Conservation of Biodiversity

in the Andes and the Amazon Basin

linking Science, NGOs and Local Communities

September 24, 2001
Cusco, Perú

Ecological Classification of Pristine Vegetation

in the Río Avisado and Río Tioyacu Watersheds, Northern Perú

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The *Forest Ecology and Remote Sensing Group* (UBT) studies:

- Spatial distribution of pristine vegetation
- Boreal, temperate, and tropical forests
- Carbon, water and nutrient status of vegetation units
- Fluxes and flux regulation within the ecosystem units

Projects of the *Forest Ecology and Remote Sensing Group* combine:

- Ground based measurements of static and dynamic ecosystem properties
- Visual & Radar Remote Sensing Data
- GIS Techniques

Presentation Overview:

- GTZ-DIAM Project, Alto Mayo, Peru
- Principles of Synergistic Data Approach
- Three Application Examples
  - Temporal Flooding Detection (Swamp Forests)
  - Fine Scale Edapic Classification (Dry Hill Forests)
  - Canopy Structure Differentiation (Heath vs. Rain Forest)
- Advanced Forest Structure Detection Techniques



- Northern Peru
- Andes, Eastern Slopes
- Tropical Climate
- Predominantely Rainforest

Background:

- Construction of Carretera Marginal in 1975
- Strong Influx of Settlers to the Alto Mayo Area
- Current Population Growth in Alto Mayo Valley exceeds 10% annually
- Strong Colonization Pressure on Pristine Forests of the Río Avisado Watershed

Our Project Link:

- Rural Development Project on Rice Irrigation and Protection of Forest for Upper Watershed
- Gesellschaft für Technische Zusammenarbeit (GTZ, Germany)
- Kreditanstalt für Wiederaufbau (Financing Partner, Germany):

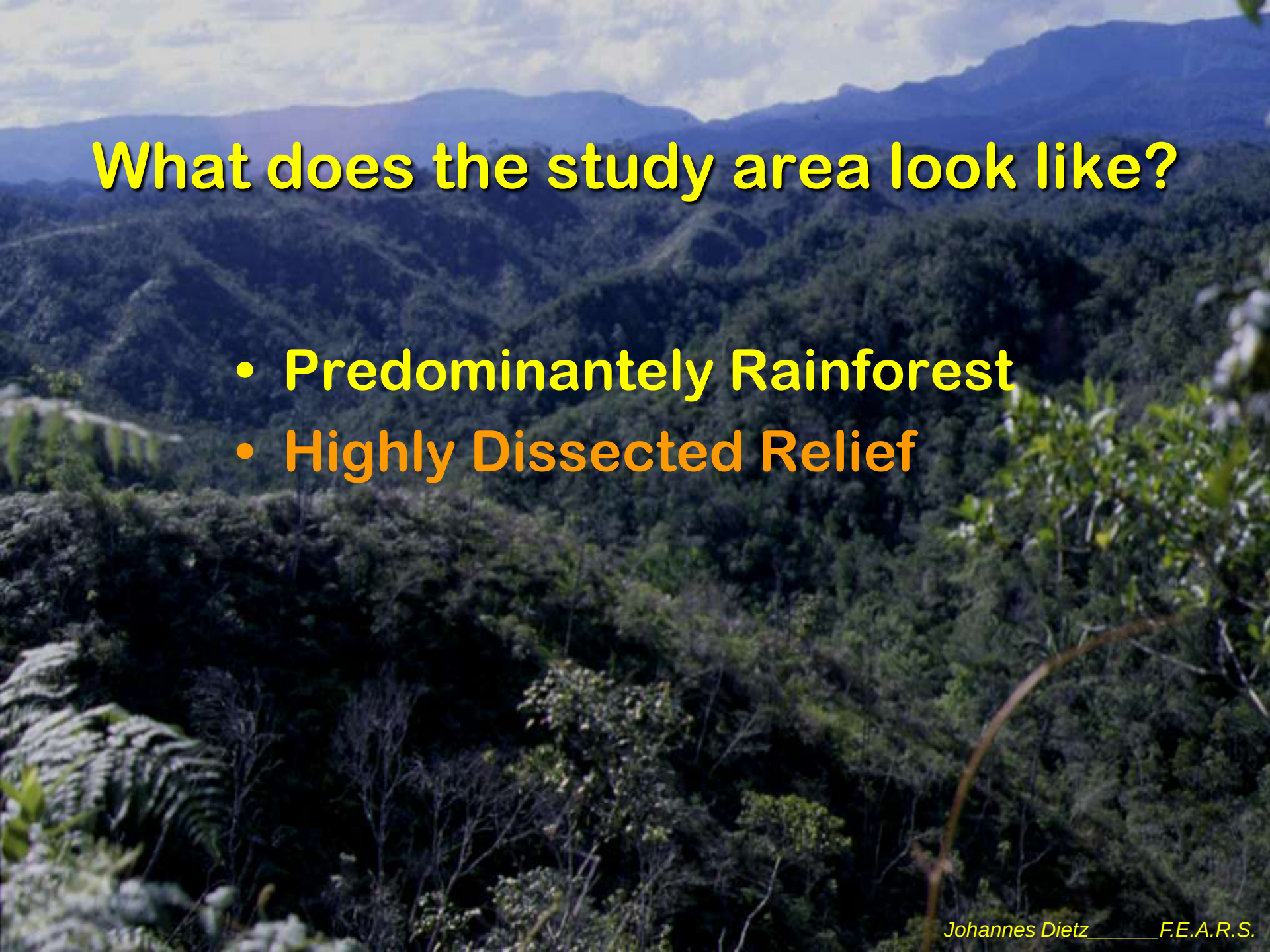
  Requires Ecological Evaluation of Watershed

Project Requirements:

- Forest & Soil Classification
- Ecosystem Evaluation
- Risk Assessment
- Forest Protection Plan

What does the study area look like?


What does the study area look like?
• Predominantely Rainforest
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What does the study area look like?

- Predominantely Rainforest
- Highly Dissected Relief

What does the study area look like?

