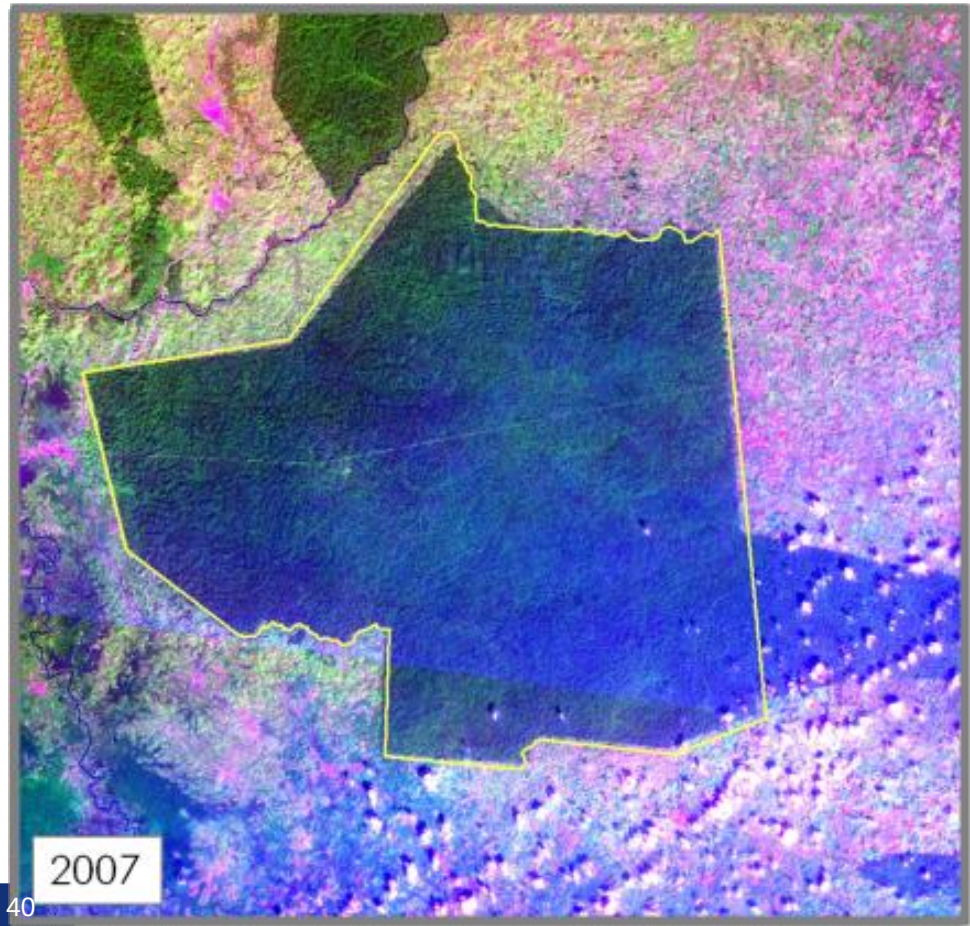
# Regional to local land cover

- **Land cover and land cover change mapping for habitat assessment and species distribution and abundance estimation**



