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Quantitative analysis of the relationship between environmental gradients and vegetation in Borana lowlands, Ethiopia

Tussie GEMEDO DALLE
Institute of Biodiversity Conservation,
Forest Genetic Resources Conservation,
Addis Ababa, Ethiopia

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- Gemedo Dalle, Brigitte L. Maass & Johannes Isselstein

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Introduction

- Borana lowlands are semi-arid rangelands
  - characterized by erratic rainfall and high rate of vegetation dynamics.
  - Vegetation dynamics is change in composition and stand structure of plant species over time (Herlocker, 1999: Dahdouh-Guebas *et al*., 2002) and it affects conservation of biological diversity and rangeland productivity (Herlocker, 1999).
  - Change in composition of vegetation is the result of continuous and complex interaction of plant communities with their environment.

Introduction

- Identifying patterns of species distribution and abundance and determining the underlying mechanisms of these patterns has been a major preoccupation of community ecologists (Ellison *et al*., 2000).

- For the pastoral community like the Borana pastoralists, plants are key resources on which livelihood depends (livestock production/ forage, food, medicine, firewood, construction and recreation).

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Introduction

- For the sustainable livestock production, development workers or rangeland managers need to know:
  - plant communities of a given site;
  - change in plant communities as a result of certain management interventions;
  - relative value of each plant community for wildlife and livestock production and
  - what factors or combination of factors will change the vegetation (Herlocker, 1999).

Introduction

- Therefore, quantitative data on vegetation is crucial in change detection, planning and resource management.

- However, despite the high significance of vegetation data for livestock production and biodiversity conservation, data on quantitative descriptions of vegetation composition in relation to environmental variables are lacking in Borana lowlands.

Introduction

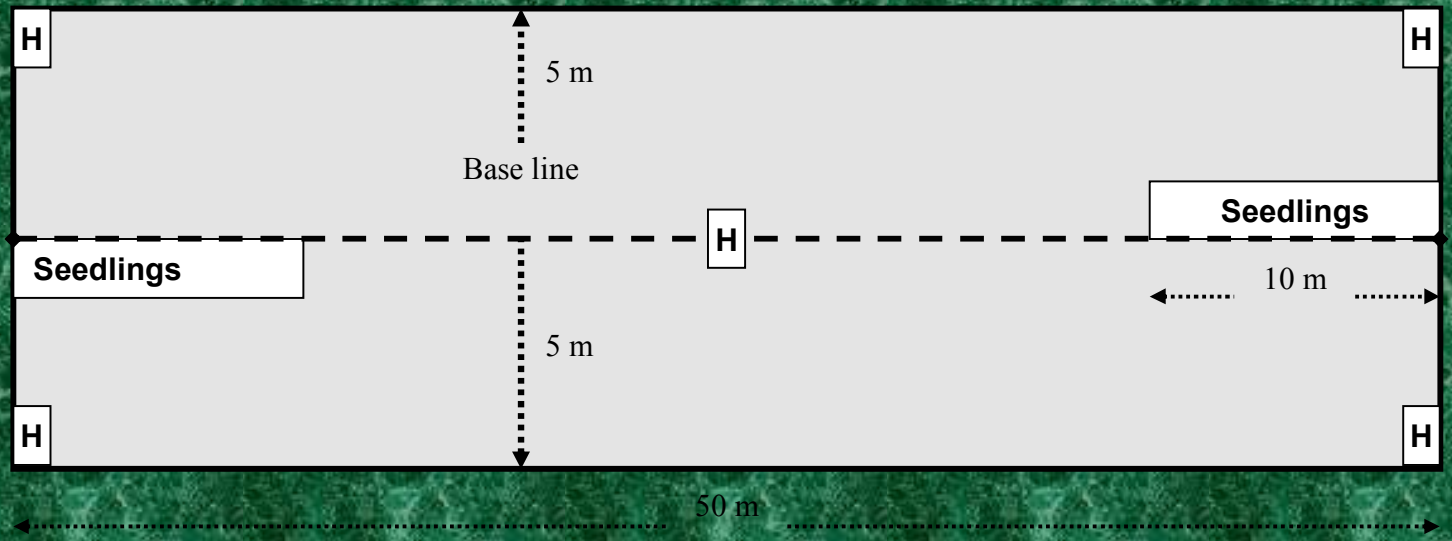
- Ordination and classification are two classes of quantitative analysis:
- CLASSIFICATION
- produces a hierarchical grouping of samples
- plotted as a dendrogram where difference (distance) is apparent
- ORDINATION
- extracts axes that reflect gradients in species composition
- results often plotted in 2 or 3 dimensions, showing relationships among samples

