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Developing a protocol to use remote sensing as a cost effective tool to monitor contamination of mangrove wetlands

Johannes H. Schellekens, Fernando Gilbes-Santaella, Augustine Rodriguez-Roman, and Yomayra Roman-Colon

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- Introduction
  - Remote sensing in mineral exploration or the search for chemical anomalies in the rocks
  - The effect of chemical anomalies on vegetation
  - Reflectance of vegetation
  - Mangroves
    - Importance of mangroves
    - Reflectance of mangroves
  - Remote sensing to monitor mangroves for metal contamination

Remote sensing in mineral exploration or the search for chemical anomalies in the rocks

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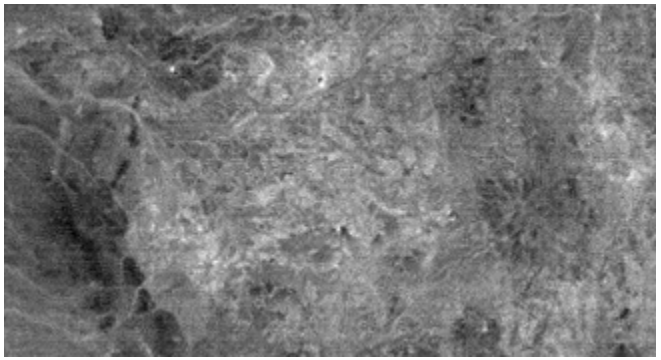
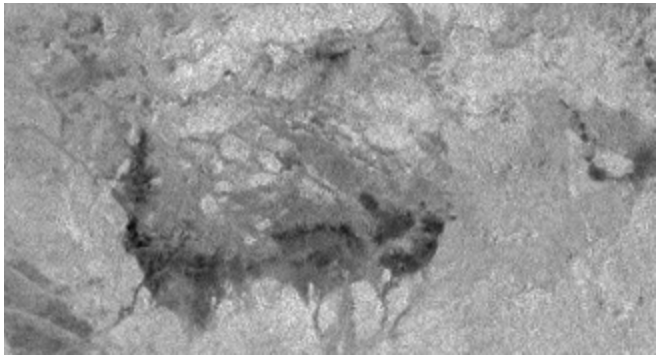
- The use of images from space borne platforms for mineral exploration has the advantage of large area or synoptic coverage which allows for portrayal of the Earth on regional basis.



TM 4/2 bright areas mark denser vegetation



3 km

TM 7/5 hook-shaped area coincides with general altered zone. Band 7: hydrous minerals absorb radiation - dark

Remote sensing in mineral exploration or the search for chemical anomalies in the rocks

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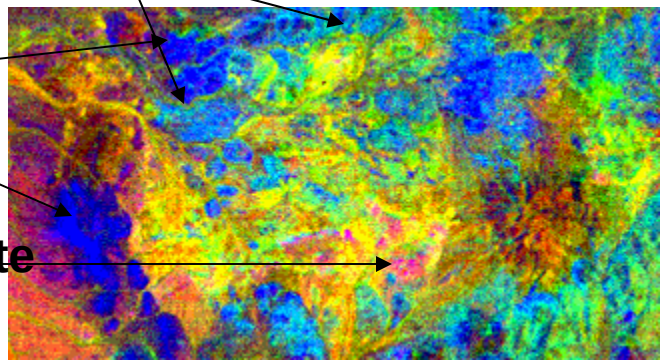
- Kaolinite & alunite areas are a possible indication of a gold deposit
- Quantitative analysis of multispectral bands allows the distinction and enhancement of certain compositional properties

andesite

basalts

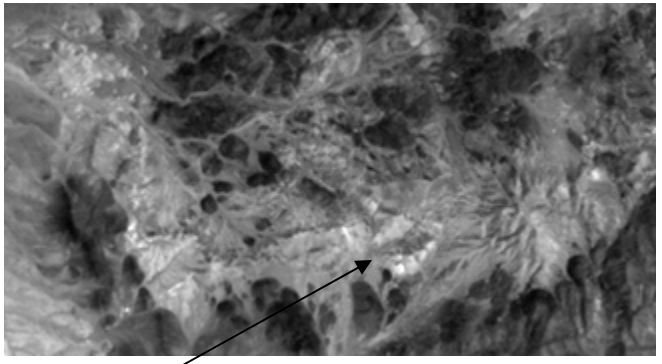
Kaolinite&alunite



Ratio color map: blue = 1/7, green = 4/2, And red = 3/1

3 km

Principal Component Analysis



Kaolinite&alunite

Remote sensing in mineral exploration or the search for chemical anomalies in the rock.

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- The direct observation of rocks and alteration zones in the tropics is hampered by the presence of thick soils and dense vegetation.
- However remote sensing techniques were developed to make use of the vegetation.

