

*Spot-4 (Take 5) workshop  
October 2<sup>nd</sup> & 3<sup>rd</sup> 2013, Toulouse*

# **Phenological monitoring of tropical forest ecosystems (North of Congo)**

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**CIRAD**

**Forest ecosystems goods and services  
Montpellier**



## CONTEXT

- Central African forests cover 1,6 Mkm<sup>2</sup> and are of prime importance at the atmosphere/biosphere interface
- At this time we have a poor knowledge of these forest ecosystems
- These ecosystems are complex with spatial (forest types) and temporal (phenology) heterogeneities

## HYPOTHESIS

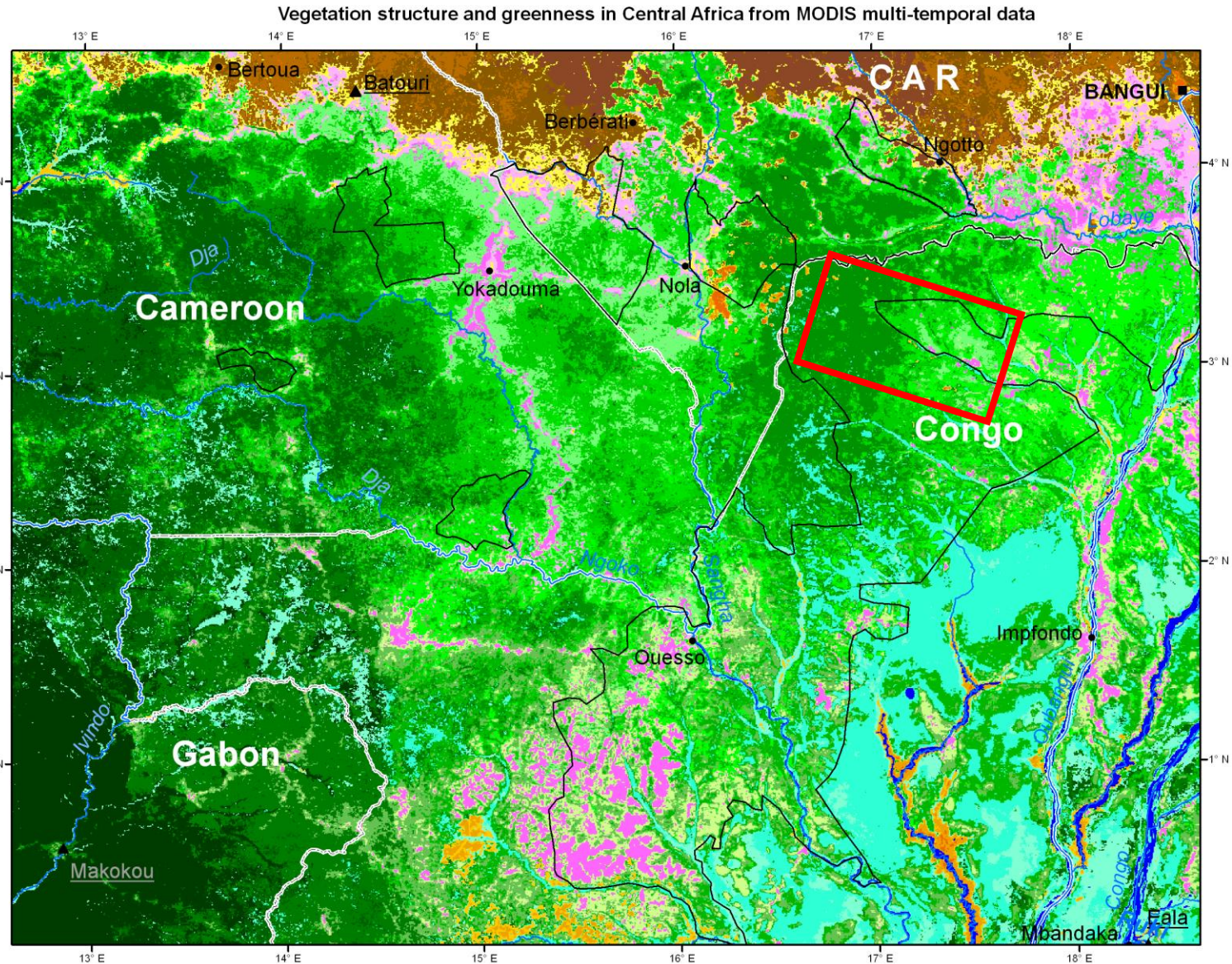
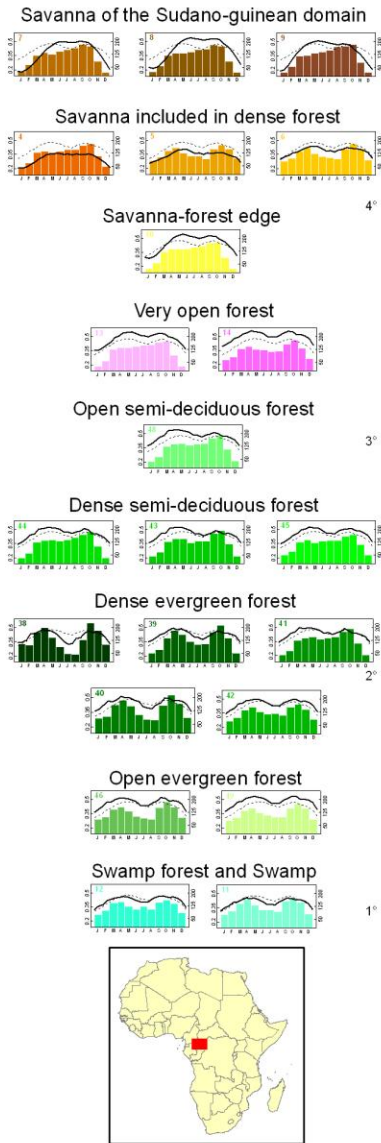
- Without accurate characterization of these ecosystems we will be poorly prepared to adopt sustainable management to face global changes (social changes and climate changes)