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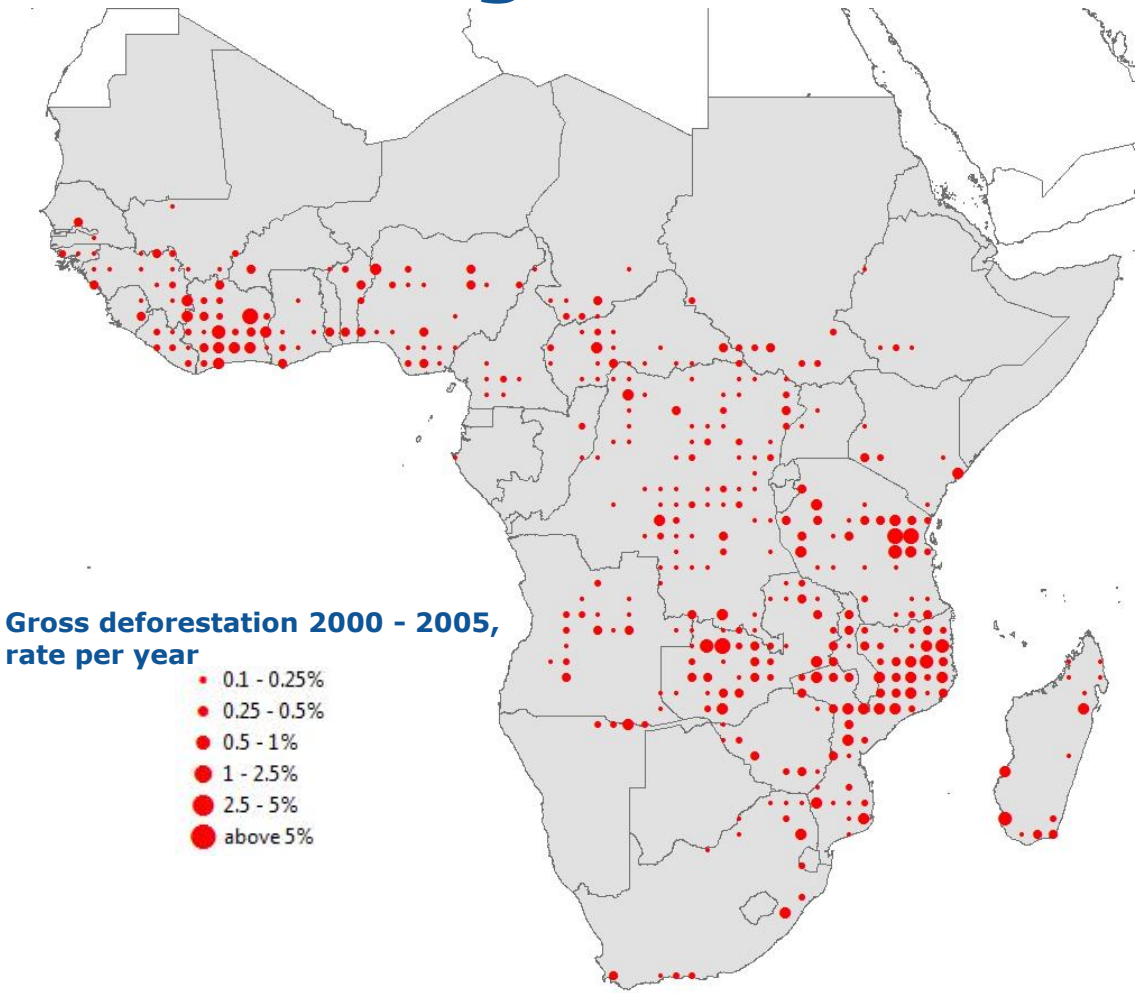
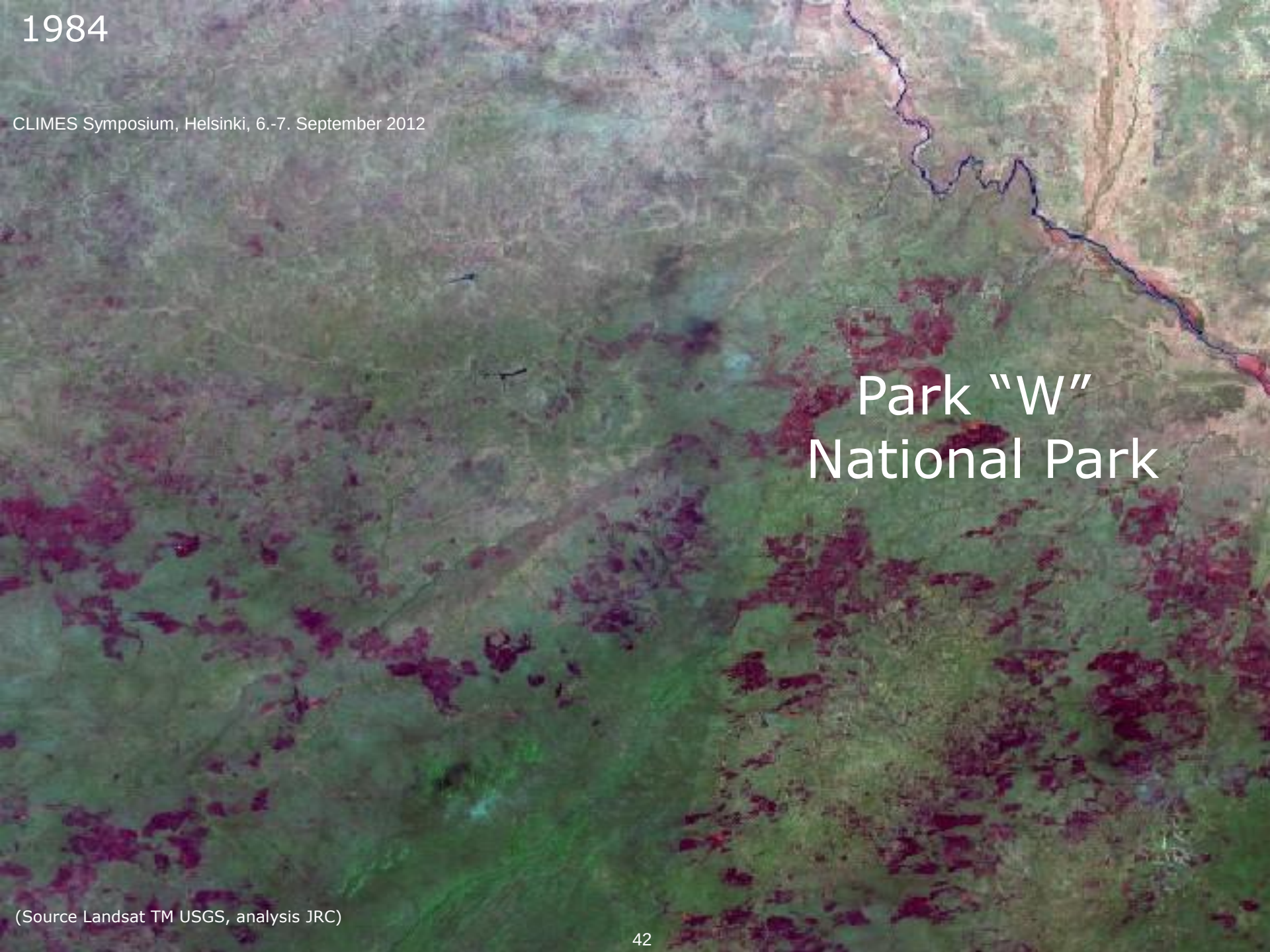
# Continental/regional LCC assessment

