# Ecological Classification of Premontane Vegetation
## in the Alto Mayo Valley, Peru


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## Problem

Forest classification and mapping of intact tropical forest areas is often difficult due to limited access in the field and low availability of spatial data.

## Approach

Mapping of tropical vegetation types was performed in a remote premontane tropical landscape of Peru. A four step approach was chosen which combined 1) field studies, 2) statistical data analysis, 3) landscape analysis and 4) remote sensing techniques.

The ecological vegetation classification is based on the observation that pristine forest structure is closely correlated with edaphic conditions which are mainly driven by topography, climate and geology. While potential vegetation classification can be done a priori, disturbance is unpredictable and must be detected directly by remote sensing.

## Study Area

The study was conducted in the Rio Avisado and Rio Tioyacu watersheds on the left banks of the Upper Rio Mayo in north central Peru (Fig. 1 a). The climate is tropical moist with one dry season per year (Fig. 1 b). The area has three geomorphologically different regions: a) montane region (1100 to 1600 m asl.) over Cretaceous and Jurassic sandstones, b) eroded hill areas (900 to 1100 m asl.) on sandy Quarternary deposits and c) floodplains below 900 m asl. (Fig. 1 c).

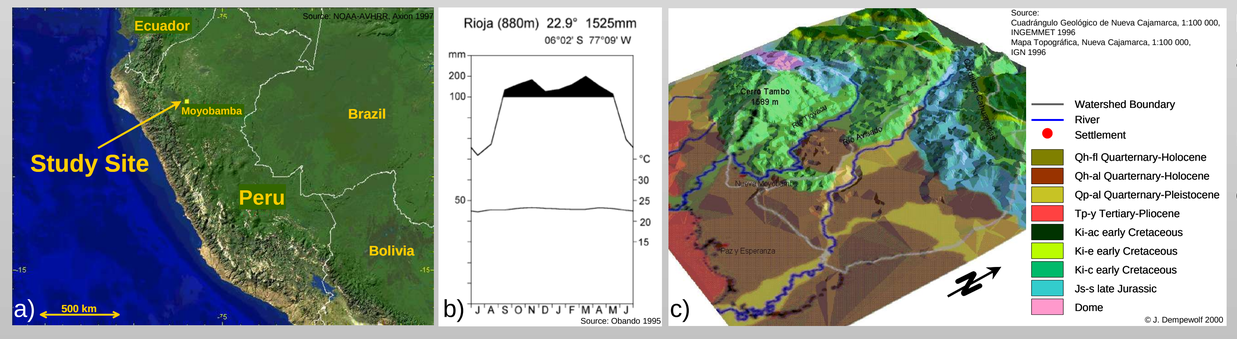



**Fig. 1:** Study area:
a) Location in north central Peru on the eastern slopes of the Andes
b) Climate diagram for Rioja, Alto Mayo valley
c) 3-D view of the studied watersheds

## Field Work

In the field biometrical data of the forest stands, structural characteristics and soil samples were collected on > 200 plots to describe the spatial variation of forests in the region.

## Analysis

Data was screened, reduced by principal component analysis and consequently submitted to a hierarchical cluster analysis (Fig. 2). Resulting classes were examined for common characteristics respecting to edaphic (soil, nutrients), biometric (above ground stand biomass) and structural properties.

## Mapping

For the upper watershed a panchromatic aerial photograph was merged with contour lines and geological information (Fig. 3) and a decision tree for the image analysis was developed (Fig. 4). This lead to the forest type map of the study area shown in Fig. 5 based on six forest types derived from cluster analysis.

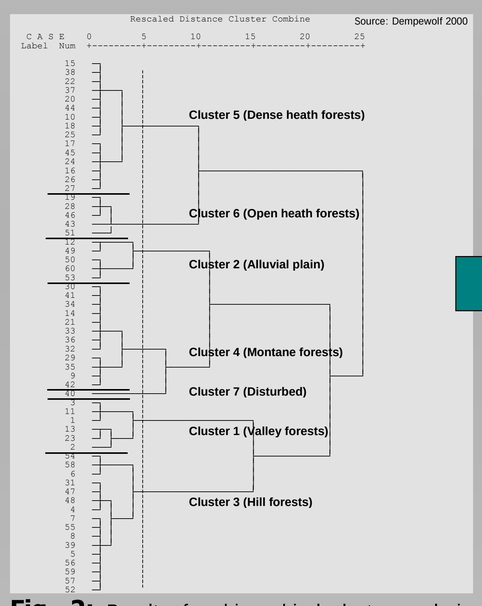



**Fig. 2:** Result of a hierarchical cluster analysis using Ward's method performed on 60 Plots yielding seven different Clusters.