Remote sensing using vegetation

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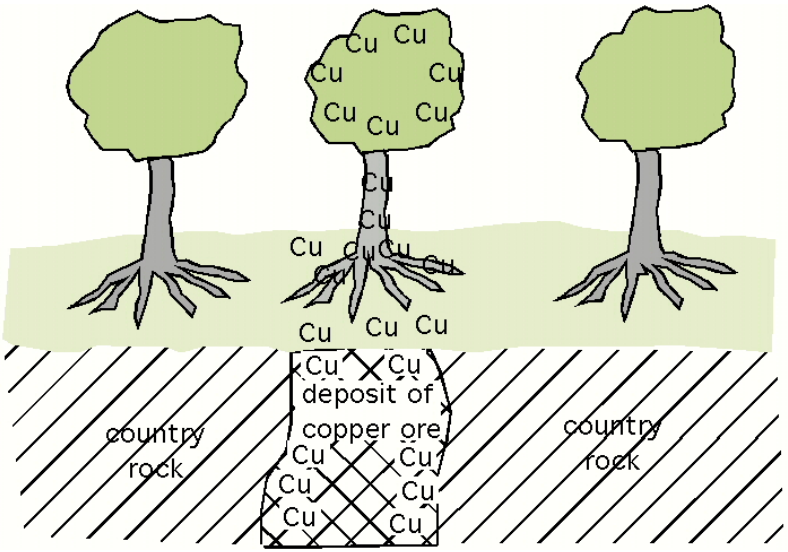
The effects of metals in the substrate of vegetation gives two types of responses in the vegatation:

Taxonomic response

Structural response



Remote sensing using vegetation

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Taxonomic response

Growth or non-growth,
e.g.: “helecho de cobre”

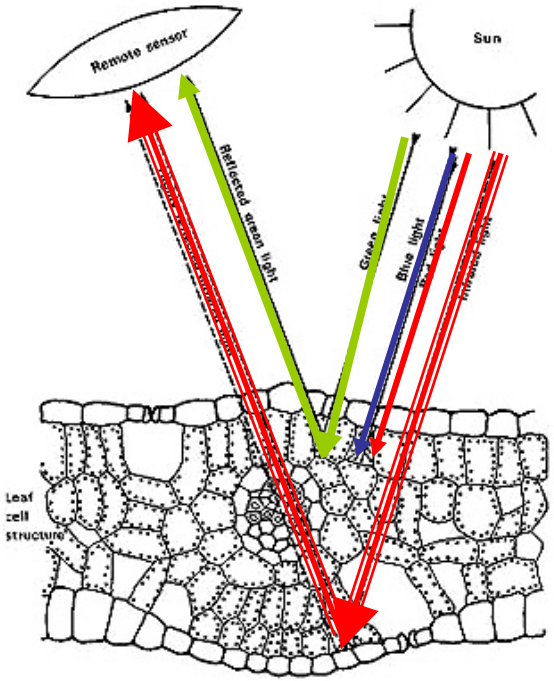
Structural response

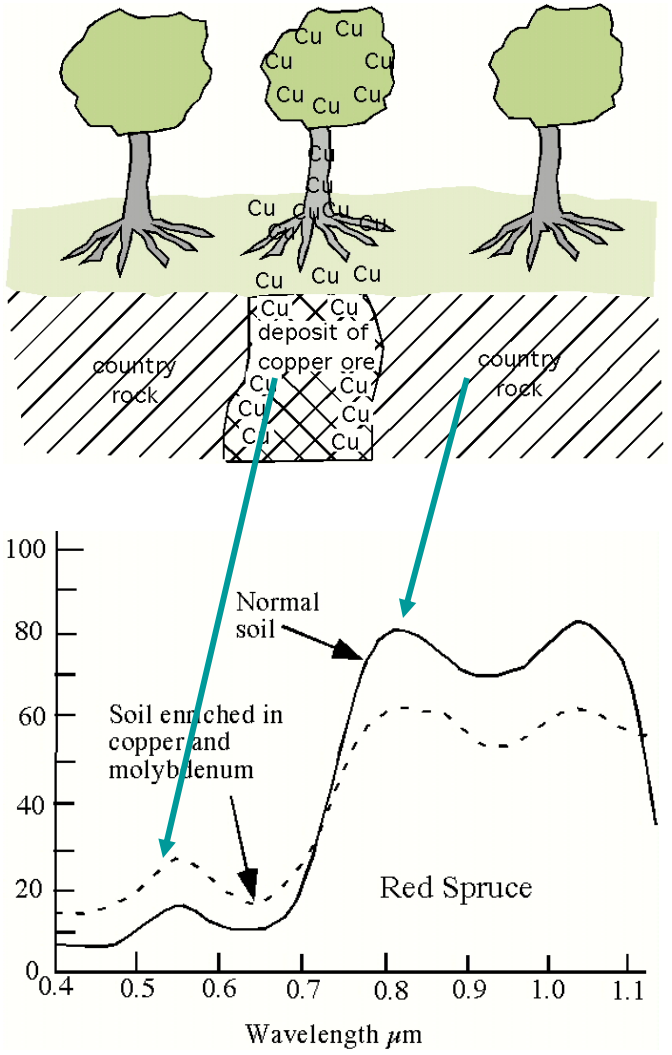
Morphological: e.g.dwarfism
Phenological: disturbance of natural rhythm
Physiological: e.g. pigment synthesis

In mangroves we plan to use the physiological response, nl chlorophyll synthesis

Reflectance of vegetation

What electromagnetic waves are reflected by the leaves?