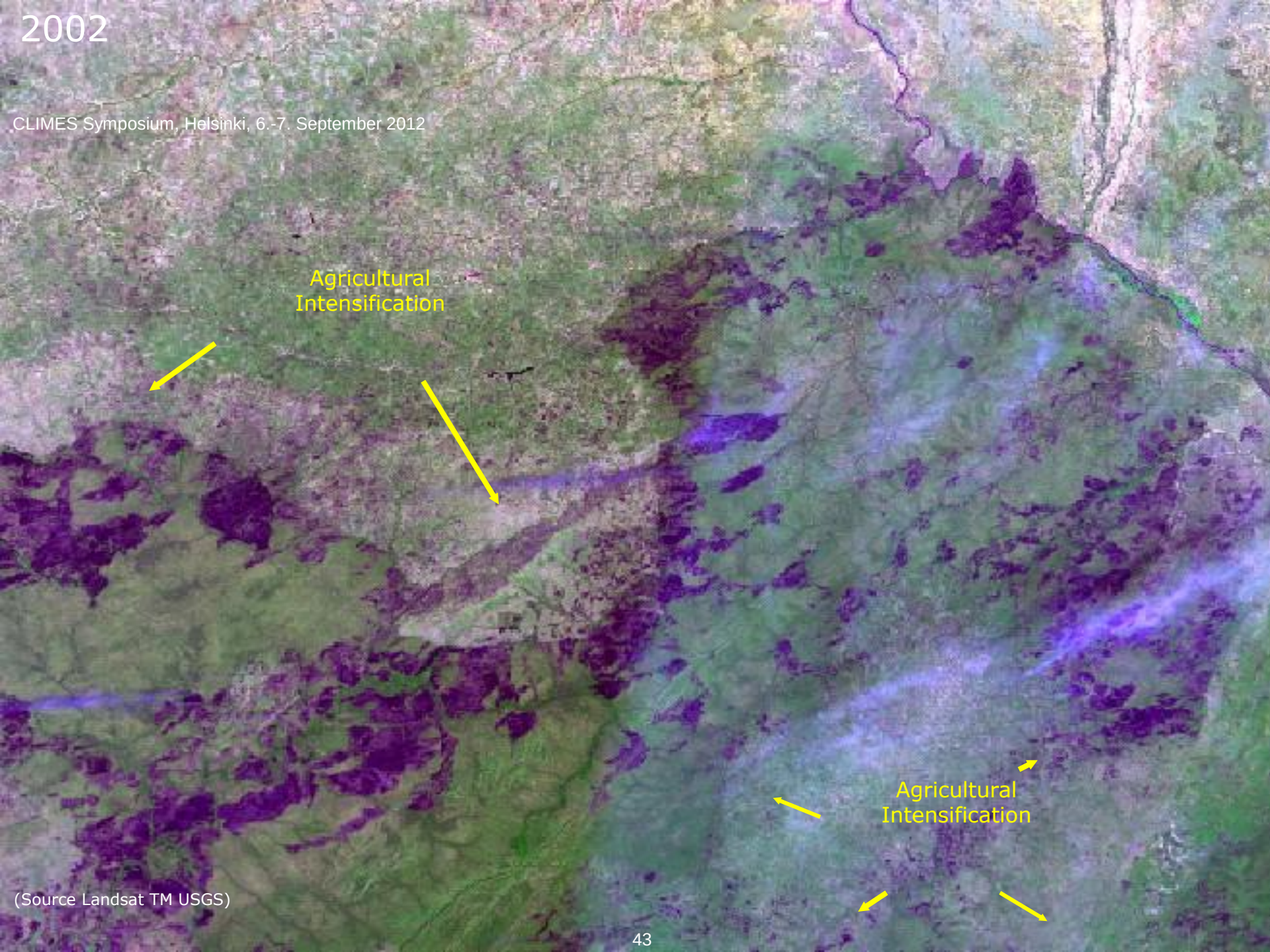


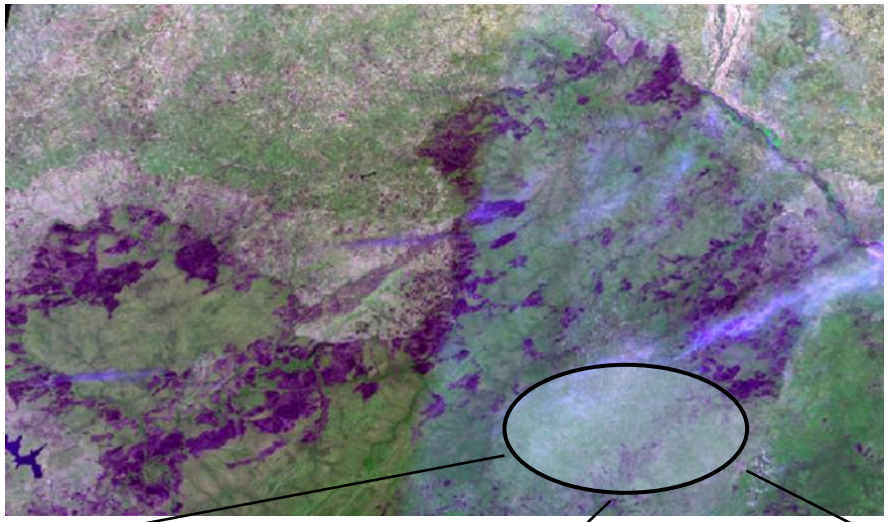

Bodart, Brink et al., 2012

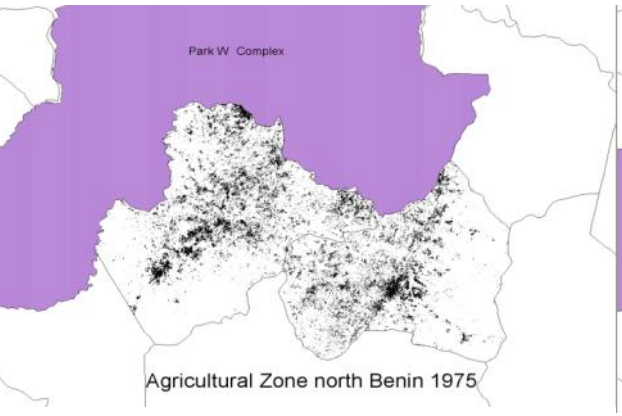


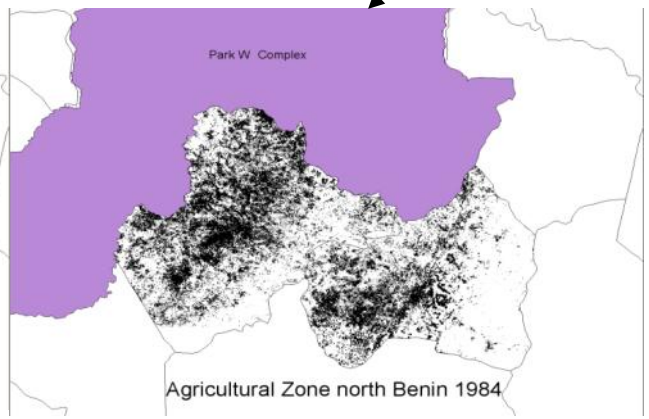


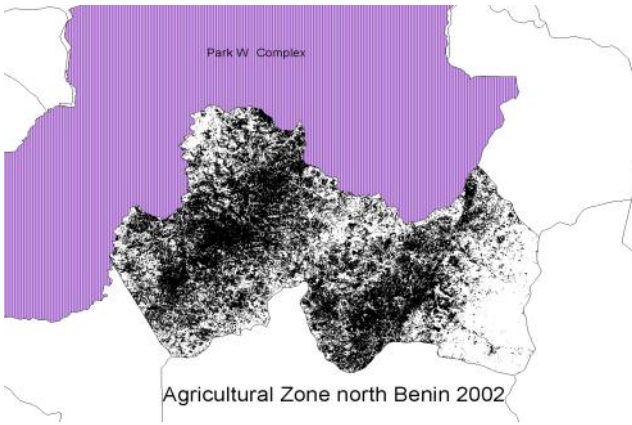

(Source Landsat TM USGS, analysis JRC)


2002
CLIMES Symposium, Helsinki, 6.-7. September 2012
Agricultural Intensification
Agricultural Intensification
(Source Landsat TM USGS)






1975 – 11% agriculture

1984 – 28% agriculture

2002 – > 40% agriculture

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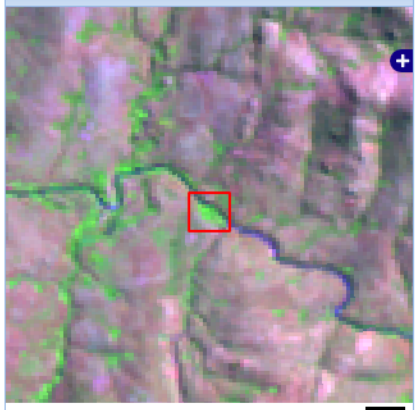
# Systematic LCC assessment in and around PAs

- **Automated wall to wall mapping approach**
- **Manual sampling based web clients for detecting changes**