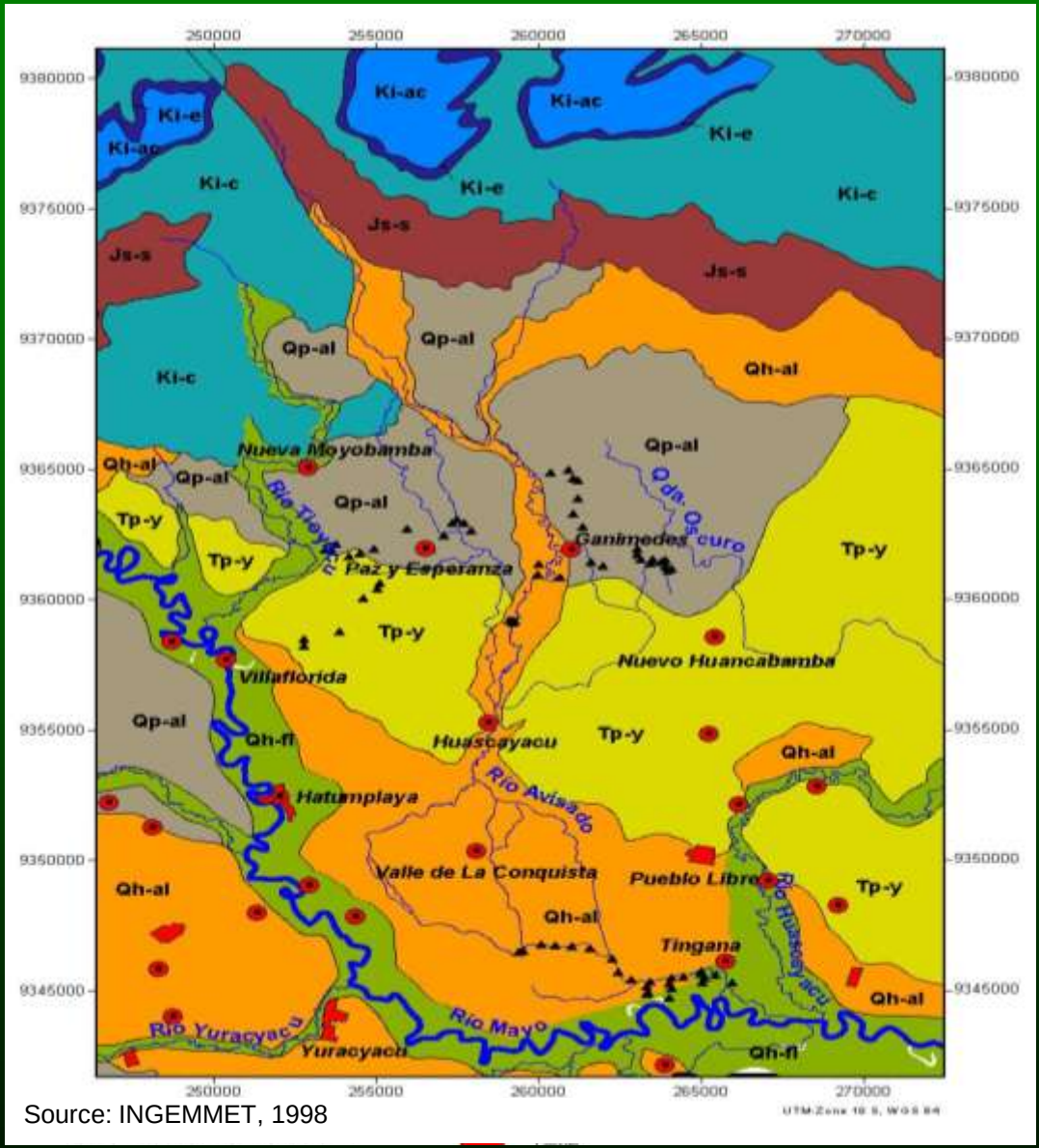
- Predominantely Rainforest
- Highly Dissected Relief
- Inaccessibility of Upper Watershed

What does the study area look like?

- Predominantely Rainforest
- Highly Dissected Relief
- Inaccessibility of Upper Watershed
- Diversity of:
  - Geomorphology
  - Vegetation

Available Data

- Geology



Source: INGEMMET, 1998

Available Data

- Geology
- Topography

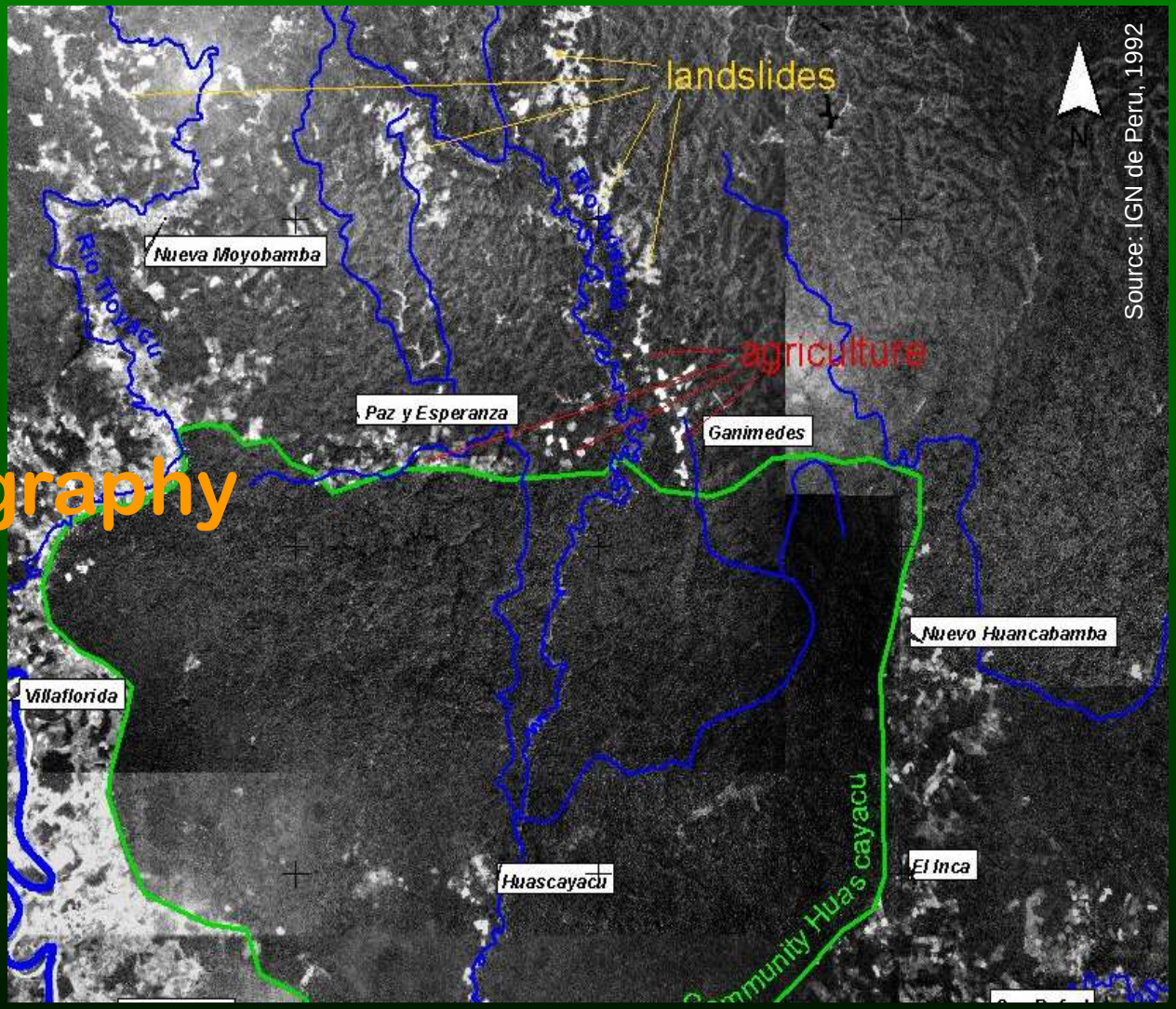
Vertical and horizontal resolution of limited value for DEM