Objectives

- The objectives of this study were to
  - explain the distribution patterns of vegetation &
  - explore environmental factors that determine
    - the spatial distribution,
    - abundance and
    - diversity of herbaceous and woody plants in the Borana lowlands.

Materials and Methods: Study area

Materials and Methods:
Sampling design



Herbaceous frequency & soil samples

Data collection: Sampling

- Data were collected from June to July 2001 from a total of 58 plots 500 m^2.
- Stratified, based on land use units and systematic random
- Line transects

Data Collection: Vegetation

- Woody species
  - Density =no./500 m^2
- Herbaceous species
  - Frequency = Sp A = NA/TN plots X 100
- Species richness (the total number of species) was determined in the:
  - 500 m^2 woody plants and
  - five subplots for the herbaceous species.

Data Collection: Environmental variables

- Abiotic environmental factors
  - altitude, slope
  - soil (0-15cm)
    - Nutrients (N, P, OM, K, Ca, Mg & CEC)
    - pH and
    - Texture (sand, clay & silt)

Data analysis

- Different multivariate techniques:
  - DCA,
  - RDA &
  - CCA of CANOCO version 4.0 (ter Braak and Šmilauer, 1998) were employed for analysis of the relationships between vegetation and environmental variables.

Data analysis

- The abundance data used for the analysis of plants interacting with their environment was:
  - density for woody species &
  - Frequency for herbaceous species.

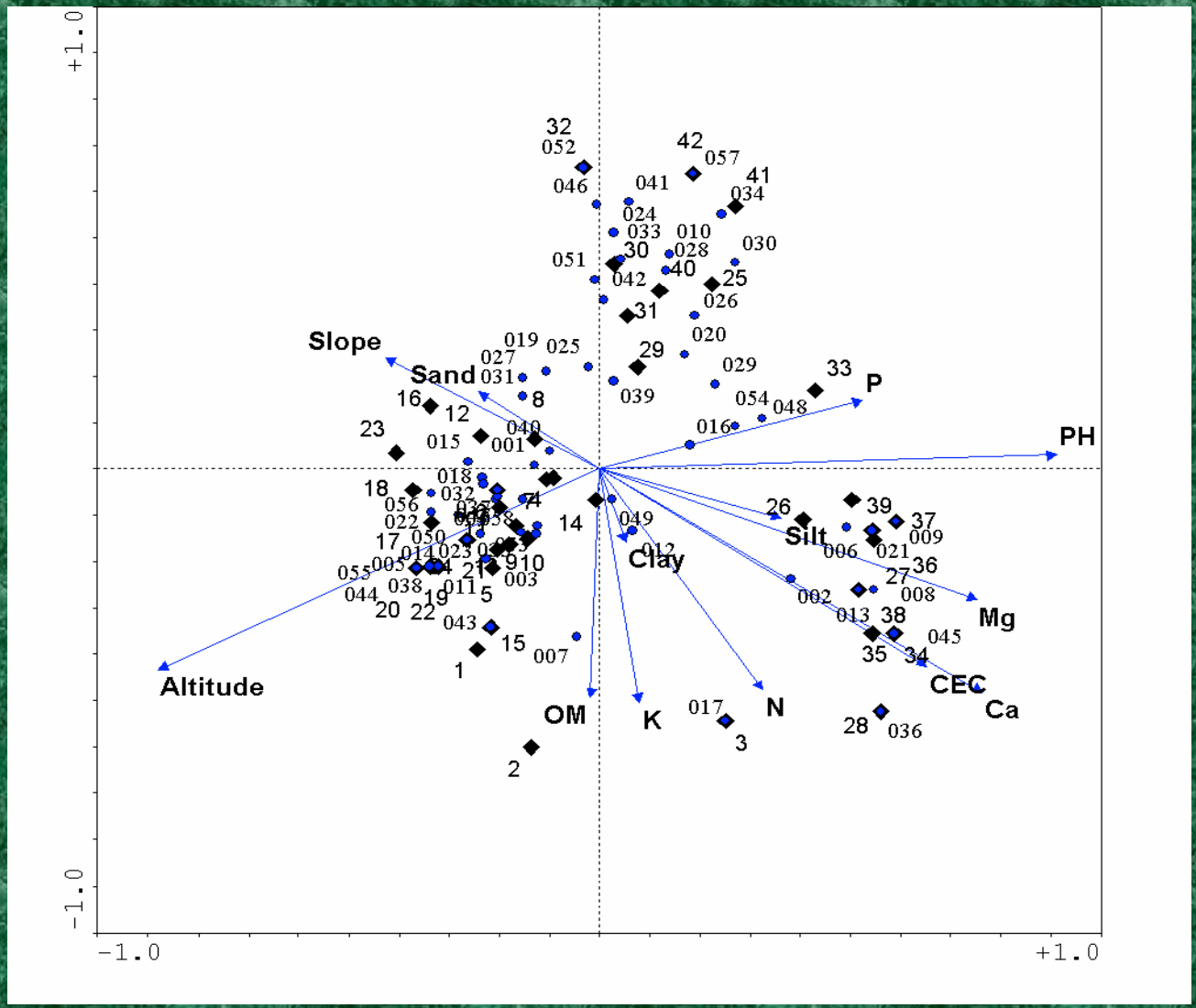
- Most important environmental variables were identified using the “Manual Forward Selection” option of CANOCO 4.0.