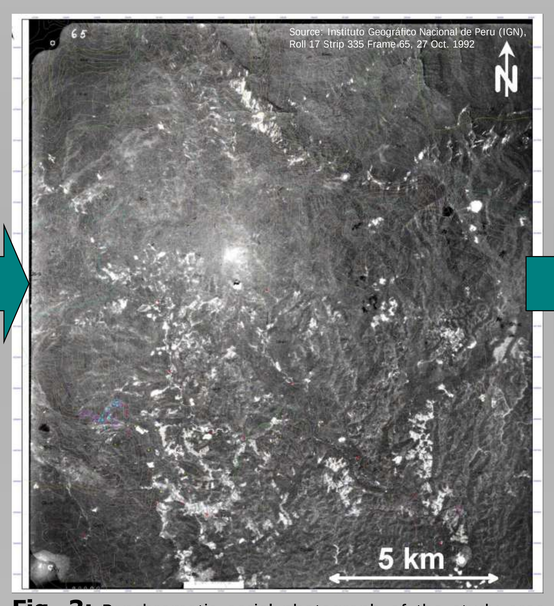



**Fig. 3:** Panchromatic aerial photograph of the study area with contour lines, geology and plot locations using GIS techniques.

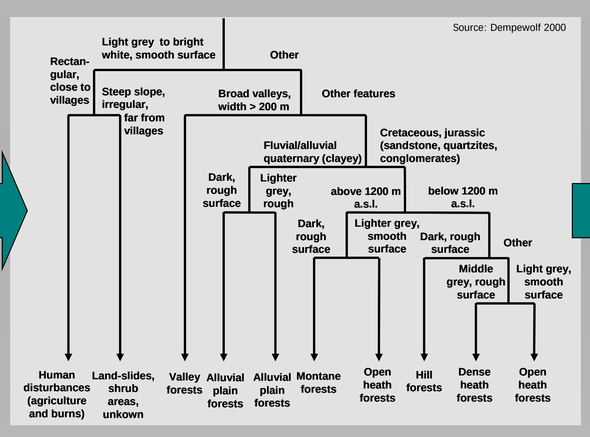



**Fig. 4:** Decision tree developed for the mapping based on the statistically achieved classification of the forest types. It combines biometrical, geological and topographical information in order to adjust the method to the structural properties of each respective forest type.

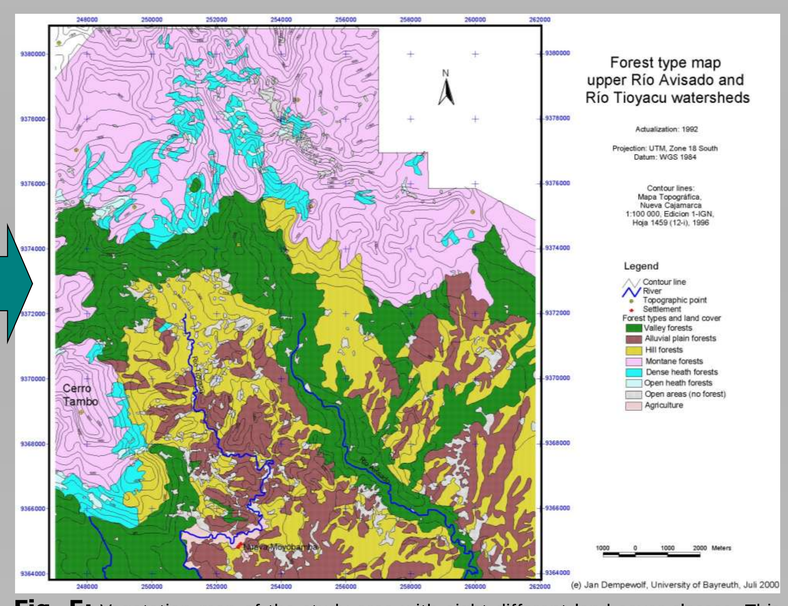



**Fig. 5:** Vegetation map of the study area with eight different land cover classes. This map was derived from the aerial photograph (Fig. 5) by applying the criteria shown in Fig. 6.




**Fig. 6 a-j:** Ten classified forest types including the floodplains of the lower watershed. Ordered along a moisture gradient from dry to wet the forest types are:
From the upper watershed: Open Heath Forest (a), Dense Heath Forest (b) both with extremely low vegetation, Montane Forests (c), Hill Forests (d), Alluvial Plain Forests (e), Valley Forests (f).
From the lower watershed: Impoverished Premontane Rain Forests (g), Premontane Rain Forest (h) and the two inundation forest types Renacales (i) and Aguajales (j).