Available Data

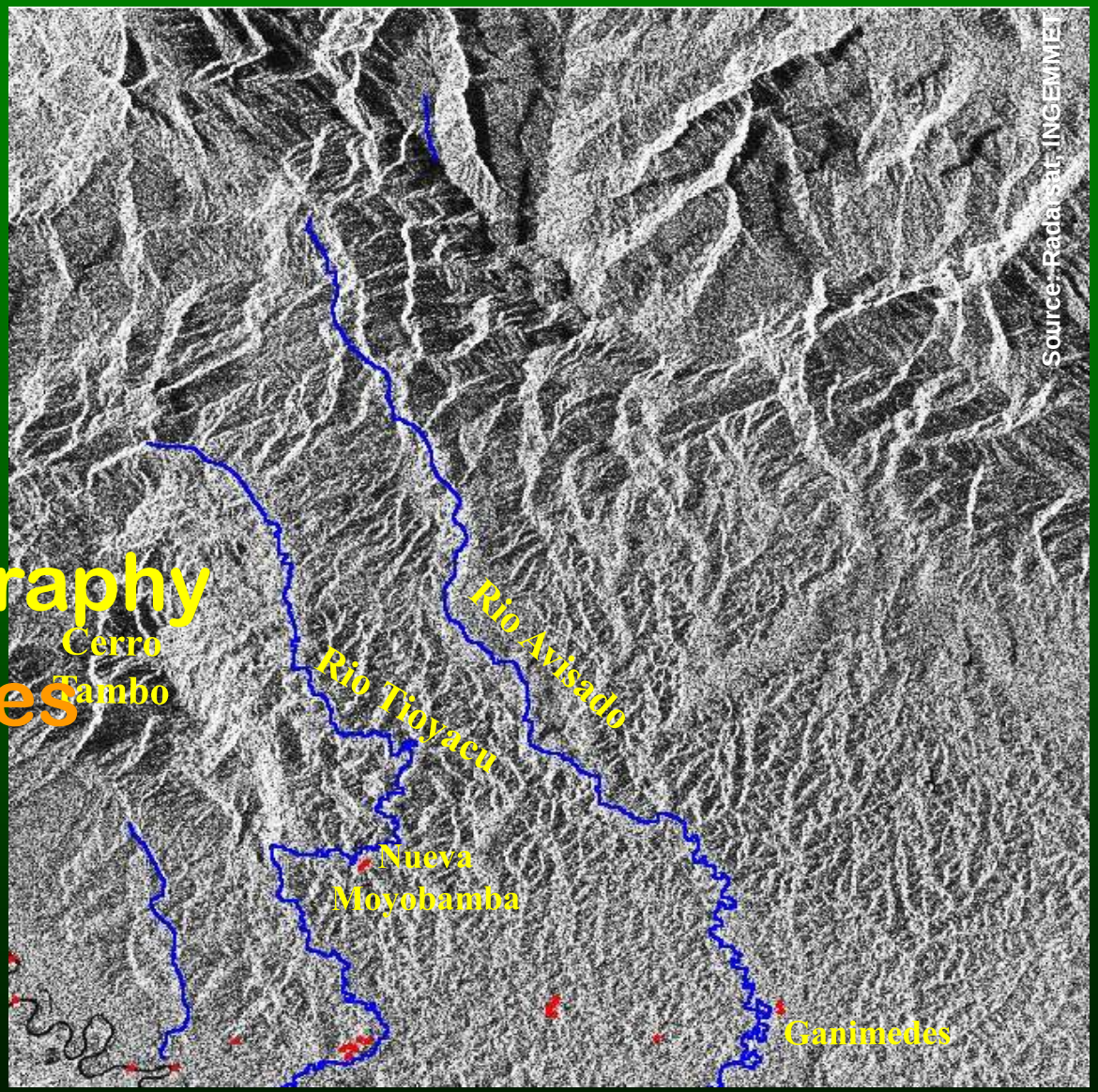
- Geology
- Topography
- Aerial Photography

- Repeat time >10 years
- Limited interpretability in closed forest areas



Available Data

- Geology
- Topography
- Aerial Photography
- Satellite Images



Visible Range & Infrared Imagery
(TM-Landsat , SPOT, IKONOS)

- Irregular repeat cycles
- Provide surface reflectance properties and surface texture only

Single C- or L-Band Radar

- Low spatial resolution

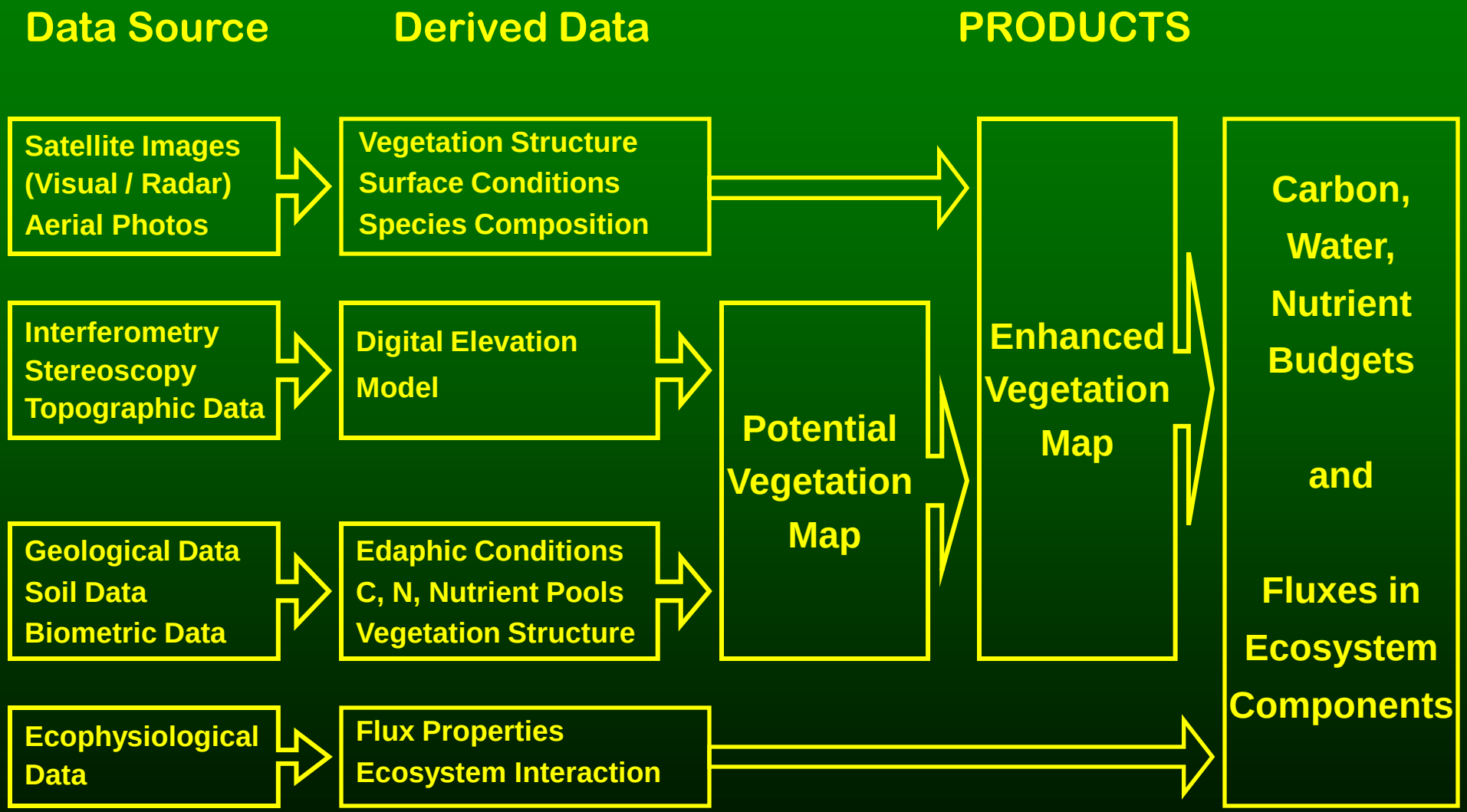
Problem:

Currently available data sets either do not provide sufficient spatial or temporal resolution to perform an ecological classification in tropical forests

Solution:
Synergistic Data Processing Approach

- Remote Sensing
- Ground Truthing
  - Biometry
  - Soil Assessment
- Eco-physiological Measurements

Synergistic Use of Ecological and Remote Sensing Data



Advantages:

- Synoptic Forest Classification is based on established physical and ecological principles
- Provides robust classification procedure, with validity beyond ground truthing areas
- Ecosystem inventories and flux properties of vegetation are quantifiable
- Disturbance detection is an integral part of the process
- Monitoring and change detection are possible - based on structural properties



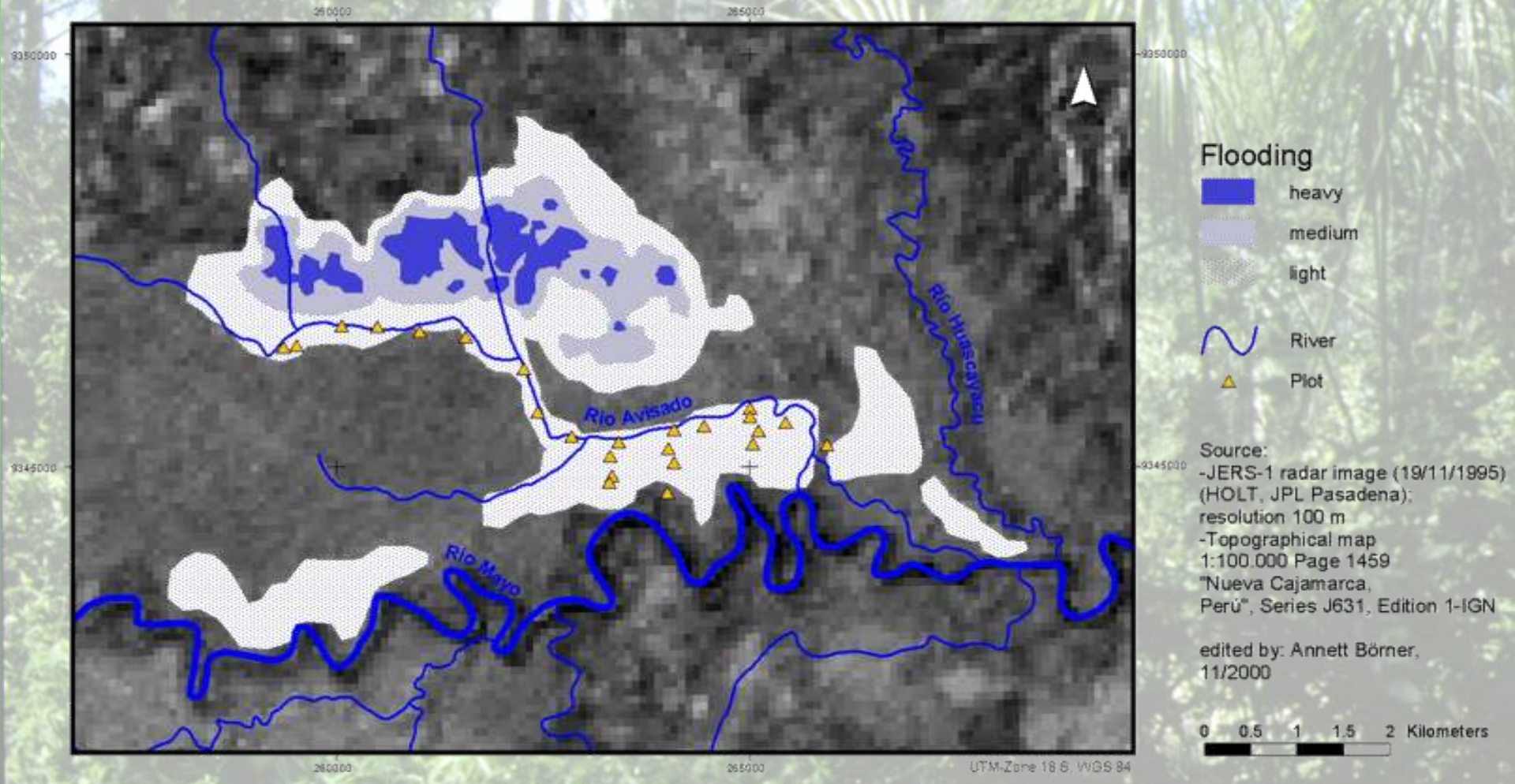
Example 1:
Floodplain Forest
- Temporal Resolution -

- Differentiation between two inundation forest types and upland forest
- Duration of flooding determines the occurrence of “Aguajales”
- L-Band Radar (JERS-1) detects flooded areas

Floodplain Forest

- Temporal Resolution -

Plate 7: Flooded Areas in the Innundation Forests During the Rainy Season
(Río Avisado, Alto Mayo, Northern Peru)