- Physiological changes: chlorophyll synthesis

Reflectance of vegetation

What causes the reflection pattern?

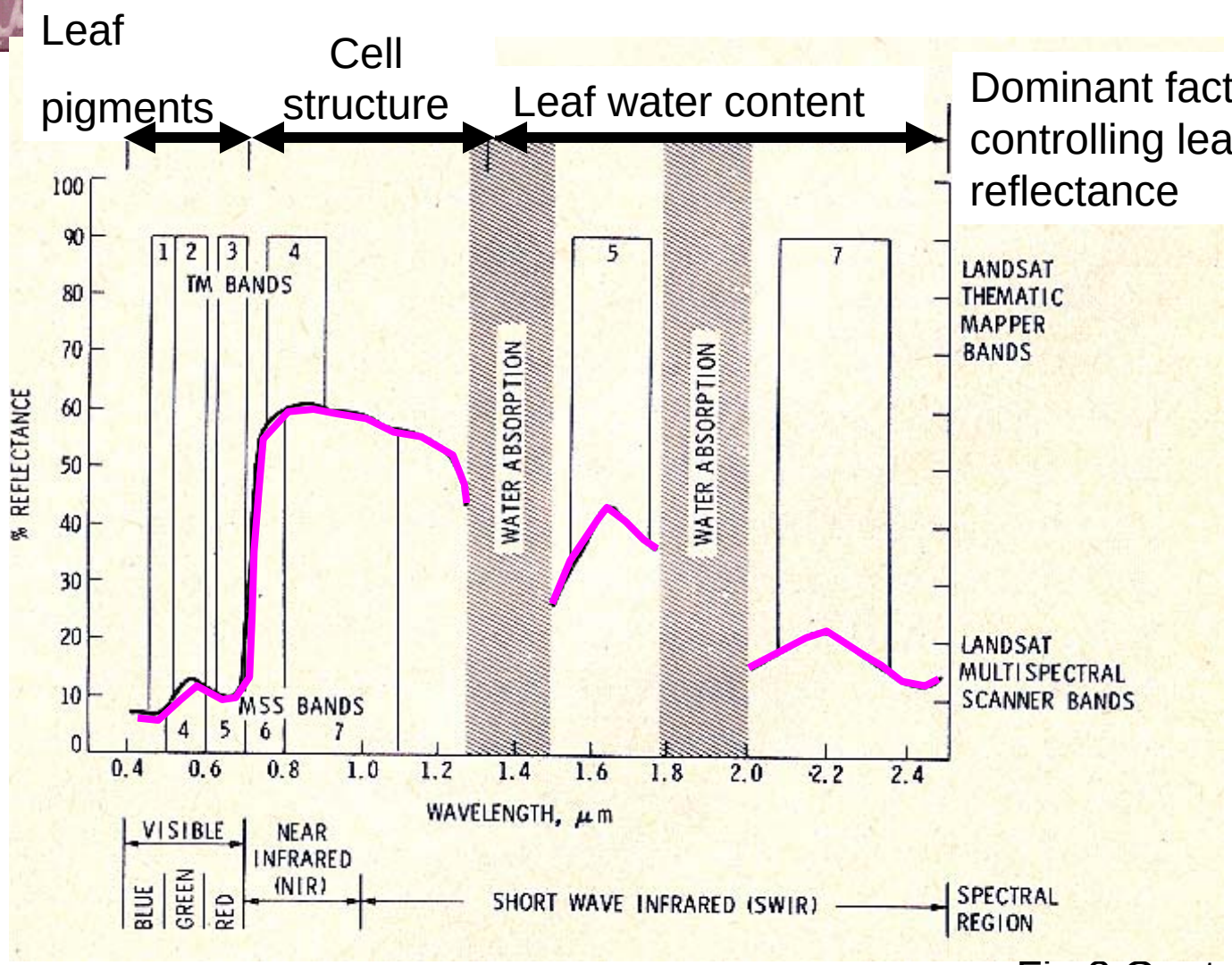


Fig 3 Goetz et al, 1983

Reflectance of vegetation

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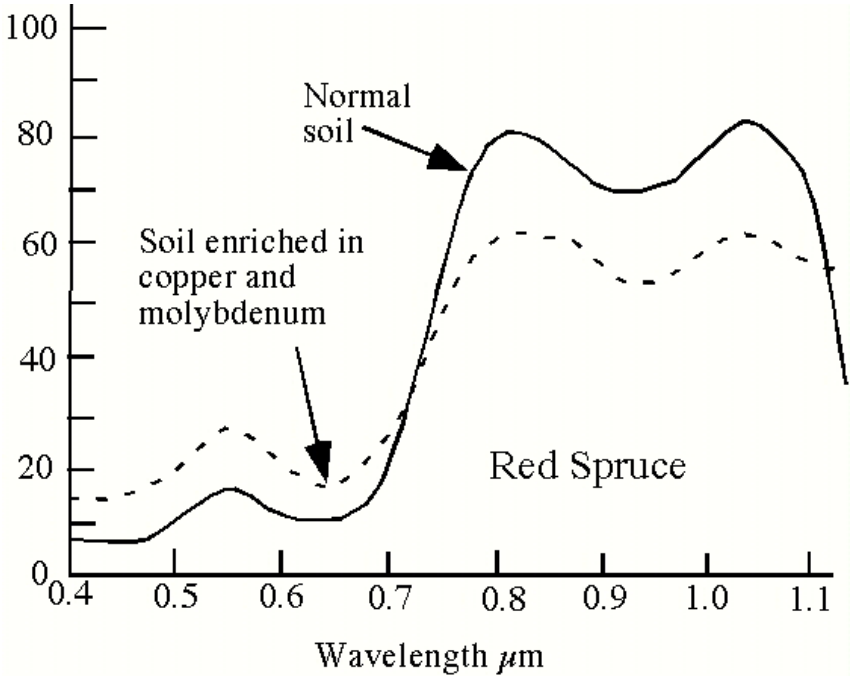
- Studies of reflectance patterns and metal content of substrate yielded varying results
- Red spruce shows an increase in reflection in visible light and reduction in the Infra red.
- This is not always the same for every tree species