## OBJECTIVE

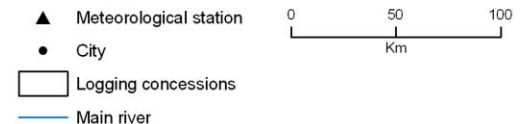
- Improving Central African forests knowledge by mapping spatial patterns of structure and greenness using satellite images



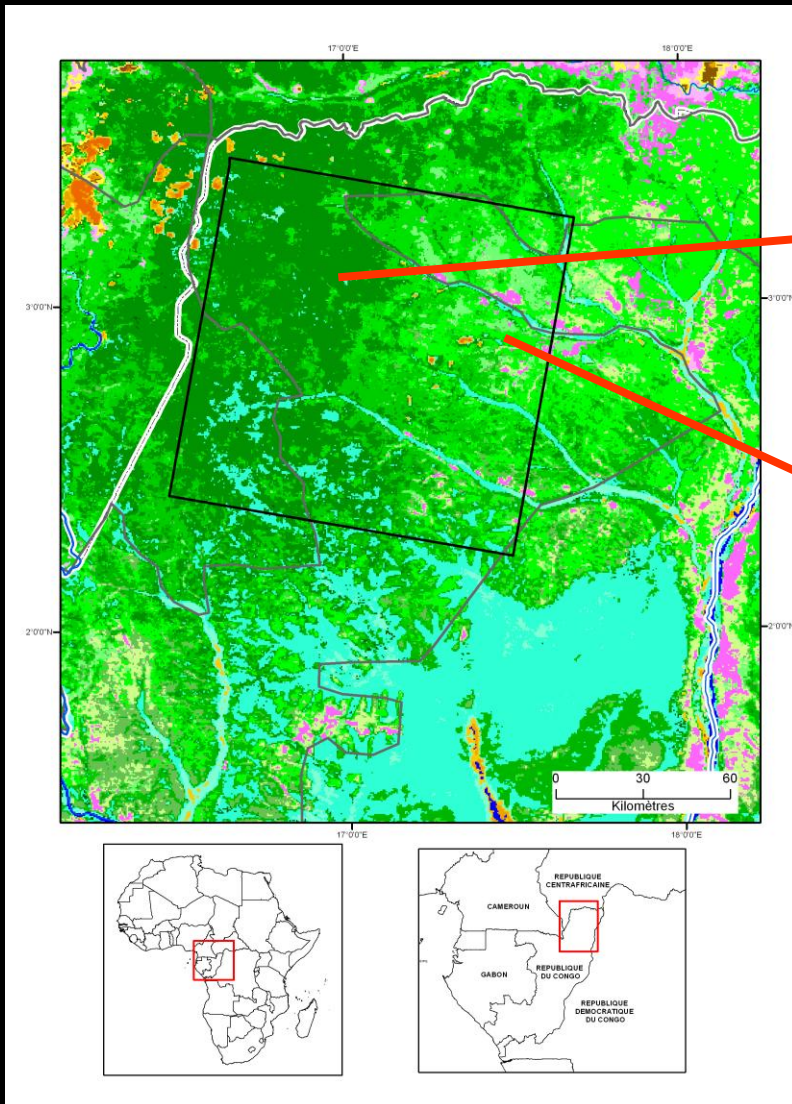
# Central African forests characterization



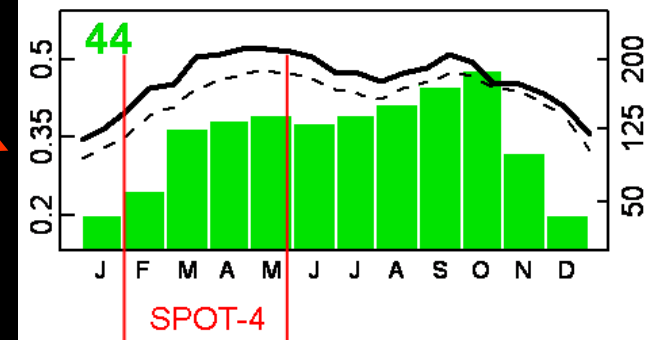
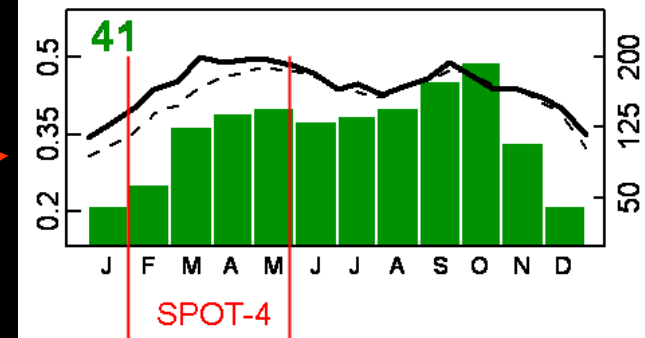
Gond, V., Fayolle, A., Pennec, A., Cornu, G., Mayaux, P., Camberlin, P., Doumenge, C., Fauvet, N., Gourlet-Fleury, S., 2013, Vegetation structure and greenness in Central Africa from MODIS multi-temporal data, Philosophical Transactions of the Royal Society (series B), 368: 20120309 <http://dx.doi.org/10.1098/rstb.2012.0309>