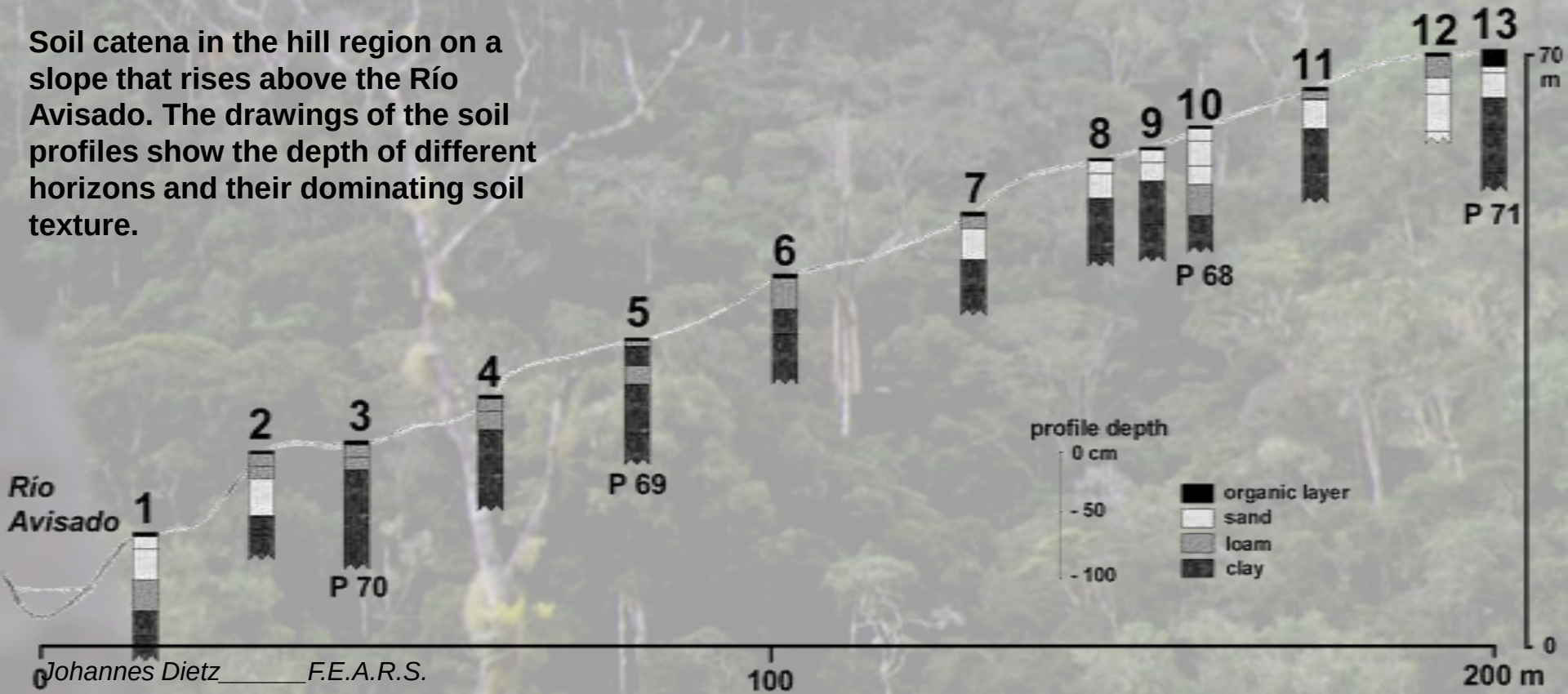
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Example 2:

Hill Forests

Small scale variation of topographic position drives soil and forest composition

Soil catena in the hill region on a slope that rises above the Río Avisado. The drawings of the soil profiles show the depth of different horizons and their dominating soil texture.



Hill Forests

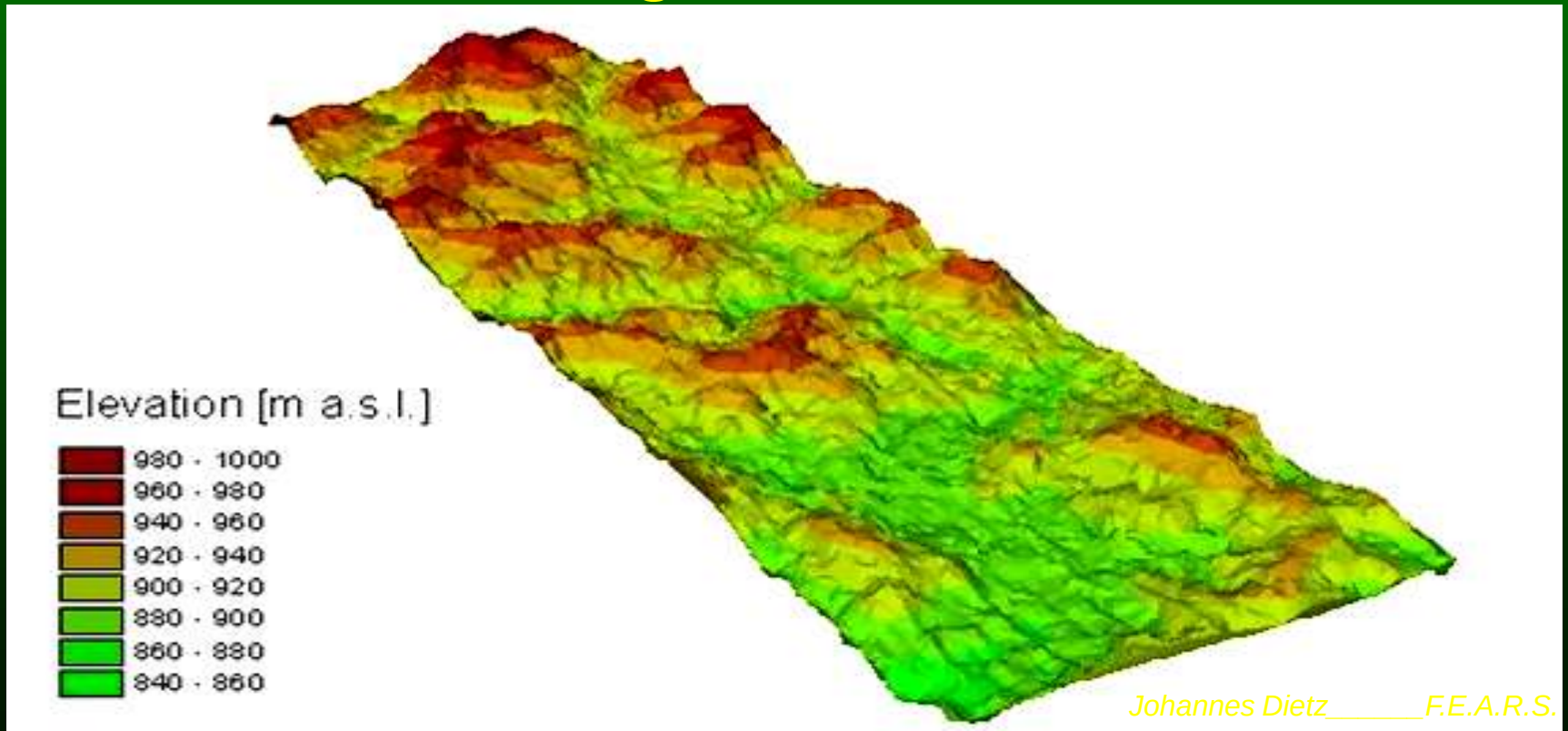
What was needed?