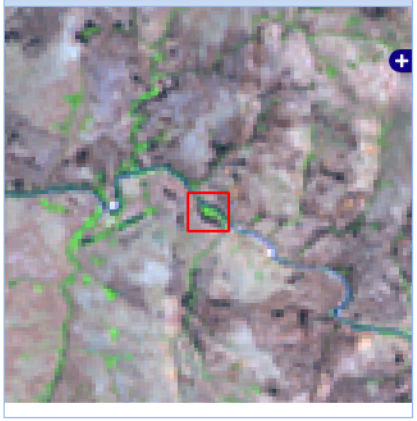
View all sites | View a single site | **Edit a sample** | NDVI for PA buffers

Currently selected site is **test**....Currently selected sample is **S2359165205_E046304159047_test**

**Imagery, 1984-1994**



**Imagery, 1995-2004**



**Imagery, 2005-2009**

< PREV | SIGN OFF | NEXT >

**Choose classes**

| tp1 | tp2 | tp3 | |
|---|---|---|---|
| | | | Closed forest |
| | | | Open forest |
| | | | Natural/agriculture mosaic |
| | | | Shrublands |
| | | | Herbaceous (inc. grass) |
| | | | Agriculture (plantation) |
| | | | Agriculture (arable) |
| | | | Open water |
| | | | Flooded vegetation |
| | | | Urban |
| | | | Bare ground |
| | | | Cloud / Shadow |
| | | | No Data |
| MIX | MIX | MIX | |
| | | | Certain |
| | | | Fairly certain |
| | | | Not at all certain |

Commit Changes

7

**Land cover 1**

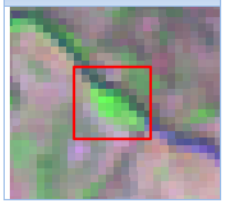
3

**Land cover 2**

**Land cover 3**

Previous: Shrublands

**Sample box, 1984-1994**



**Change band combination**

Red: 5
Green: 4
Blue: 3
Apply band combination

1

**Sample box, 1995-2004**

**Apply a stretch to ESRI imagery**

- MinMax
- Histogram
- 1 std. deviation
- 2 std. deviation
- Default

Apply

2

**Sample box, 2005-2009**

**Progress**

GO!!

Sample 4 of 443

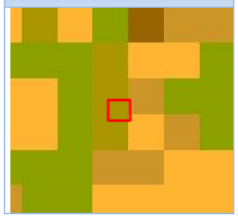
443 samples still to validate

6

- Water
- Evergreen needleleaf forest
- Evergreen broadleaf forest
- Deciduous needleleaf forest
- Deciduous broadleaf forest
- Mixed forest
- Closed shrublands
- Open shrublands
- Woody savannas
- Savannas
- Grasslands
- Permanent wetlands
- Croplands
- Urban and built-up
- Cropland/natural veg mosaic
- Snow and ice
- Barren /sparsely vegetated

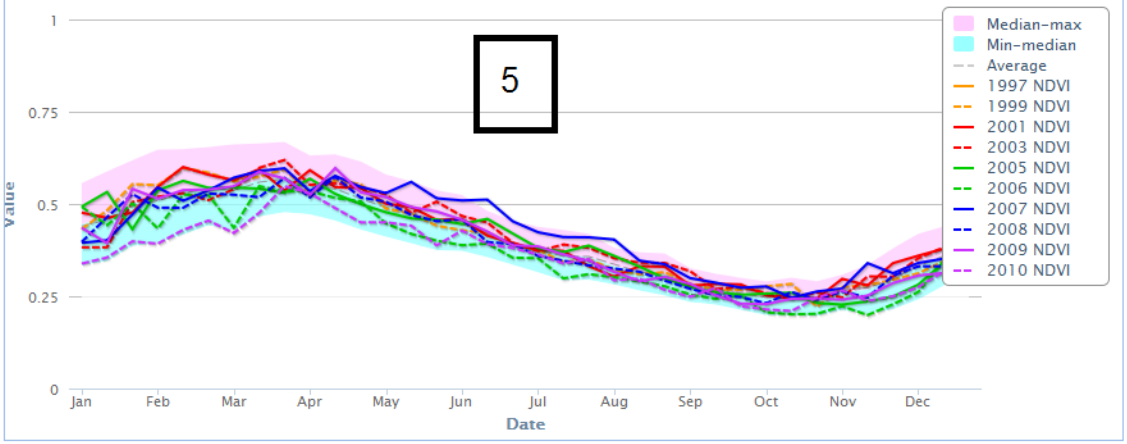
4

**MODIS landcover 2001**



**MODIS landcover 2008**

**NDVI values for selected years (plus aggregated statistics from 1998 to present)**




5

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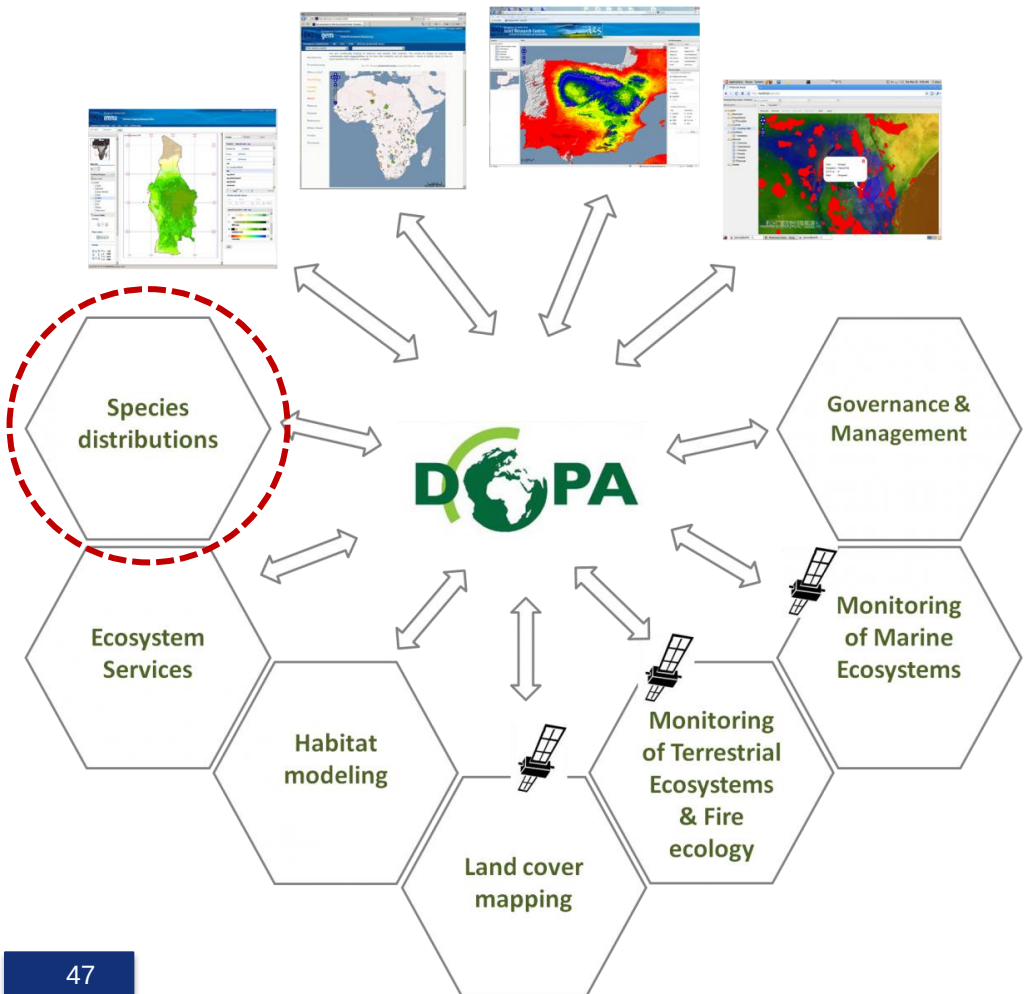
# DOPA components (3)