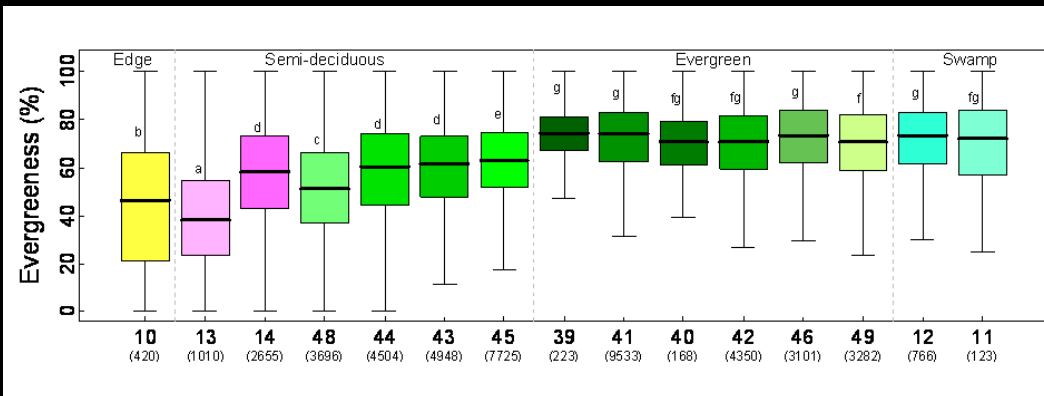
# Different phenologies for different forest types



Evergreen forests (<30% deciduous)



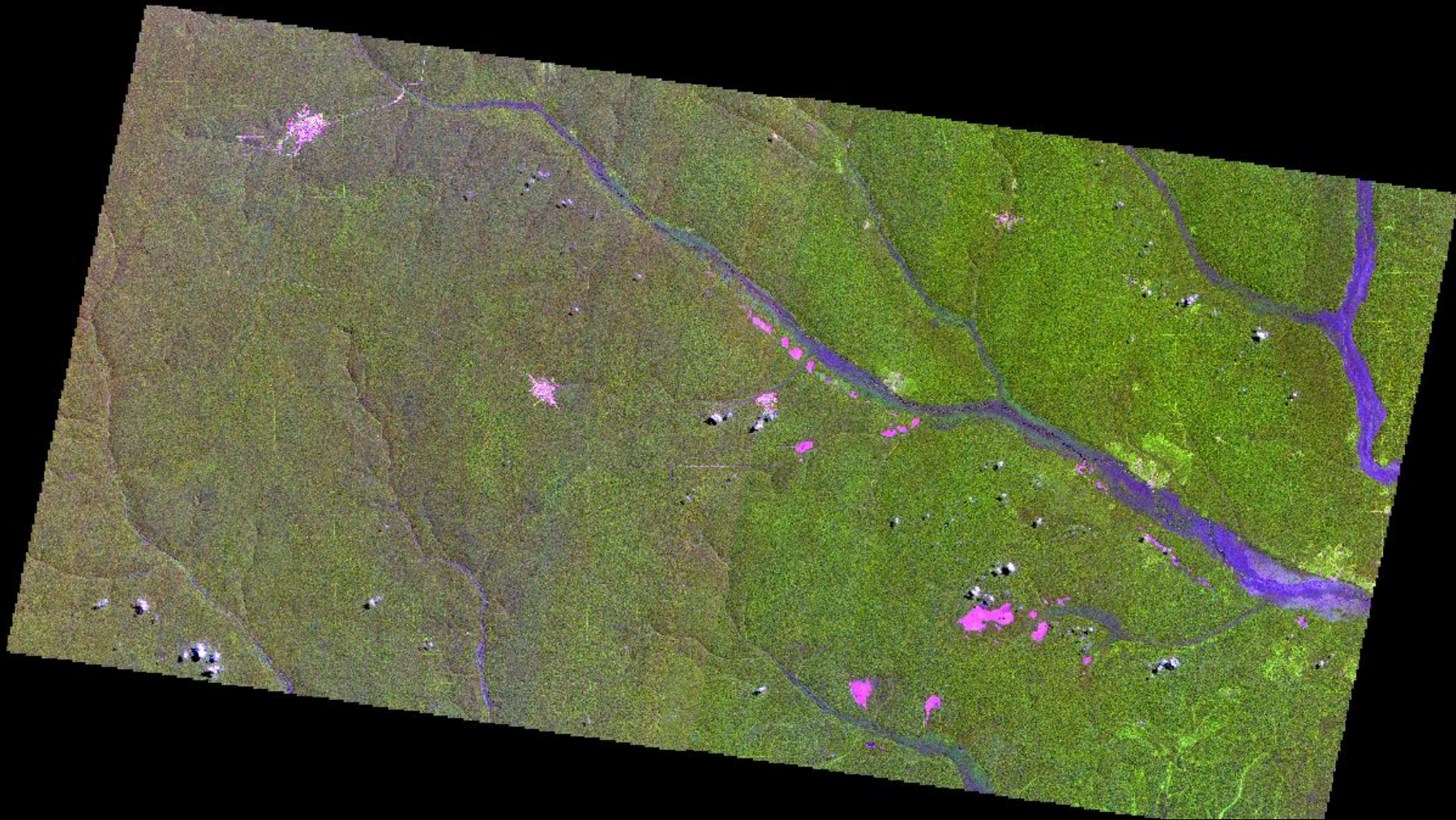
Semi-deciduous forests (>40% deciduous)