## Results

Ten forest types were identified in the study area. The ecological classification is based on edaphic, biometric and structural parameters. Examples are shown in Fig. 8 a-j. The forest types vary not only by structural aspects and soils but also in terms of their biomass allocation (cf. Tab. 1). Unusual units in the area are the heath forests. They are named after similar vegetation types from Sarawak, Borneo described by Whitmore (1993). Sharp transitions from the surrounding rainforest under comparable edaphic conditions are typical. Tree age analysis results indicate disturbance as a cause for this abrupt change in vegetation.

**Tab. 1:** Biomass parameters for twelve vegetation types classified in the study area.

| Vegetation Type | | Growth Density | Basal Area[a] | Biomass[b] | |
|---|---|---|---|---|---|
| Name | Figure | stems[c] ha$^{-1}$ | m$^2$ ha$^{-1}$ | t ha$^{-1}$ | |
| Open Heath | 6 a) | **3312** (1800)* | **11** | **26** (23)* | Dempewolf 2000 |
| Dense Heath | 6 b) | **5883** (1400)* | **20** | **69** (46)* | Dempewolf 2000 |
| Montane | 6 c) | **5224** (1100)* | **40** | **245** (147)* | Dempewolf 2000 |
| Hill | 6 d) | **4590** (1200)* | **36** | **202** (164)* | Dempewolf 2000 |
| Alluvial Plain | 6 e) | **3280** (700)* | **42** | **183** (93)* | Dempewolf 2000 |
| Valley | 6 f) | **4287** (1200)* | **40** | **240** (103)* | Dempewolf 2000 |
| Impover. Premont. Rainf. | 6 g) | **2239**** | **35**** | **190**** (56)* | Börner 2000 |
| Premontane Rainforest | 6 h) | | | | Börner 2000 |
| Renacal | 6 i) | **518***** | **33***** | **207***** (60)* | Börner 2000 |
| Aguajal | 6 j) | | | | Börner 2000 |
| Shapumbal | 7 a) | **1337** (739)* | **7** (3)* | **36** (14)* | Dietz 2002 |
| Chamizal | 7 b) | **17021**[d] (11221)* | **6** (2)* | **14** (6)* | Dietz 2002 |

[a] Determined with relascope by Bitterlich
[b] Standing above ground biomass calculated after Ogawa 1965
[c] Only stems with girth (bh) > 10 cm
[d] All stems
* Standard deviation in parentheses
** Combined value for both premontane rainforest types
*** Combined value for both inundation forest types

## Conclusion

The presented combined descriptive and functional classification method is a robust tool for the ecological characterization and mapping of inaccessible tropical forest areas with sparse existing data.

## Outlook

Similar heath forest types which were described from the mountain slope region were recently discovered on very wet and level sites (Fig. 7 a) in the upper hill area. Many slopes of this remote and difficult to access region also harbor extremely open forests with an impenetrable understory of the fern *Sticherus* spec. ( Fig. 7 b). Both vegetation types are currently under investigation and a detailed soil survey has been conducted.

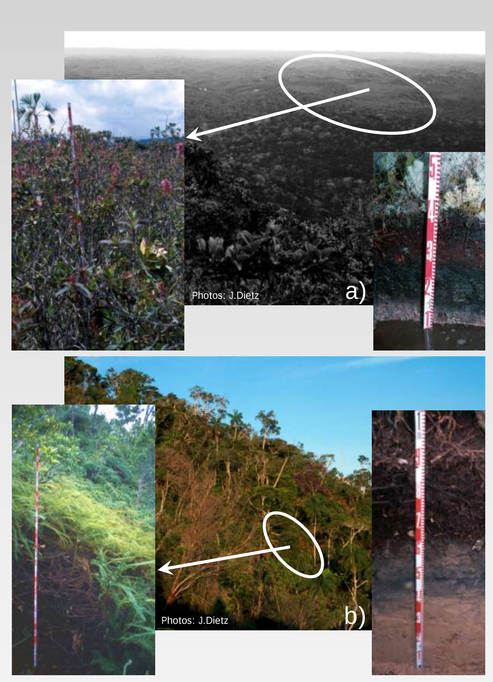



**Fig. 7 a-b:** Formations currently under investigation are:
a) Open Heath Forest type stands on wet and level sites and
b) dense fern undergrowth (*Sticherus* spec.) of open stands.


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