- High resolution topographic map for the classification of small scale edaphic situation

Hill Forests

What did we do?

- Create a grid of GPS-reference points
- Derive a high resolution Digital Elevation Model
- Derive soil and vegetation variation from DEM



Example 3:

Heath Forest vs. Rain Forest

- Direct Structure Detection -



- Both Forests Show an Irregular Patchwork of Contrasting Vegetation Types

Problem:

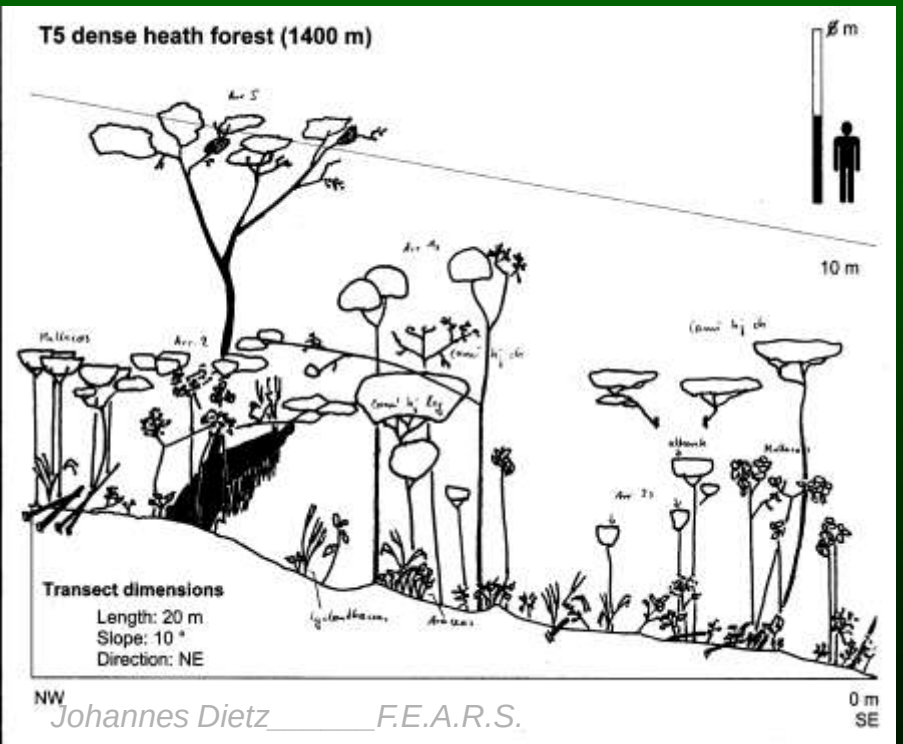
- Vegetation Distribution is Independent of Edaphic or Topographic Situation
- A Potential Vegetation Map does **NOT** predict actual Vegetation Cover

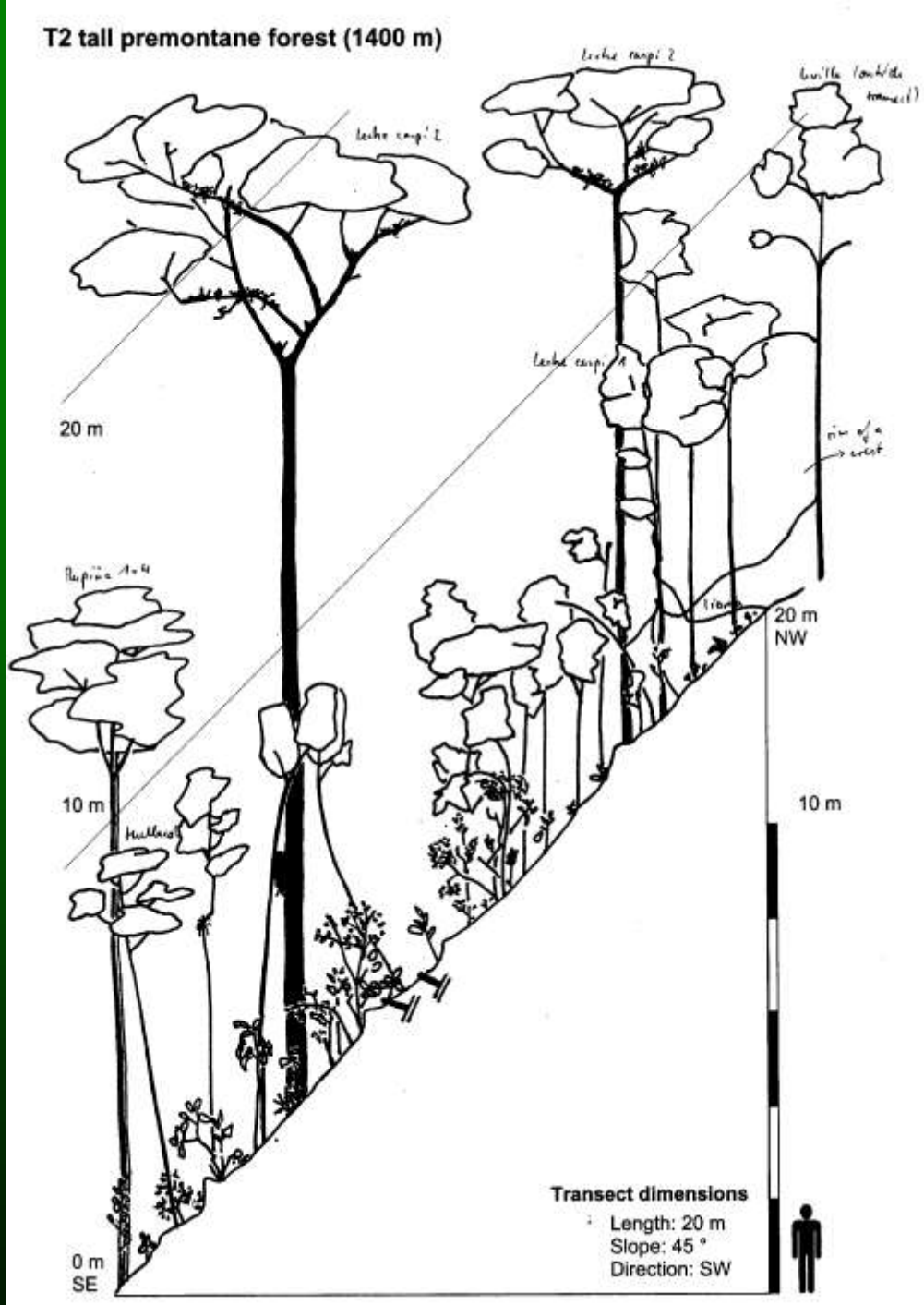
Solution:

- Direct Forest Structure Classification by Image Analysis

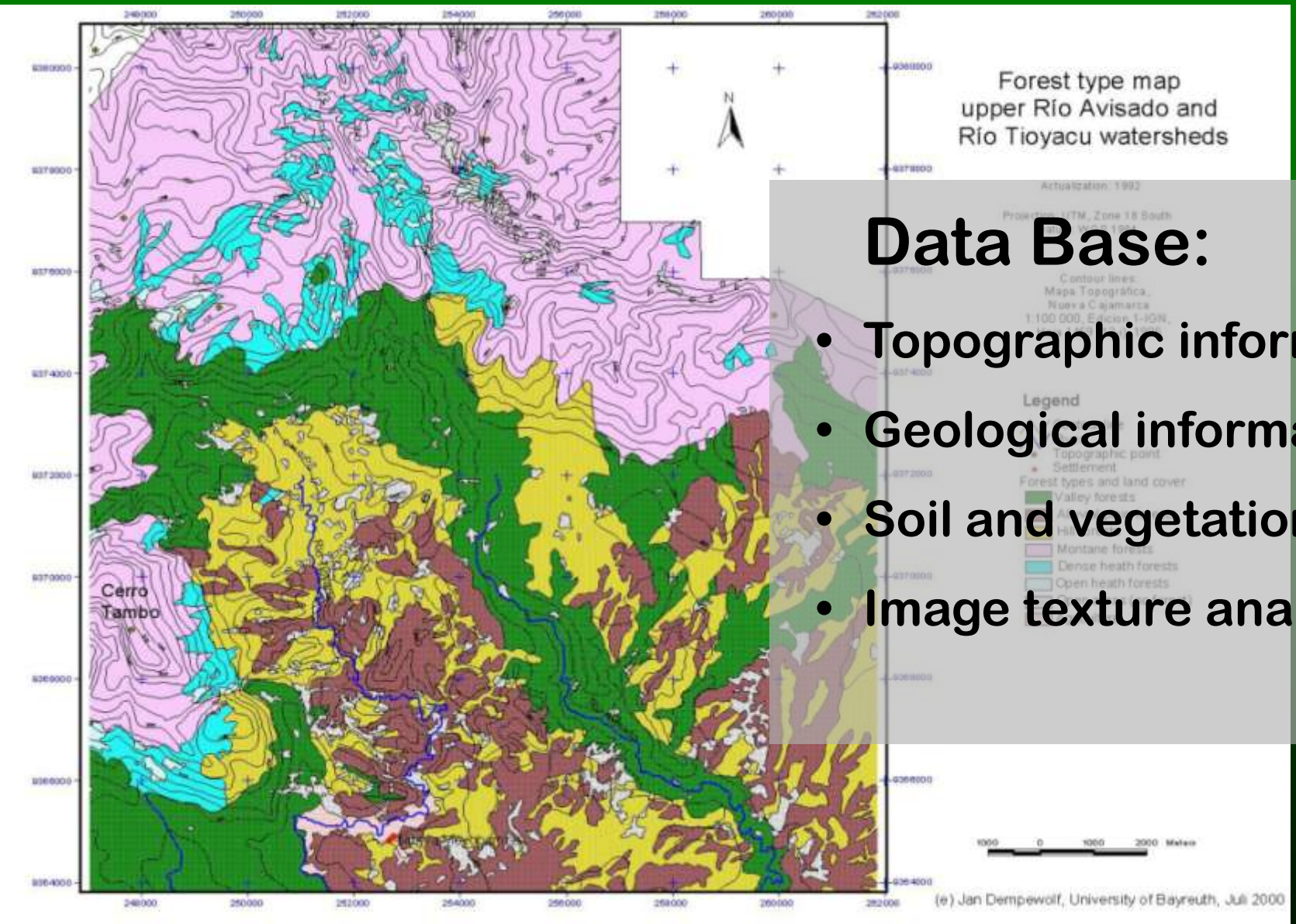
Heath Forest vs. Rain Forest

Pronounced Difference in Structural Properties





Synergistically Obtained Forest Map of the Río Avisado Watershed



Data Base:

- Topographic information
- Geological information
- Soil and vegetation plots
- Image texture analysis

However…

…for large tropical forest areas

- Stereoscopic DEM Generation
- Thematic Visible Range Image Interpretation
- Ground Based Change Detection & Monitoring

…is time consuming and expensive

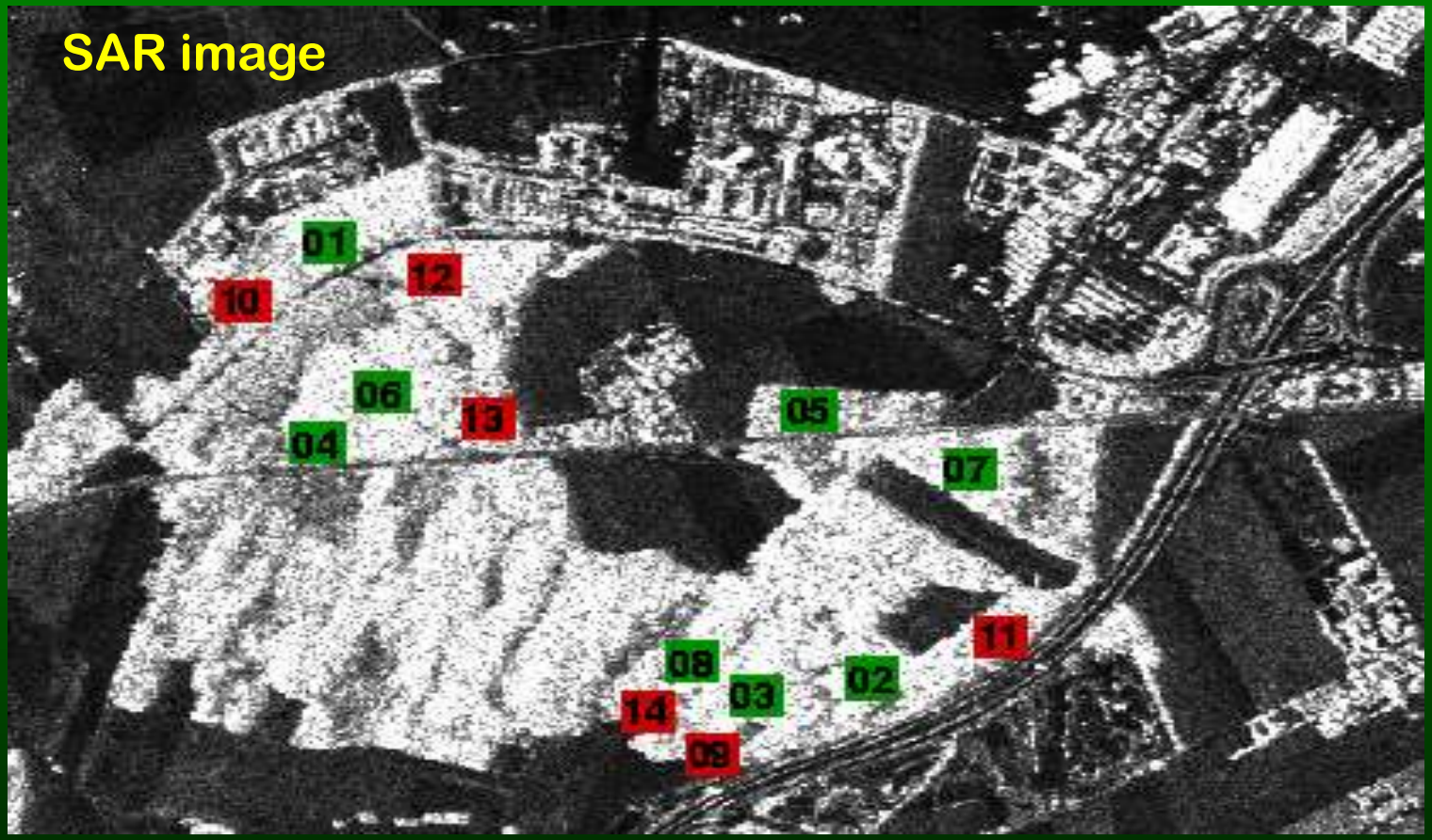
What will get us further?