Structure and functioning of forest types are identified with 37.898 inventory plots (1/2 ha)



# Spot-4 (Take-5) data, Congo-1



# Geology, Congo-1

Carnot sandstones

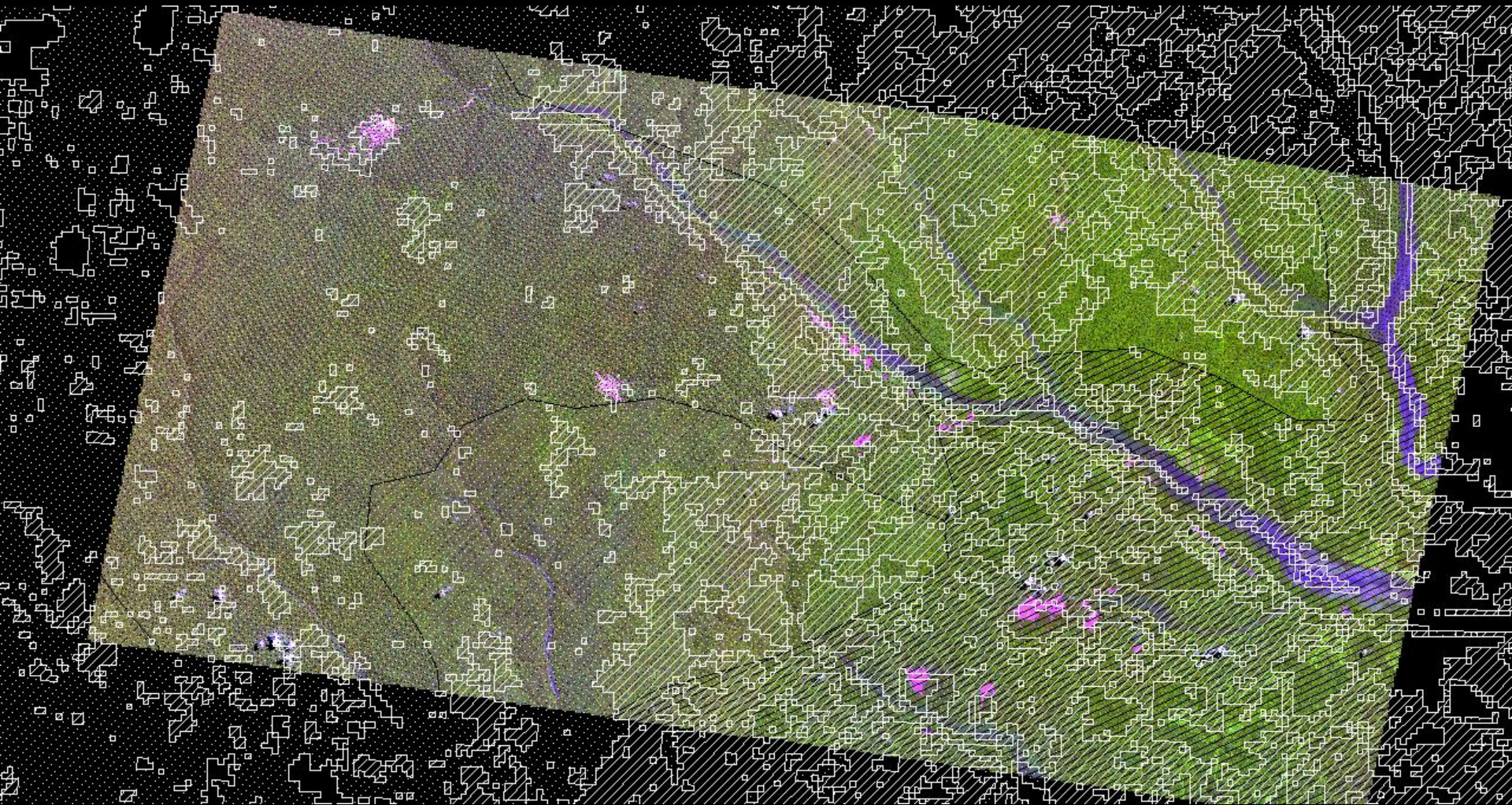
Bambio sandstones

Metamorphic rocks (Quartzite)