Reflectance of vegetation

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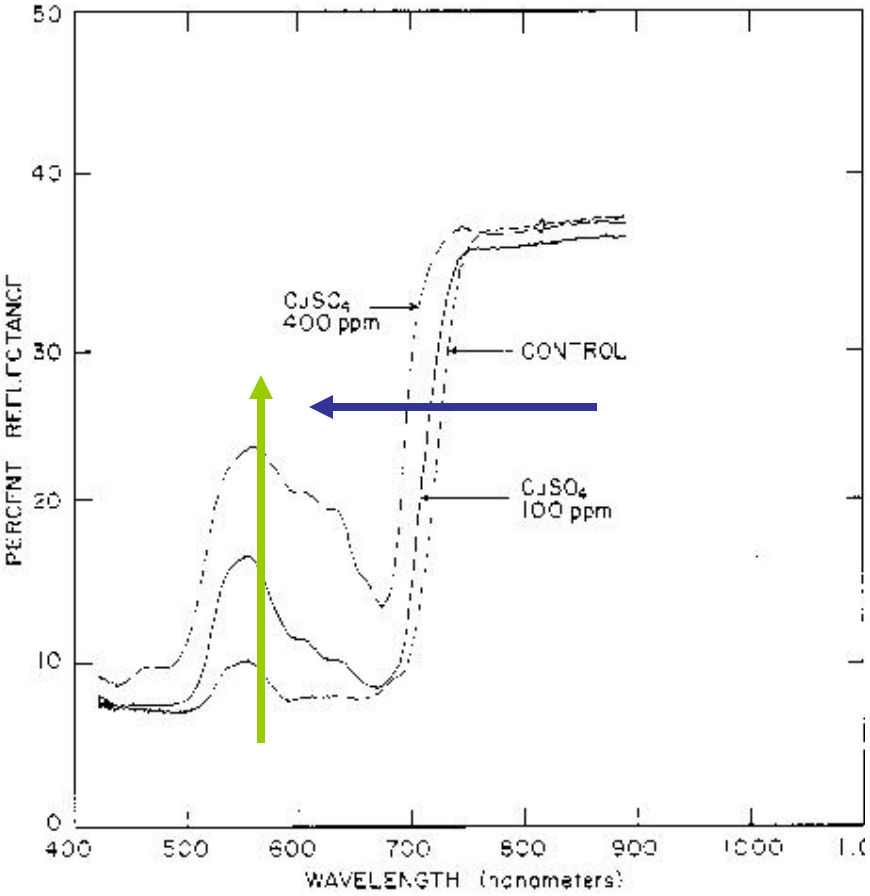
- Laboratory test
  - Effects of Cu-contamination on sorghum
  - Obvious reflection increase in visible light
  - Shift towards the blue wavelength of the infra red shoulder (blue-shift)



Reflectance of vegetation

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- Remote sensing for mineral deposits using changes in the vegetation works, but with a lot of variables.
- Remote sensing may be able to detect changes in the chlorophyll production caused by chemical anomalies in the substrate.
- Can the technique also be used to detect metal contamination in mangrove wetlands??
- A work in progress

Importance of mangrove wetlands

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- Why mangroves?
  - The health of mangrove wetlands is of critical importance to society in tropical marine regions, including coastal protection, wildlife refuge, nursery of marine life.
  - Mangroves provide >10% of essential dissolved carbon in the oceans – influences global warming
  - Mangrove wetlands have a more simple composition than the average tropical forest and may allow the use of remote sensing to detect anomalies