- **eSpecies**
  - towards services for mapping species diversity

BirdLife INTERNATIONAL GBIF RSPB IUCN

http://especies.jrc.ec.europa.eu/



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# Species Information Services

- **Requirements**
  - Answer fundamental conservation questions:
    What is where / where is what?
  - Produce value-added analyses:
    Derived indicators, e.g. species richness
  - Cross-sector analyses
    e.g. species within PA, country, species per land cover type, species irreplacibility index
  - Species information from the global to local scale
  - Scalable, sustainable system
  - Must be requirements-driven and not data-driven

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# Species Information Services (cont.)

- **Data providers and datasets**
  - IUCN Red List of Threatened Species
  - Global Biodiversity Facility (GBIF) species occurrence data
  - Birdlife species range data and Important Bird Areas (IBAs)

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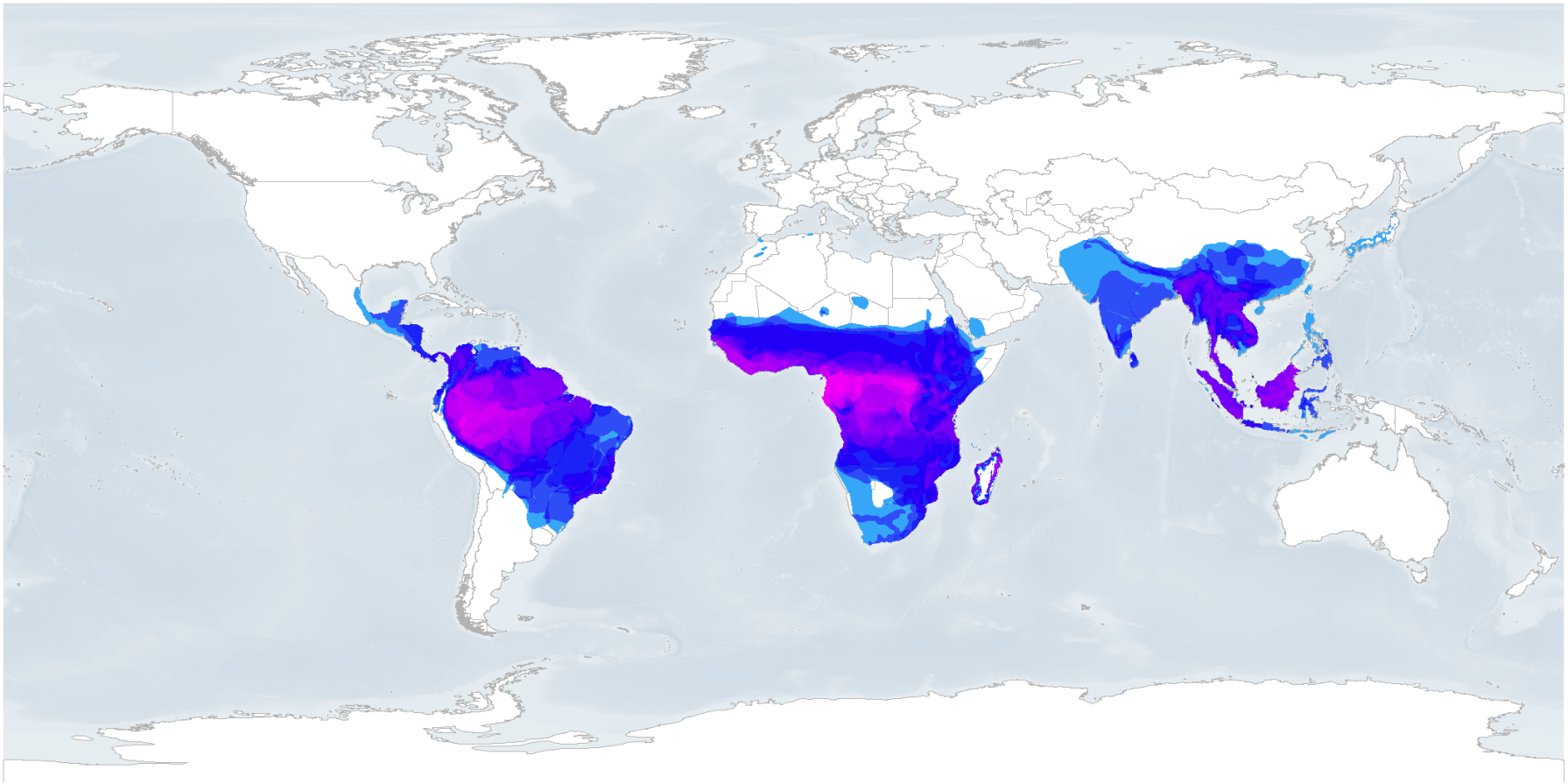
# eSpecies - Analyses - Species richness (Primates)