Congo basin alluvium



# Forest types (from MODIS), Congo-1



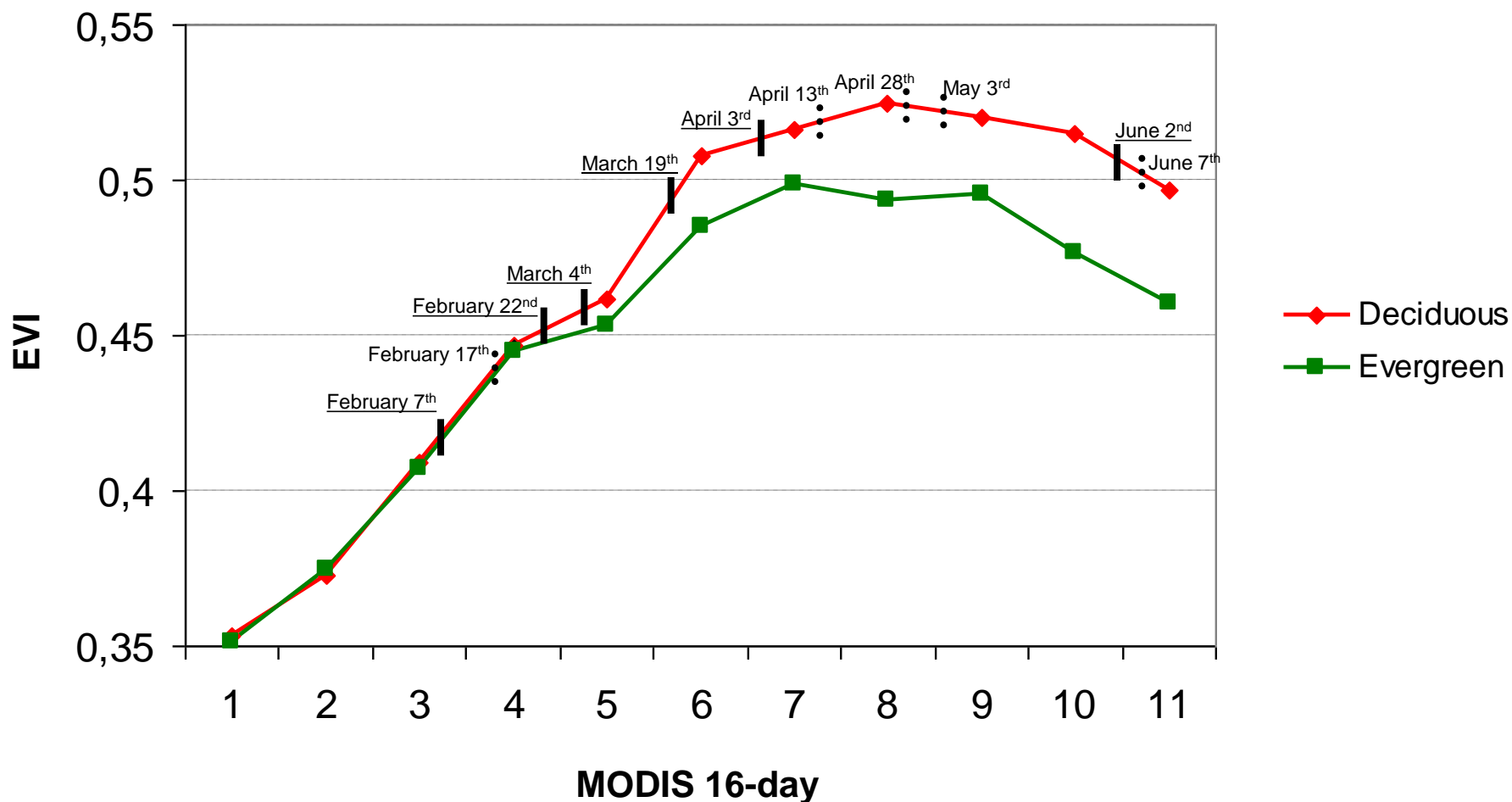
Evergreen forests (<30% deciduous)

Semi-deciduous forests (>40% deciduous)



# MODIS and Spot-4 temporal acquisitions (Take-5), Congo-1

## Temporal acquisitions, Congo-1



# Specific challenges with Spot-4 (Take-5) data, Congo-1

Very satisfactory Spot-4 (Take-5) data set acquisition

- In time (good description of central period with begin and end period acquisition to complete the data set)
- In space (the two forest types are correctly observed)

Questions are:

- Will the temporal profiles obtained with Spot-4 (Take-5) confirm the ones obtained using MODIS?
- What additional information on phenology can be provided using Spot-4 (Take-5) in order to better understand the spatial distribution of tropical forest types?