Using remote sensing to detect heavy metals in substrate of mangroves

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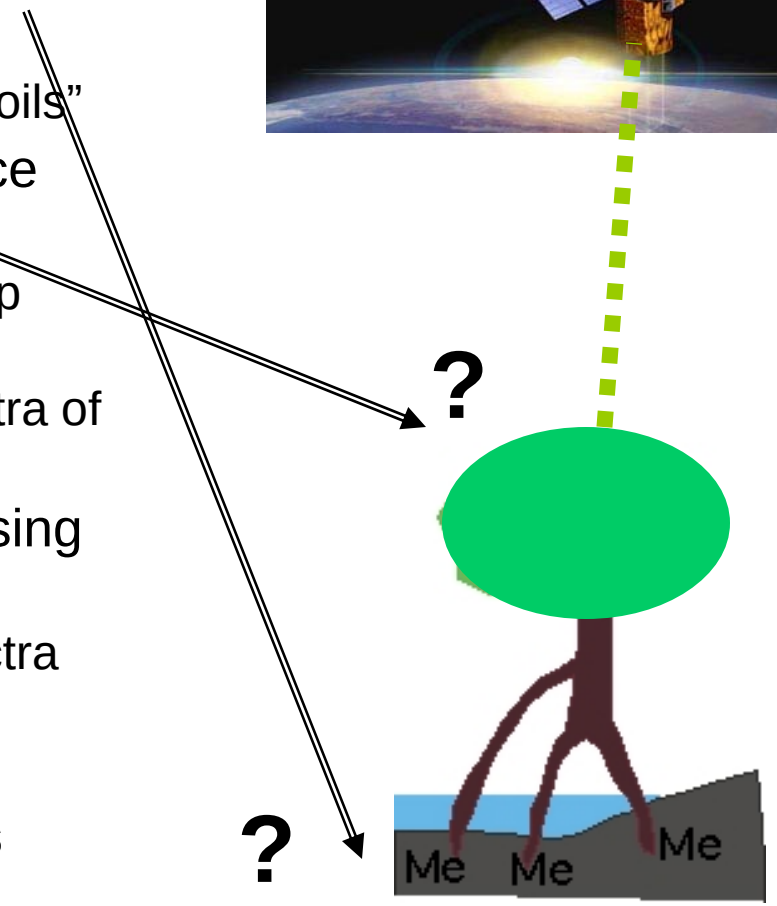
- The problem has three parts:
  - Contamination in substrate?
    - Chemical analyses of the “soils”
  - Do the contaminants influence the leaves?
    - Chemical analyses of the top leaves
    - Measuring reflectance spectra of the top leaves
  - Can we see the difference using satellite images?
    - Comparing reflectance spectra of contaminated and non-contaminated mangroves
    - Process the satellite images



Remote sensing to monitor mangroves for metal contamination

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The proposed research:

- Using selected mangrove areas
  - Chemical analyses of the “soils” (As, Cd, Cr, Pb, Hg, Ni, Co)
  - Analyse top leaves of canopy
    - Chemical analyses of the top leaves
    - Measuring reflectance spectra of the top leaves
  - Compare reflectance spectra of contaminated and non-contaminated mangroves
  - Process the satellite images using the differences in reflectance
  - If successful:
    - Write a protocol to process the images and discern possibly contaminated areas
    - Enter data in GIS as guide to monitors

Using remote sensing to detect heavy metals in substrate of mangroves

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- Some pilot projects
  - Comparison of known heavy metal contaminated mangroves with non-contaminated mangroves
  - Joyuda Lagoon next to Ni-Co laterite
  - Guayanilla reported Hg contamination
  - Arecibo in watershed with porphyry copper deposits
  - Guanica and Punta Ballena pristine

Using remote sensing to detect heavy metals in substrate of mangroves

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Sampling substrate and leaves from the top of the canopy

Scanning the standard and the leaves with the GER 1500 spectroradiometer

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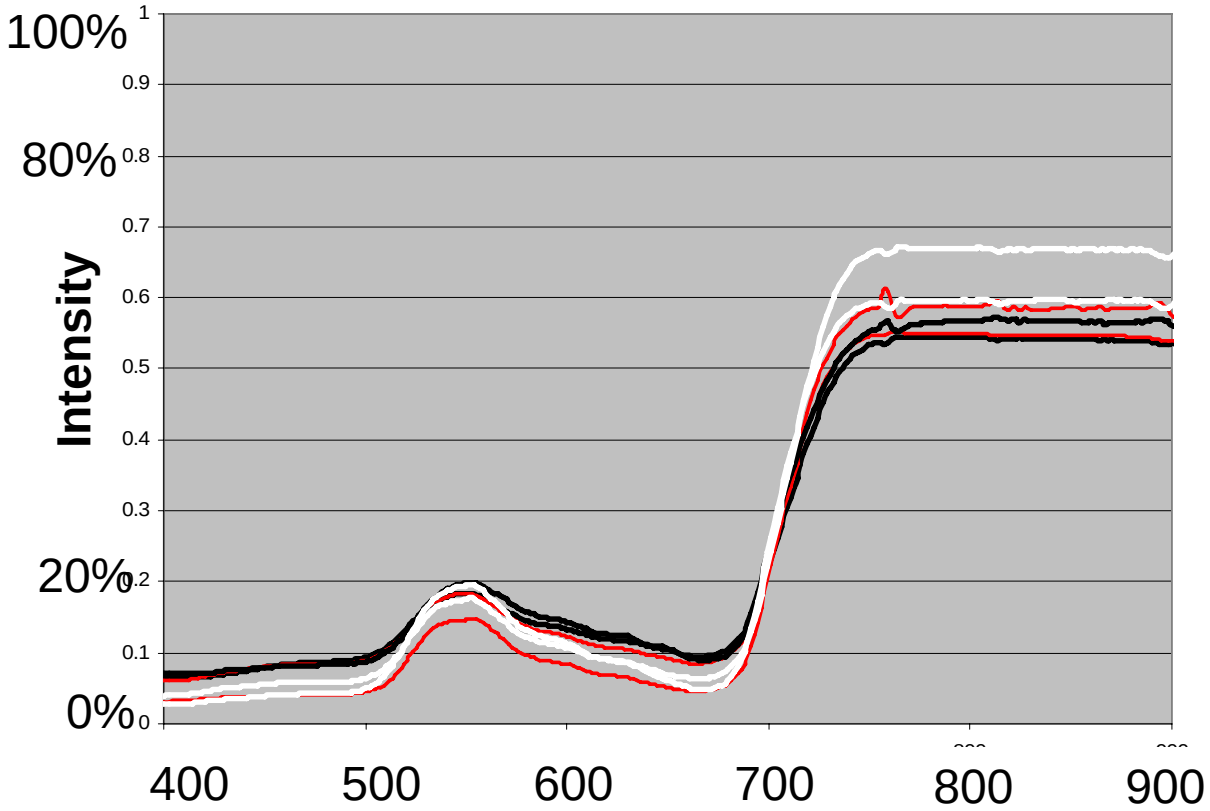
Guayanilla:
Close to industry