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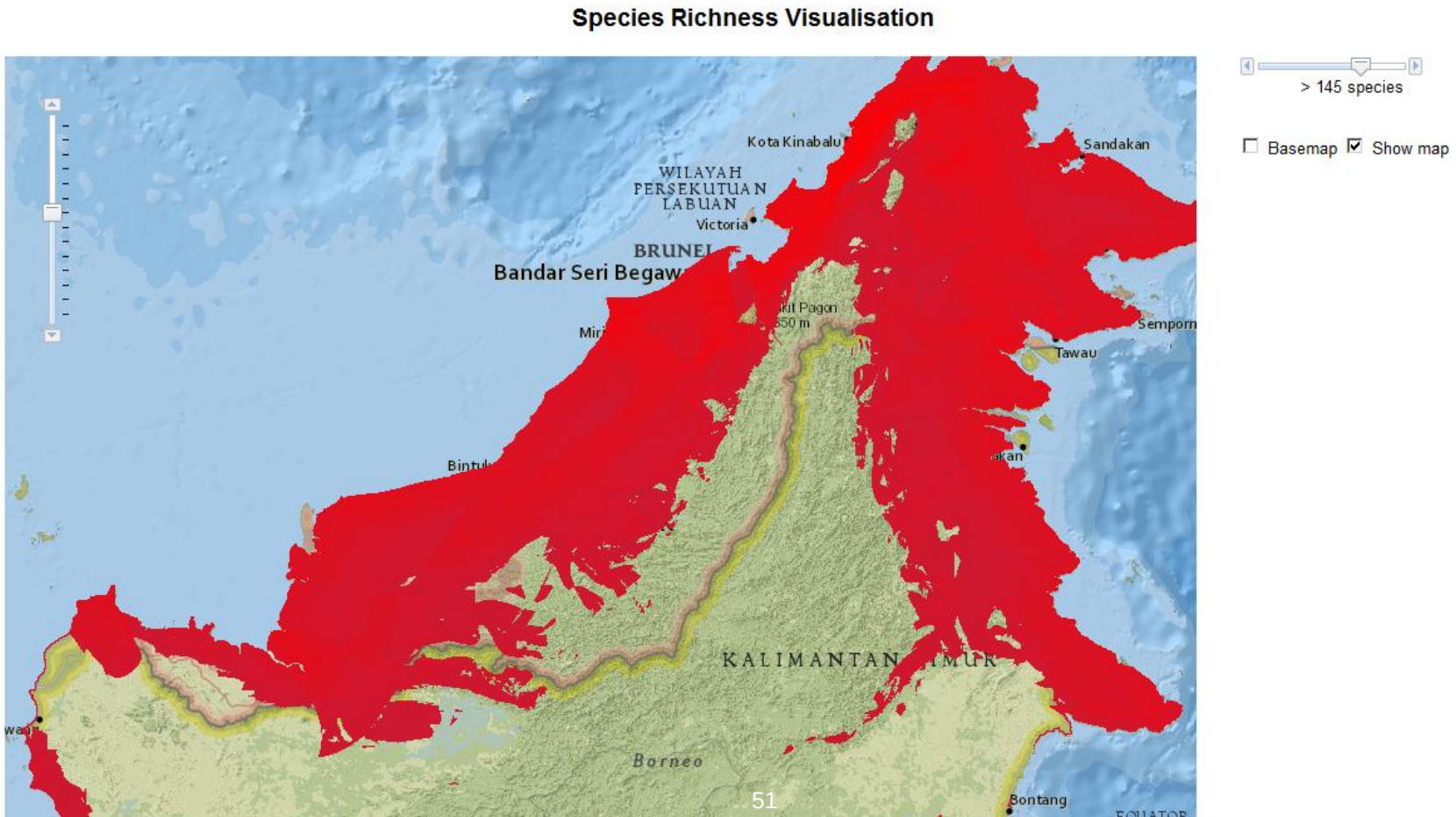
# eSpecies: Web services for species data (ranges, occurrences, ...)



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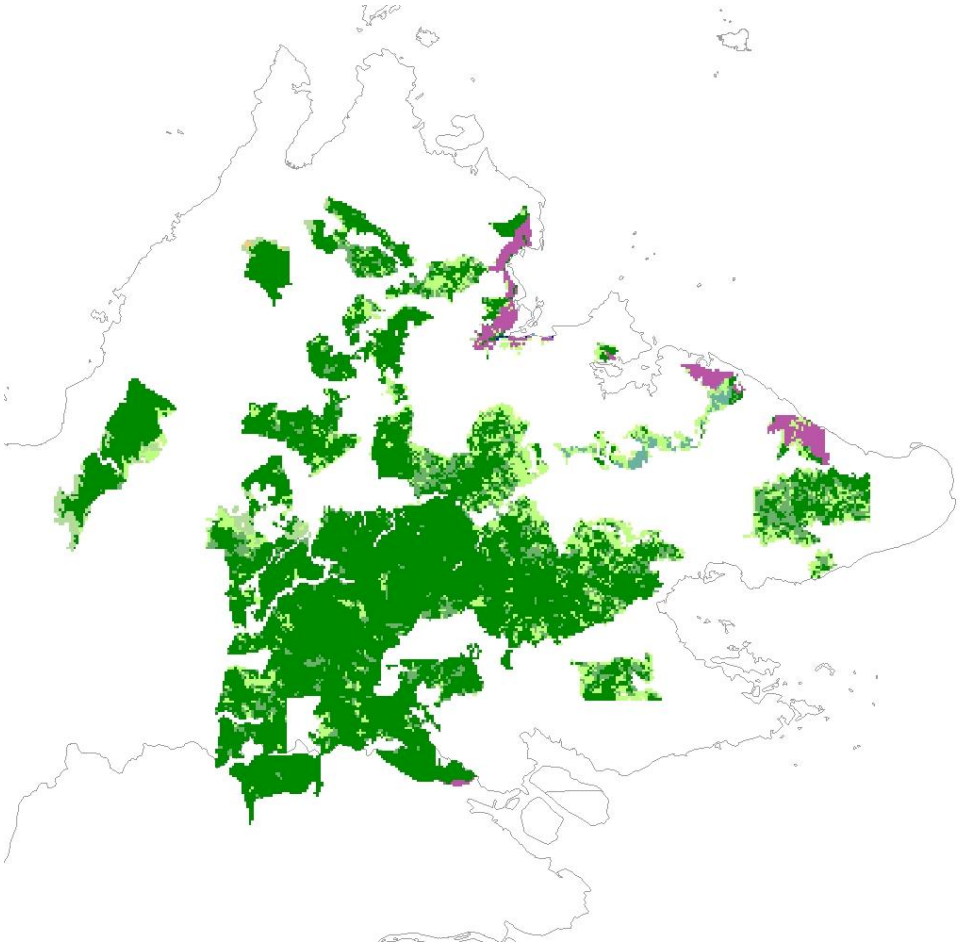
# eSpecies - Species land cover analyses