Other pathways to use Sentinel-2 (Spot-4 (Take-5)):



# Monitoring logging activities : forest tracks



March 4<sup>th</sup>

April 3<sup>rd</sup>

April 13<sup>th</sup>

June 2<sup>nd</sup>

30 days

10 days

50 days

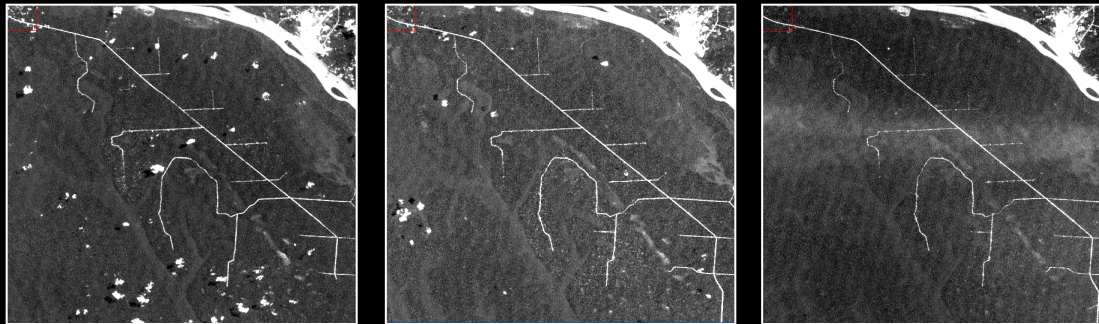
Opening

Logging

Spot-4 (Take 5)  
Congo 1



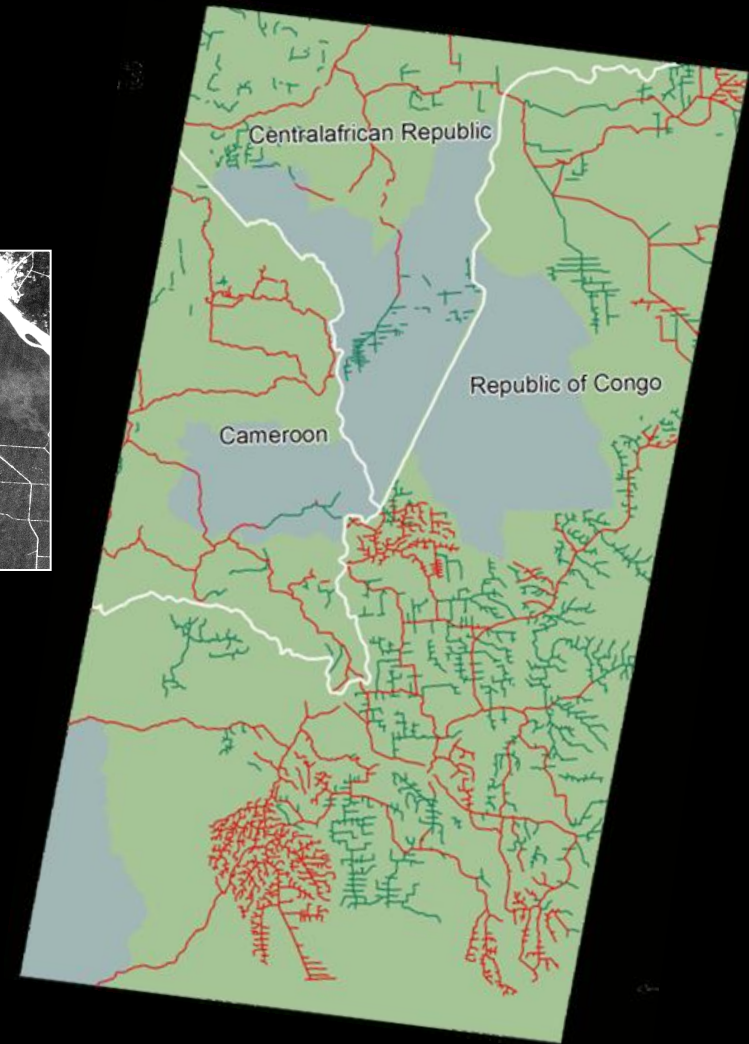
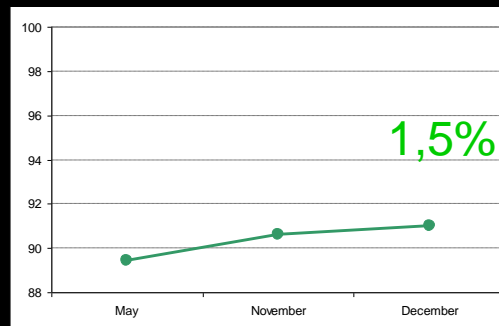
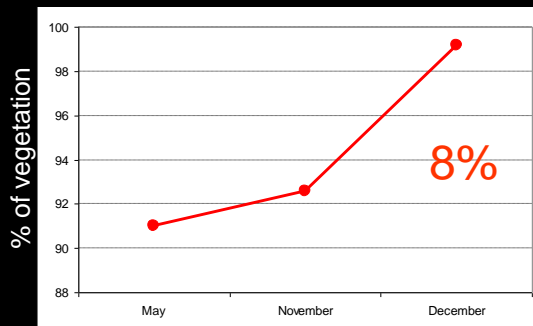
# Monitoring logging activities : road networks