Arecibo mangrove, next to urbanization, sewage treatment plant and electrical substation

Punta Ballena:
Pristine mangrove

Guayanilla: Mangrove reflectance patterns



average NDVI red 0.60

average NDVI black 0.71

average NDVI white 0.75

Chemical analyses

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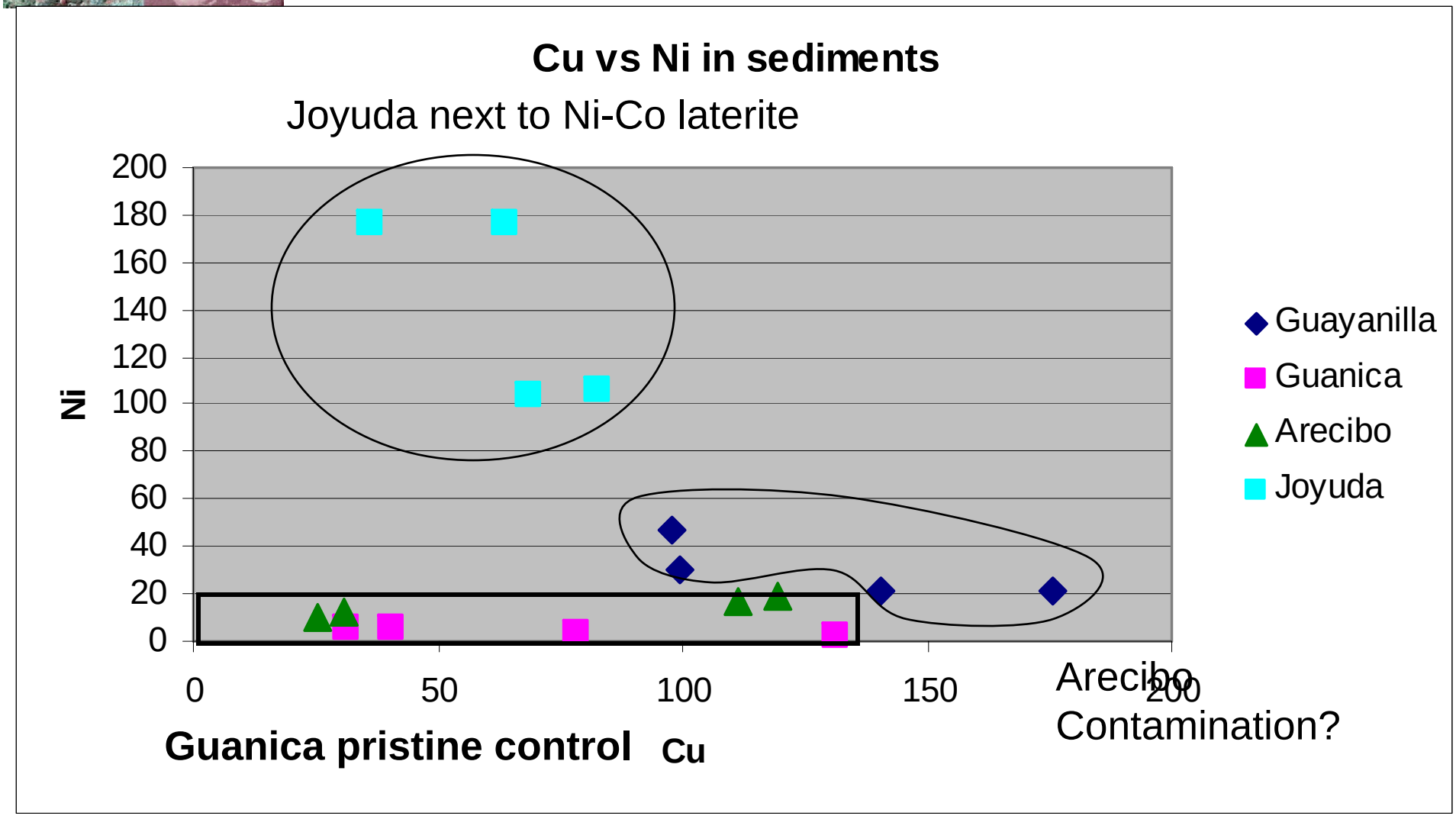