The technical solution could be provided by

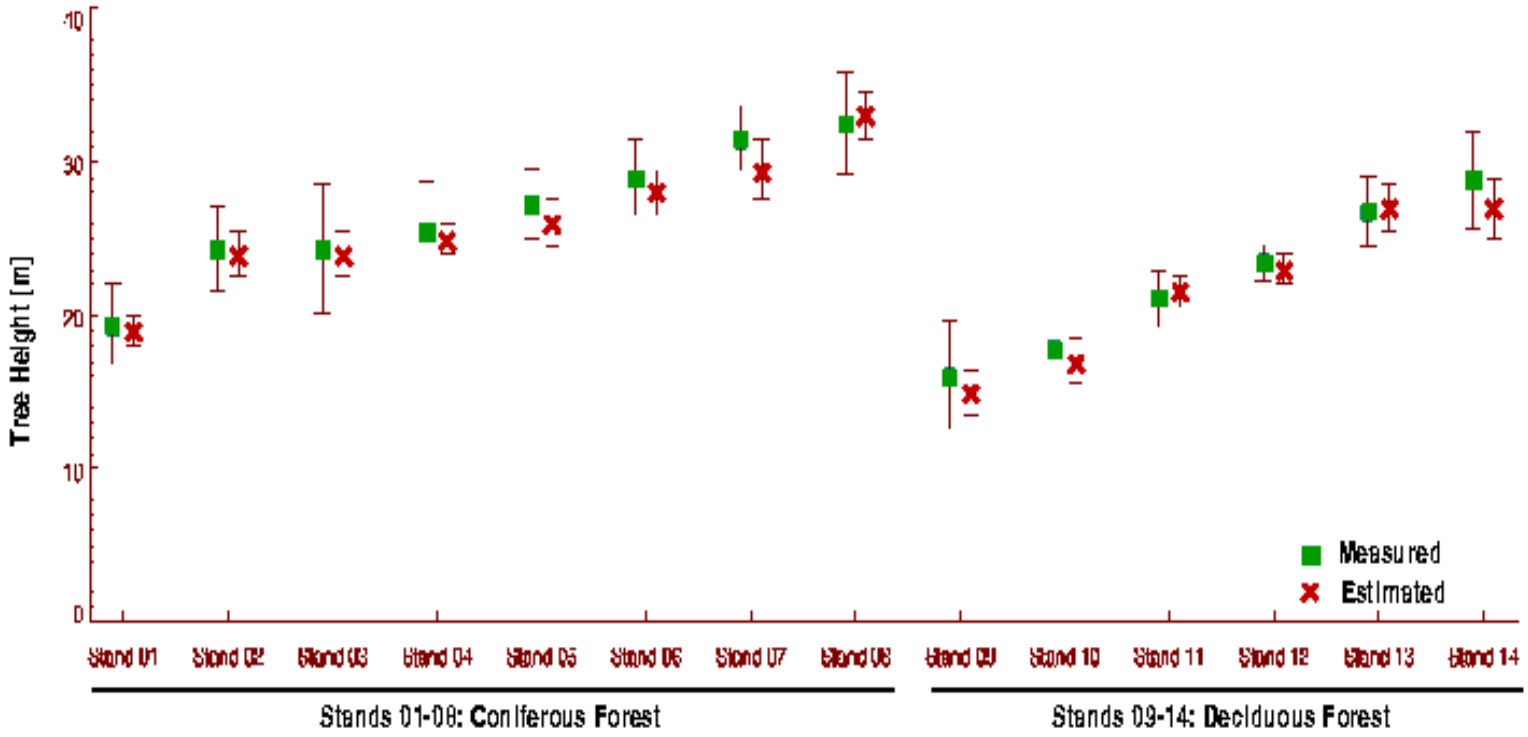
Advanced Synthetic Aperture Radar

Image Analysis…

Tree Height Estimation by Polarized Interferometric Radar:



Tree Height Estimation by Polarized Interferometric Radar:



Tree Height Estimation by Polarized Interferometric Radar:

Improvements:

- Automatic Ground Surface DEM Generation
- Automatic Tree Height Measurement
- Vertical Accuracy for both is within 2 m

Accurate tree height determination permits prediction of forest biomass by robust allometric relationships for structurally well defined forest types

(cf. Ogawa et al., 1965)

Forest height and Biomass estimation by SAR

Conventional Biomass Estimation by Radar Backscatter Saturation:

	Biomass Saturation Limit [t ha^{-1}]	% of Earth's Vegetated Area	% of Total Biomass Stock
L-Band	40	35%	8%

Biomass Estimation based on Polarimetric Interferometry:

Tree Height + DEM	250	75%	80%

Biomass estimation by remote sensing will improve dramatically

Conclusion

- Non-supervised classification of the Río Avisado watershed proved to be feasible with our synergistic data approach
- For larger forest areas the application of advanced satellite radar imaging techniques will provide:
  - Precise Digital Elevation Maps
  - Accurate forest structure data for inventory
  - Reliable repeat time images for change detection

Field work and data analysis was performed by

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Cooperating partners

- Max-Planck Institute for Biogeochemistry, Jena, Germany
- Gesellschaft für Technische Zusammenarbeit (GTZ), Germany
- Proyecto Especial Alto Mayo (PEAM), Moyobamba, Peru
- Universidad San Martín, Facultad de Ecología, Moyobamba, Peru
- Deutsche Gesellschaft für Luft- und Raumfahrt (DLR), Germany
- Jet Propulsion Laboratory (JPL-NASA), Pasadena, USA

MPI-BGC Jena

DLR

JPL

UNSM UNIVERSIDAD NACIONAL DE SAN MARTIN

gtz

Peam

This work was funded by the Gesellschaft für Technische Zusammenarbeit (GTZ) under coordination of
Ing. Arno Perisutti (Desarollo Integral Alto Mayo - DIAM)