May

November

December

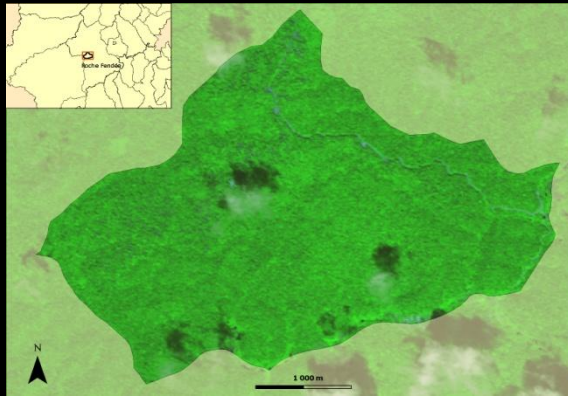


Ecological process of  
vegetation recovery

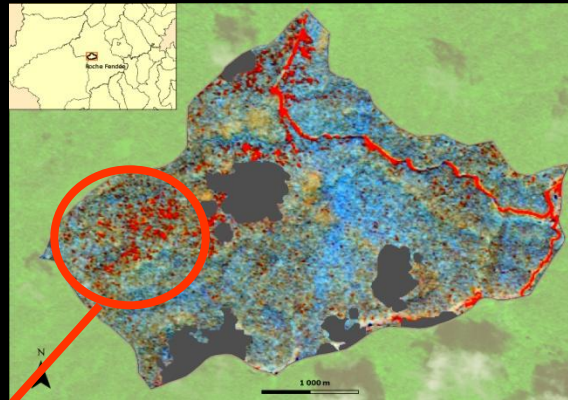


# Monitoring logging activities : logging impacts

SPOT-5, RFE-65 plot  
November 7<sup>th</sup>, 2010



Multi-index color composite  
(NDVI, NDWI and MIR)

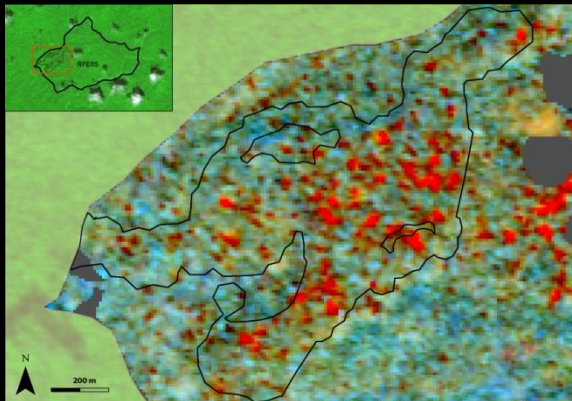


In French Guiana, 10.000 ha  
are exploited per year

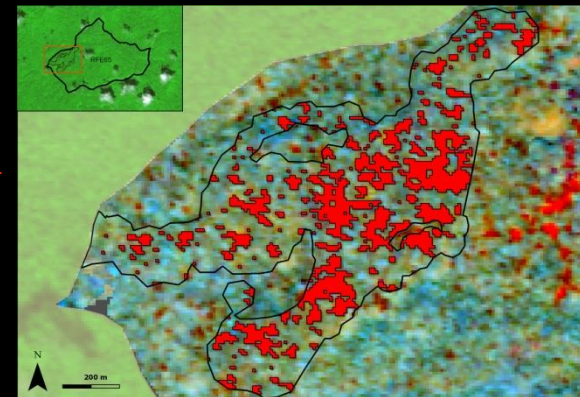
Thanks to the SEAS reception station  
these areas are regularly monitored  
using SPOT-5 (10m)

Development of a Timber Quality  
Index within the certification framework  
(PEFC and FSC)

Production Unit (78ha)



Impacted areas digitalization



From Spot / Sentinel-2

20,8ha impacted (26,6%)

Timber statistics

3,9 trees/ha and 19,8 m<sup>3</sup>/ha (5m<sup>3</sup>/tree)

Timber Quality index

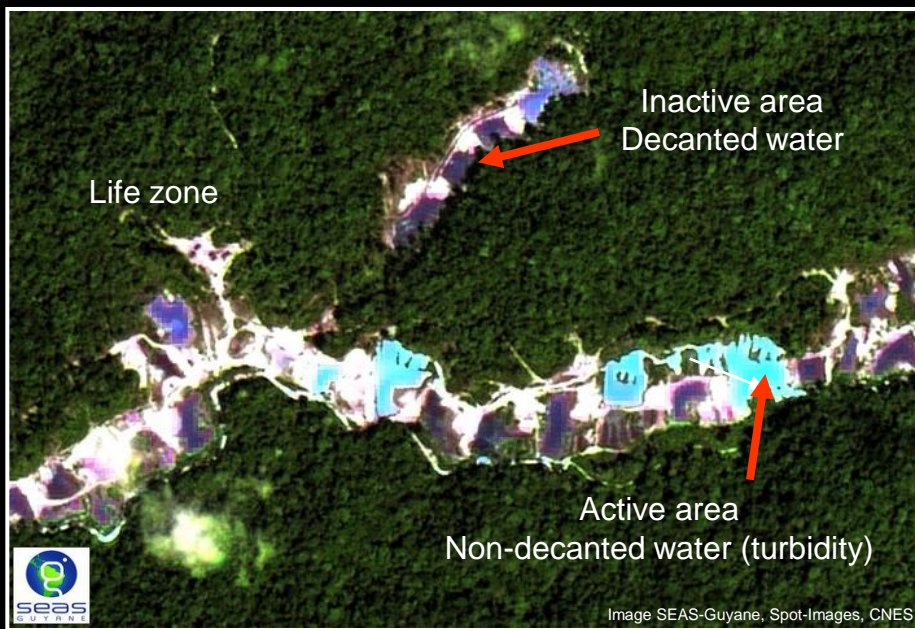
675m<sup>2</sup> impacted per tree  
134m<sup>2</sup> impacted per m<sup>3</sup>