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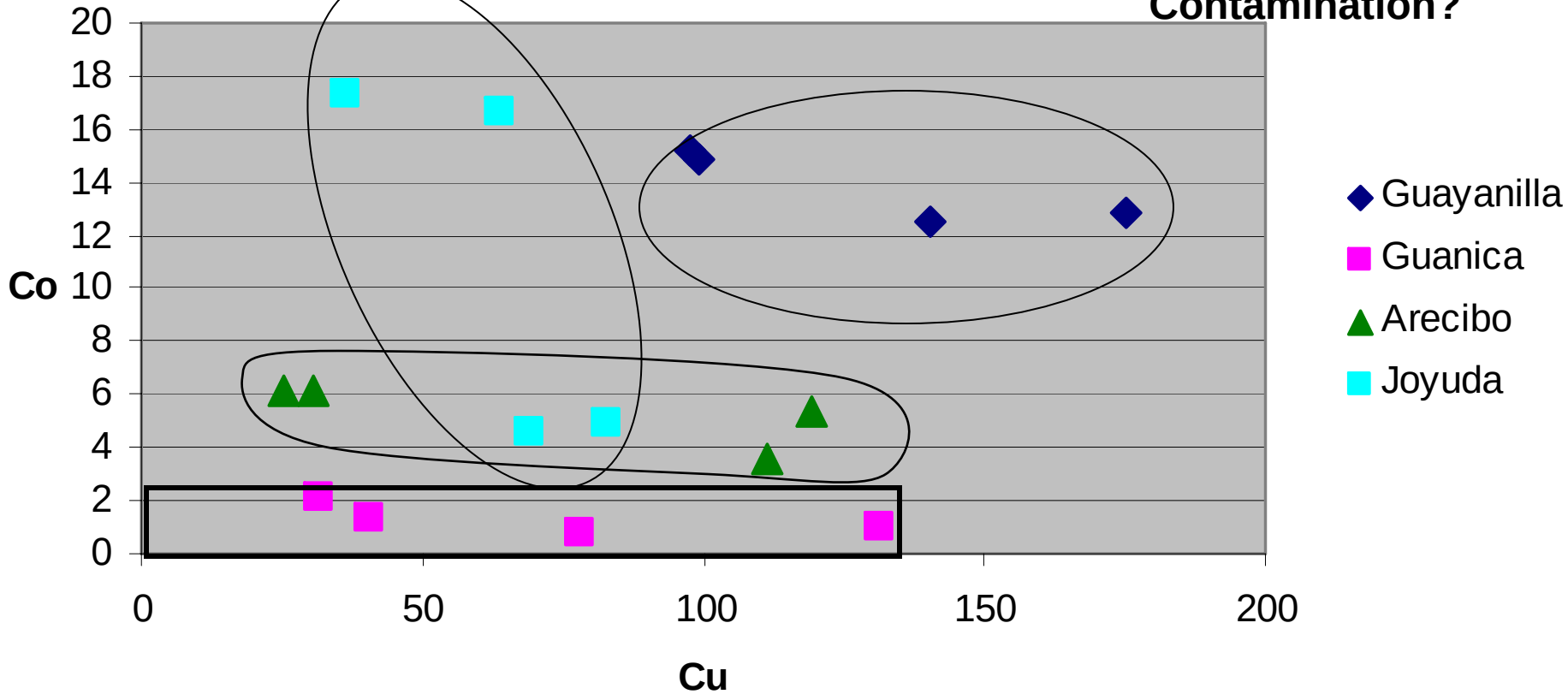
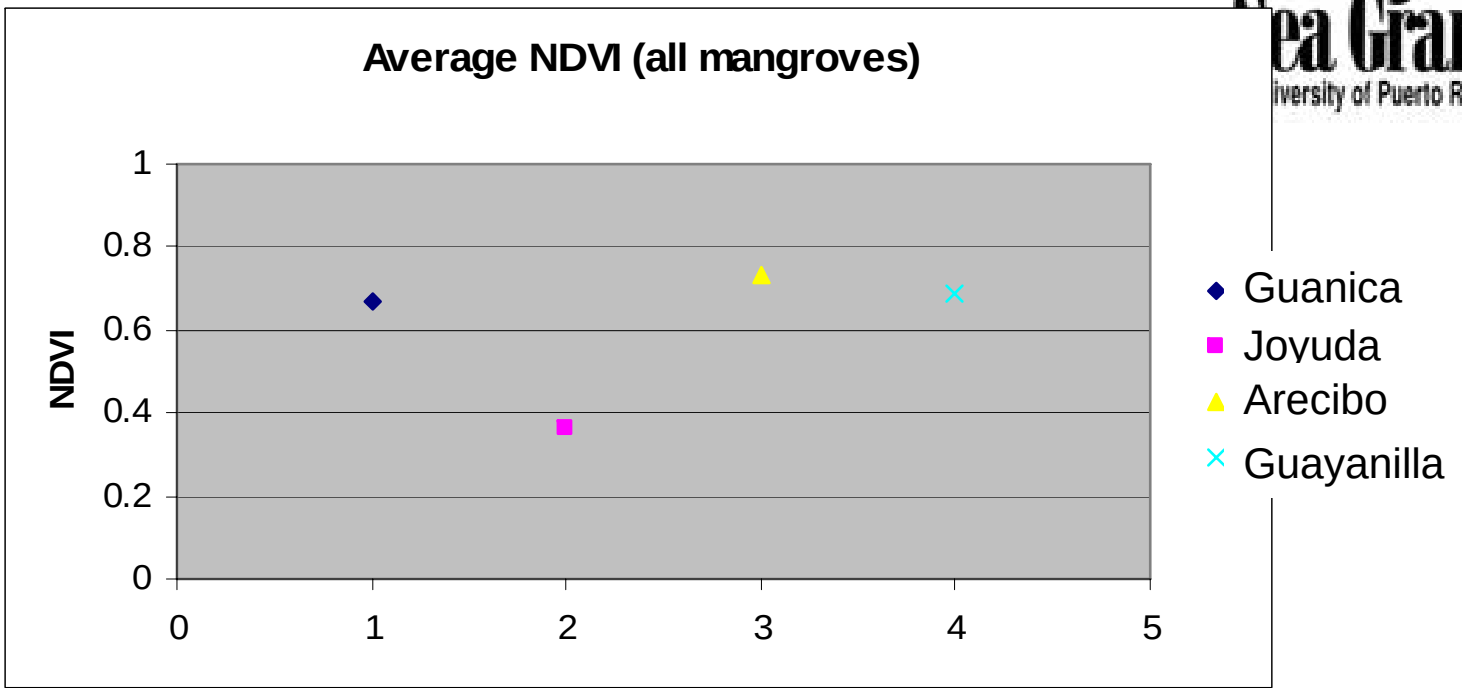
Co vs Cu in sediments