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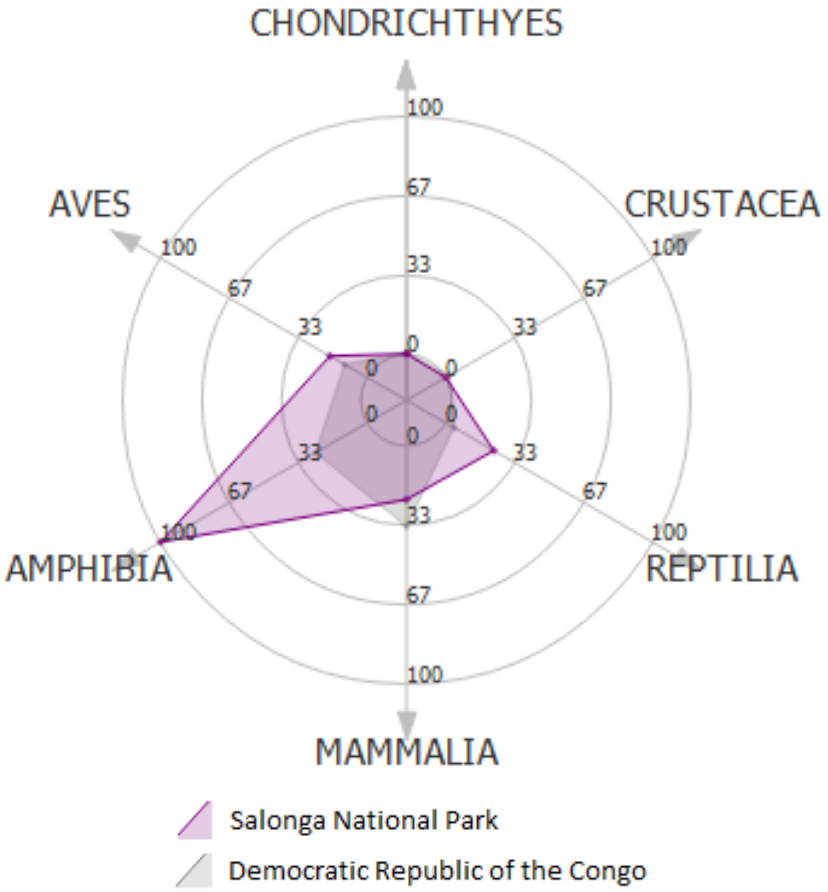
# eSpecies - Species irreplacibility analyses



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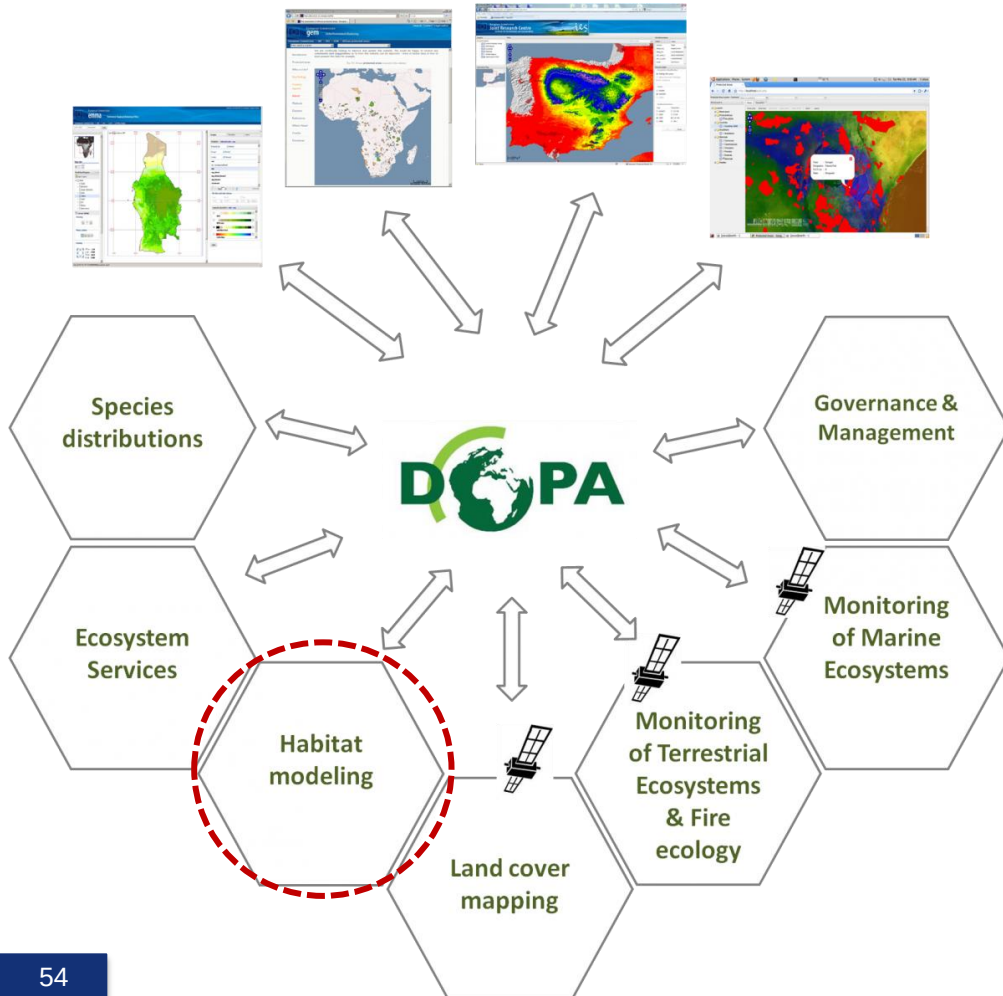
# DOPA components (4)

- **eHabitat**
  - A web service for identifying unique habitats, ecological forecasting, detecting seasonal changes, ecological niche modelling, ecological connectivity, …

http://ehabitat.jrc.ec.europa.eu/



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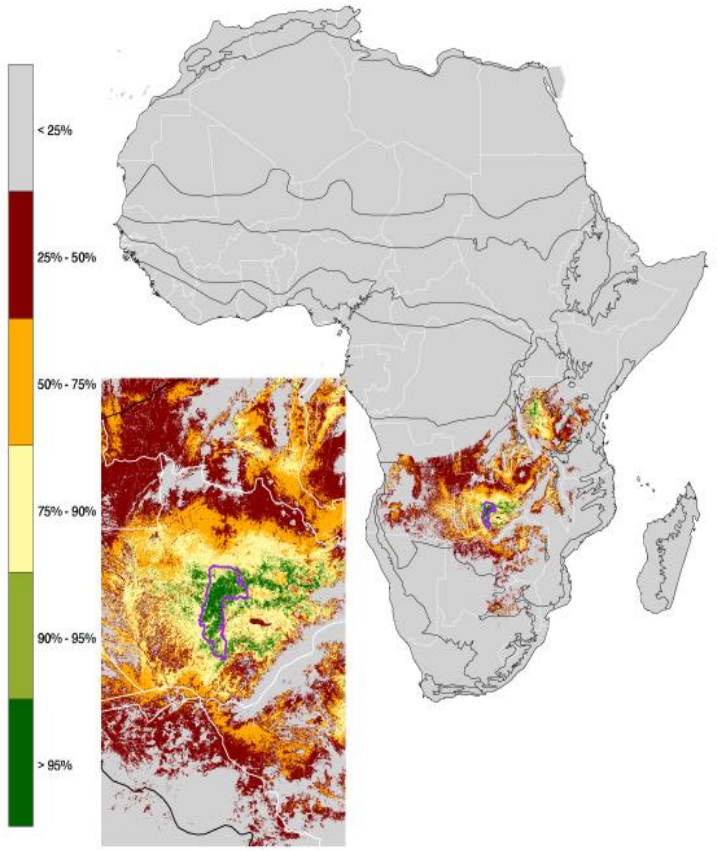
# eHabitat: Web services for ecological modelling and forecasting