Results

Relationships between plants and environmental variables

- Most important environmental variables identified :
  - Woody plants-environment
    - altitude, pH, Ca, Mg and CEC
  - Herbaceous plants-environment
    - altitude, Ca, CEC, pH, Mg, sand and slope

Results: Woody plants-EV



CCA shows the spatial distribution of species in relation to environmental

Results: Woody plants-environment

- The first axis was a gradient of pH whereas the second axis gradient of OM
- The eigenvalues for the first and second axes were 0.696 and 0.464, respectively, demonstrating that
  - there was good dispersion of species along the first axis, (the pH gradient).

Results: Woody plants-environment

- CCA triplot of samples, species and environmental variables based on the first two axes explained 21.4% of the variance in the species data.
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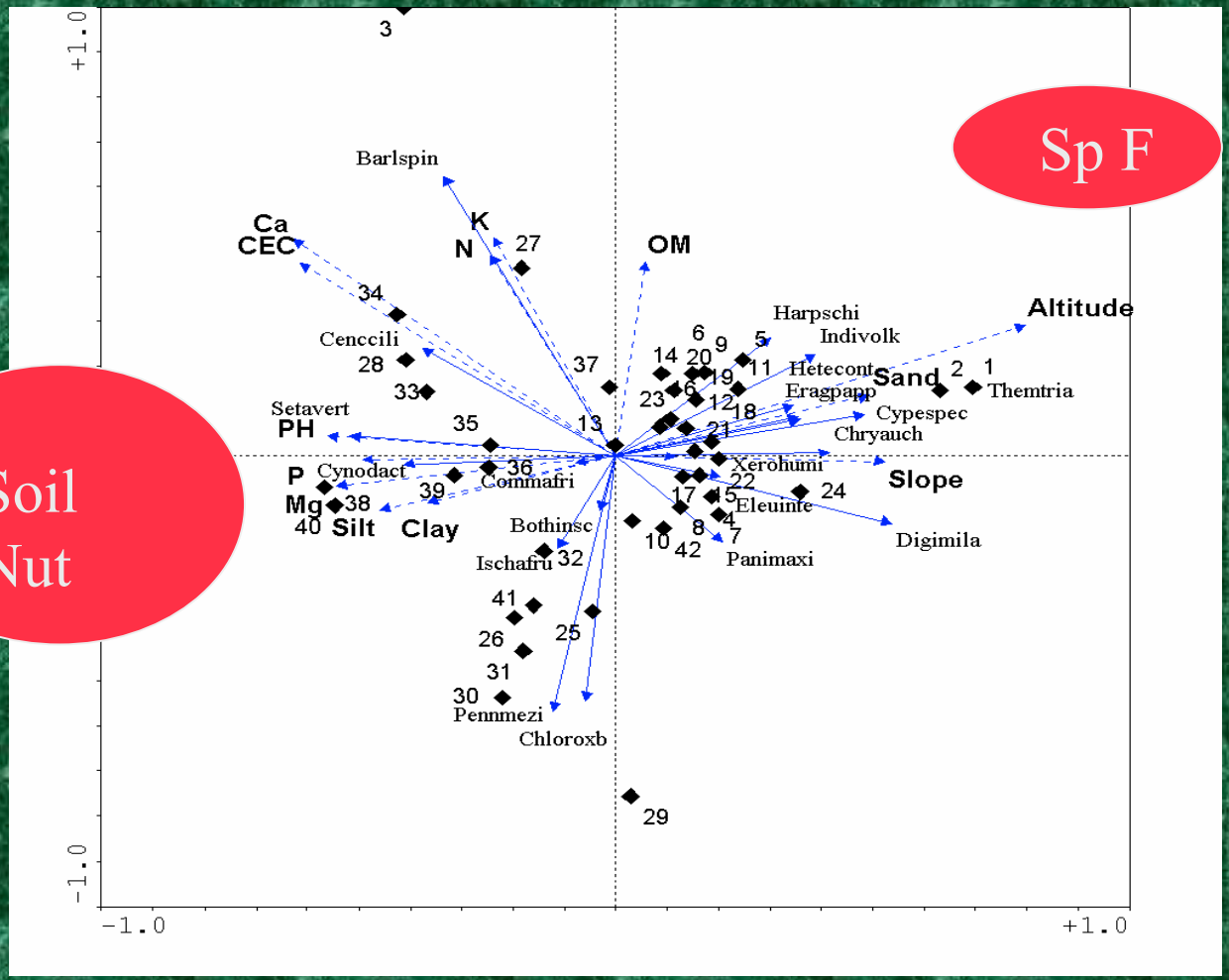
- Monte Carlo test showed that the first axis was statistically highly significant (P = 0.005) demonstrating the relationship between woody species and the environmental variables was significant.

Results: Herbaceous species and environmental variables



Sp F

Soil Nut

Altitude was the major factor that determined the spatial distribution of herbaceous species.

RDA ordination diagram of the relationship

Results: Herbaceous species and environmental variables

- The first axis was a gradient of altitude and the second gradient of K.
- The first two axes of RDA cumulatively explained 17.3% of the variance in the species data & 46.4% of the variance in the species-environment relationship.

- The first canonical axis was statistically highly significant (P = 0.005)
  - demonstrating the relationship between the herbaceous species and the environmental variables was significant