From logger

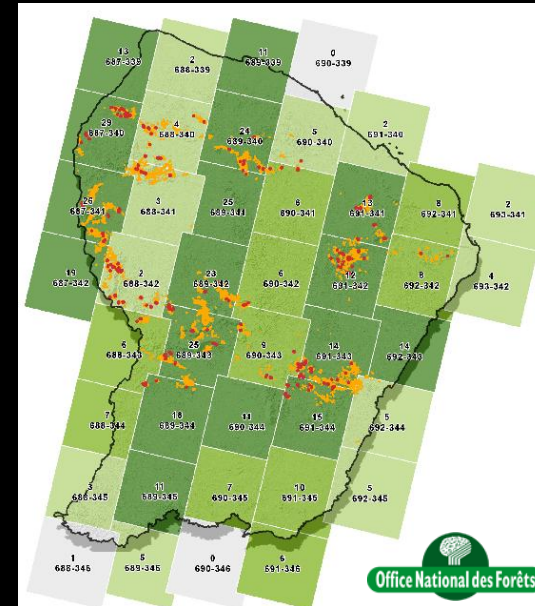
308 trees for 1550 m<sup>3</sup>



# Illegal small-scale gold mining monitoring



Gold mining map (2012)



Used images

2008: 219

2009: 283

2010: 419

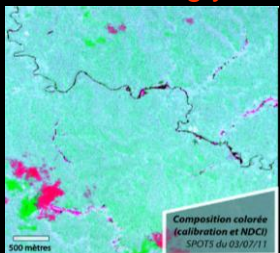
2011: 149

2012: 160

1.230 images

## Mining Activity Observatory (2008-2013)

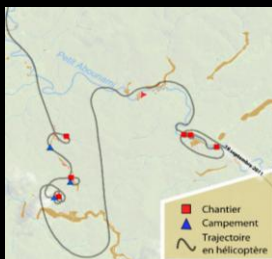
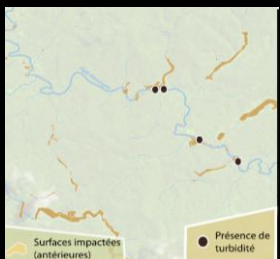
Active mining yard



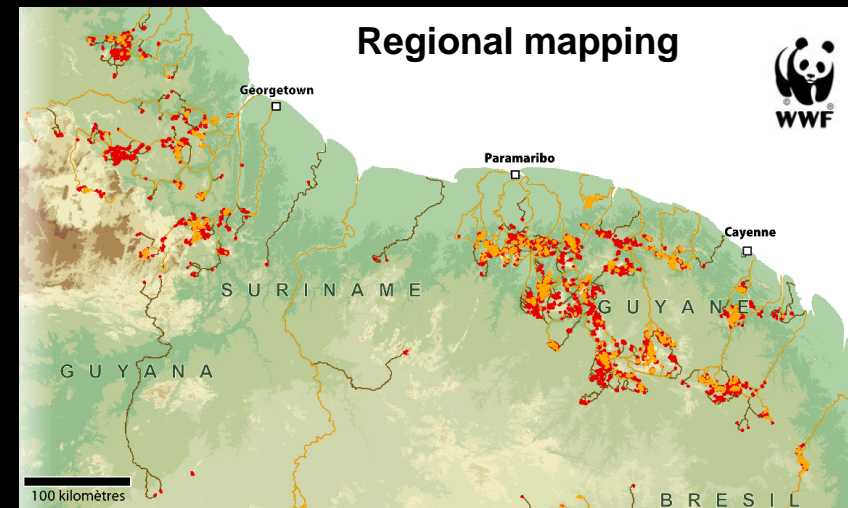
Impacted areas



Validation



## Regional mapping



Export technique

Spot-4 (Take 5)  
Congo 1



# Next steps

Starting work during Spring 2014:

- Geo-database development joining remotely sensed data (MODIS and Spot-4 (Take-5), forest inventories, meteorological data)
- Choose specific forest types sectors to extract temporal profiles from Spot-4 (Take-5) images (reflectance, vegetation index)
- Statistical comparison between MODIS and Spot-4 (Take-5) temporal profiles
- Analyzing for each forest types phenological phases and determining the ecological process
- Developing forest management recommendations at timber plot scale within the continuous acquisition data program at high temporal and spatial resolution (Sentinel-2)



Thank you for your attention