- % tree cover
- % herbaceous cover
- % barren cover
- Elevation in metres
- Slope in degrees
- Aridity index
- % water body presence
- NDVI
- NDWI

*Mapping ecological Similarities (%)*




Map of probabilities to find a habitat similar to the one found in a given protected area?

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# DOPA components (5)

- **Global Ecosystem Services**
  - towards services for mapping & analysing global ecosystem services

http://ges.jrc.ec.europa.eu/

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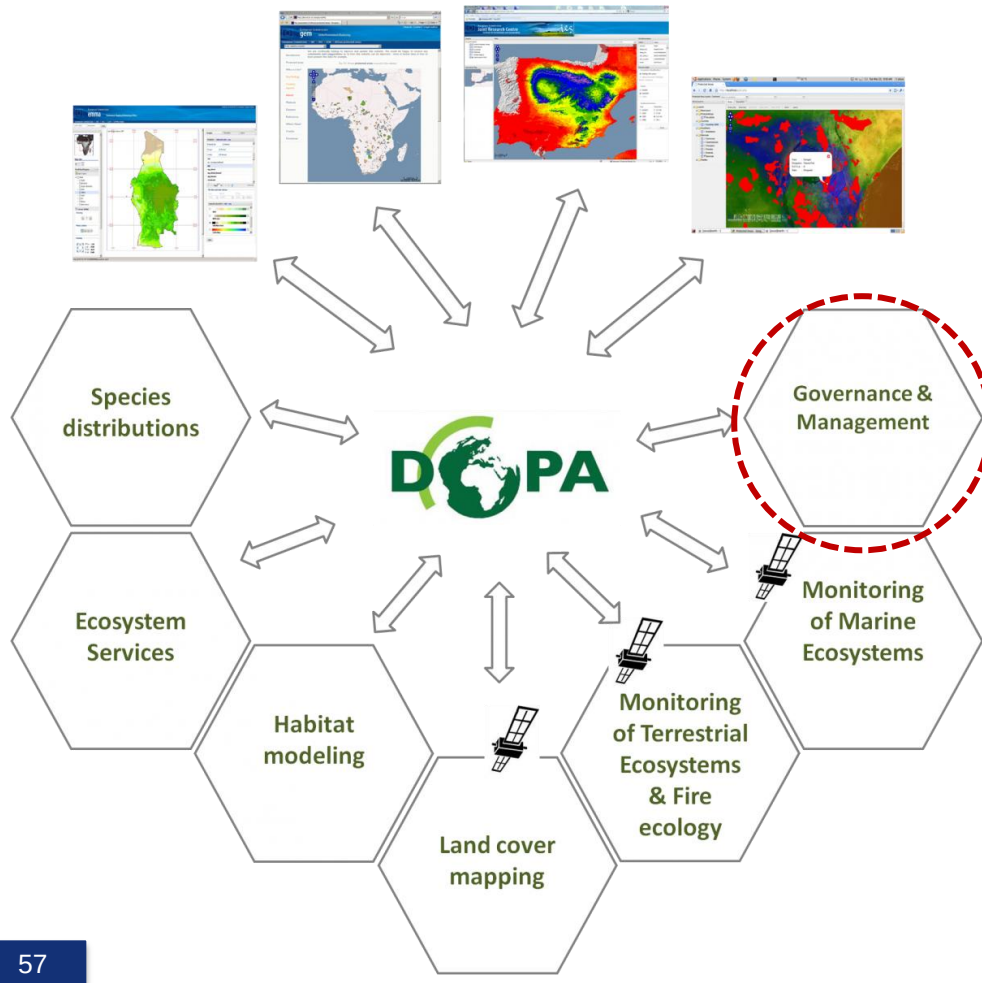
# DOPA components (6)

- **Governance & Management**
  - Under construction (tools for mapping projects & their funding, assess governance, management effectiveness, country profiles, …)



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# DOPA – work in progress

- **Not all web services ready**
- **Current web services available with very limited computational capacity (used mainly for demonstration)**
  - Increased capacity foreseen (mid 2013)
- **Analytical services subject to improvements**
  - Feedback from scientific community & end-users
- **Documentation (codes and methods) missing**

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# DOPA in summary

- **Web Services & Service Oriented Architecture (SOA)**
  - Better sharing of data and models (=improved automation & reusability)
  - Distributed responsibilities and easier maintenance
  - Easy customization of tools for different end-users
  - Increased potential for multidisciplinary analyses

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# DOPA in summary (cont.)

- **Strengths**
  - global information system
  - scalable (can be adapted to local/ regional needs)
  - Based on partnerships (improved services and indicators)
  - DOPA is free: tools are open source
- **Weaknesses**
  - IT/internet dependent (but solutions, see eStation)
  - data sharing
  - Propagation of errors and uncertainties to be dealt with

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# DOPA – only about technology?

- What about Socio-Economic indicators and the integration of PAs in the local economy?
- What about larger communities of End-Users?
- What about larger communities of Contributors?
- What about Capacity Building for potential end-users and contributors?

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# Conclusions

- **DOPA hasn't stopped biodiversity loss**
- **By permitting new combinations and integrations of data DOPA**
  - leads to informed decisions on past and current state and pressure of PAs
  - better assessments of management effectiveness
  - forecasts of Protected Area status in the future

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# Conclusion (2)

- It's taken almost 200 years to get to the level of protection we have today
- Around ½ the 130,000 existing Protected Areas were created in the last 20 years
- The CBD COP10 in 2010 pledged to expand this to 17% of terrestrial areas and 10% of marine areas by 2020
- Such expansion cannot take place in an uninformed manner – the need for DOPA is greater than ever

# Thank You

http://ehabitat-wps.jrc.ec.europa.eu/dopasimple/