Results: Environmental variables & species richness

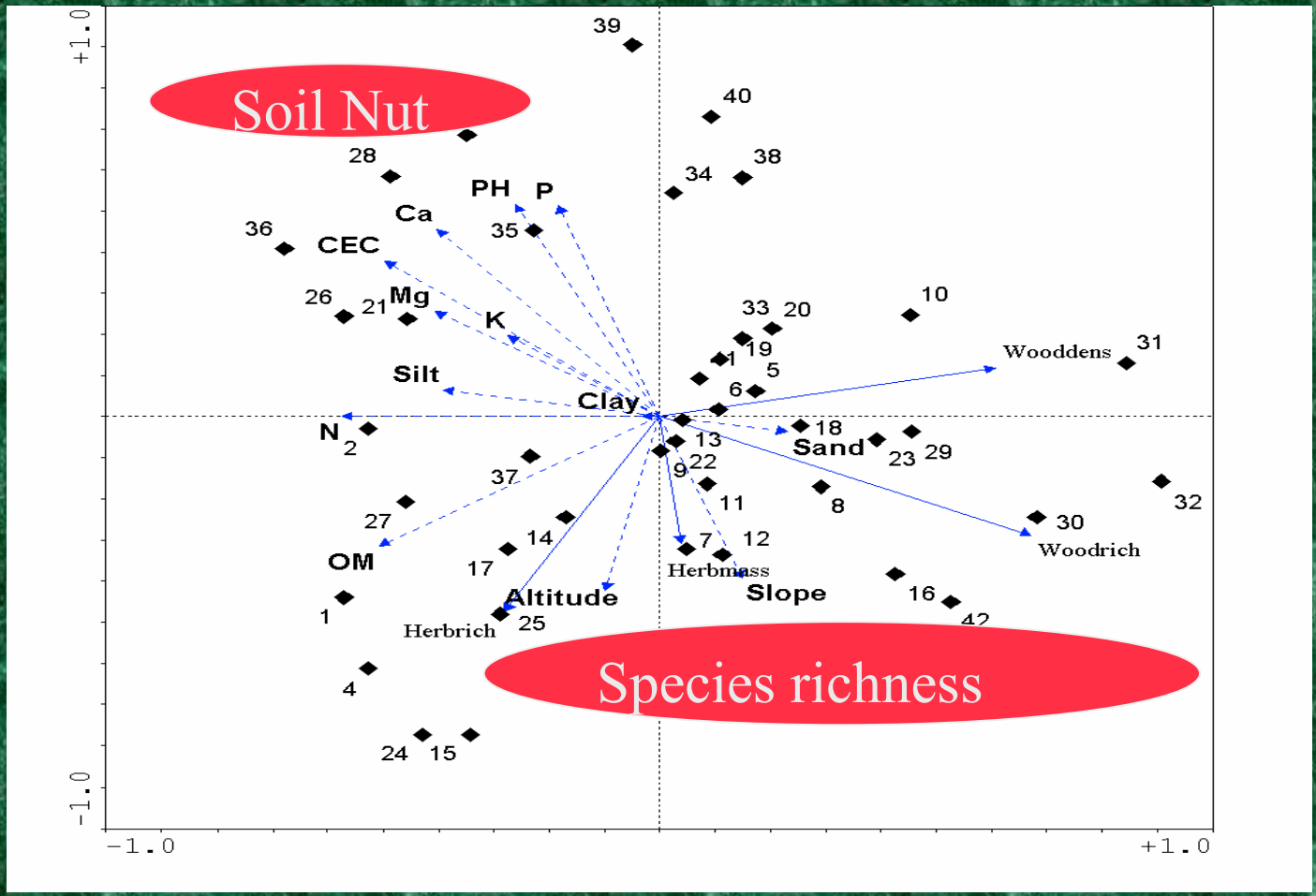
- Richness of both woody and herbaceous species was negatively correlated with P, pH, Ca, CEC, Mg & silt.

- Species richness was positively correlated with altitude, slope and sand content of the soil.

Results: Environmental variables & species richness

- RDA triplot based on the first two axes explained 32.9% of the variance in species data and 85.2% of the species-environment relationships.
- Relationship between environmental variables and species richness was statistically significant (P = 0.01).

Results: Environmental variables & SPR



RDA ordination diagram

Discussion:
Change in community composition

- Species-environment correlation result of the ordination output is a measure of the association between species and environment.

- The importance of the association is best expressed by the eigenvalue because it measures how much variation in the species data is explained by the environmental variables (ter Braak, 1987; ter Braak and Šmilauer, 1998).

Discussion: Change in community composition

- The fact that almost all eigenvalues were > 0.5 indicates that there was good dispersion of woody species along the respective environmental gradients.

- Furthermore, the length of the first DCA axis of >3 SD (for woody species) showed a substantial turnover of taxa along the main environmental gradients (Korvenpää *et al*., 2003).

Discussion (Contd)

- The explained total variance in species data by the first two axes for both woody and herbaceous species was highly significant.
- Accordingly, there was significant change in community composition along the environmental gradients.

- It was concluded that the environmental variables accounted for the main variation in the species composition of the Borana lowlands.

Discussion: Species richness & environmental variables

- Species richness was positively correlated with sand and altitude, and negatively with soil nutrients. This result concurs with the report by Abdadi and El-Sheikh (2002).

- The negative correlation between soil nutrients and species richness may be due to the dominance of few species on the relatively nutrient rich areas. Hahs *et al*. (1999) also reported that species diversity was lower on sites with higher basic cation concentrations.

Thank you very much for your attention!