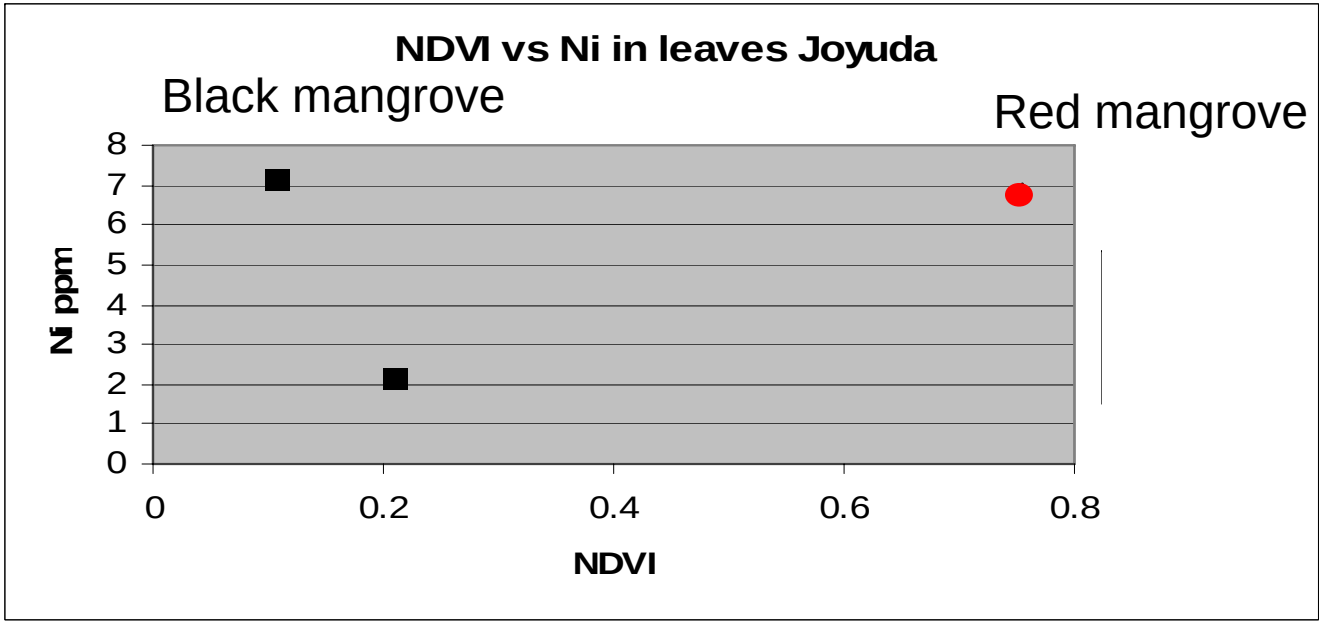
Joyuda next to Ni-Co laterite

Arecibo & Guayanilla Contamination?



GEOLOGY


Average NDVI (all mangroves)
NDVI
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
Guanica
Joyuda
Arecibo
Guayanilla


NDVI vs Ni in leaves Joyuda
Black mangrove
Red mangrove
Ni ppm
8
7
6
5
4
3
2
1
0
0
0.2
0.4
0.6
0.8
NDVI

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