Estimating taxonomic diversity and functional types of perennial forage grasses in mountain meadows

Potentialities of Pléiades imagery

Pléiades Days

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Introduction

Meadows play a major role in agro-pastoral systems. They are used as a fodder resource for animals. They are also among **the most species rich plant communities** depending on the nature and the intensity of management practices.

Remote sensing has shown **considerable potential** to estimate the spatial patterns of biodiversity. In particular, **NDVI-based variables** have been found to be **useful predictors** of plant species richness since it responds to variation in primary productivity and habitats (e.g. Levin et al. 2007).

The objective of this study is to **investigate the potential of Pléiades imagery** to explain (1) the richness patterns in plant and (2) the functional types of forage grasses in mountain meadows.

Study area

Villelongue municipality, in the peripheral area of the National Park of the Pyrenees, France (00°03'W and 42°57'N). This municipality is located in a small valley of medium altitudinal range (450 – 1800m a.s.l.).

Field sampling of plants

Selection of 30 meadows:

- Derived from the same production system
- Chosen according to an altitudinal gradient
- Distinguished by their land use (grazing alone or grazing and mowing)

Recording botanical composition:

- Period: between May and June 2012 (time of peak vegetation in each elevation)
- Point quadrat analysis method
- 50 punctual observations along a 20 m long transect (one observation every 40 cm)
- Recording of each plant species when the foliage contacts a steel needle stuck vertically

Indicator of taxonomic diversity

Species richness (SR) per meadow

Sum of all the different species

Dominant species :

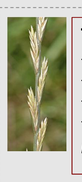
Plantago lanceolata, Rhinanthus minor, Anthoxanthum odoratum, Lolium perenne, Holcus lanatus, Festuca rubra, Dactylis glomerata, Ranunculus bulbosus, Trifolium reprens, Trifolium pratense.

Indicators of functionnal diversity

Functional types of perennial forage grasses per meadow

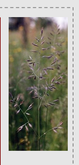
Classification of plant communities based on functional traits

(Source : Cruz et al. 2002)



Type A :
- high growth rate,
- high growth speed
- low biomass accumulation
- high leaf area with short life

Ex. Lolium perenne, Poa trivialis

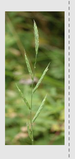


Type C :
- low growth rate,
- low growth speed
- low biomass accumulation
- low leaf area with long life

Ex. Festuca rubra, Agrostis capillaris

Type B :
- high growth rate,
- low growth speed
- high biomass accumulation
- high leaf area with long life

Ex. Dactylis glomerata



Type D :
- low growth rate,
- very low growth speed
- medium to high biomass accum.
- low leaf area with very long life

Ex. Brachypodium pinnatum

Species of rich environnement | **Species of poor environnement**

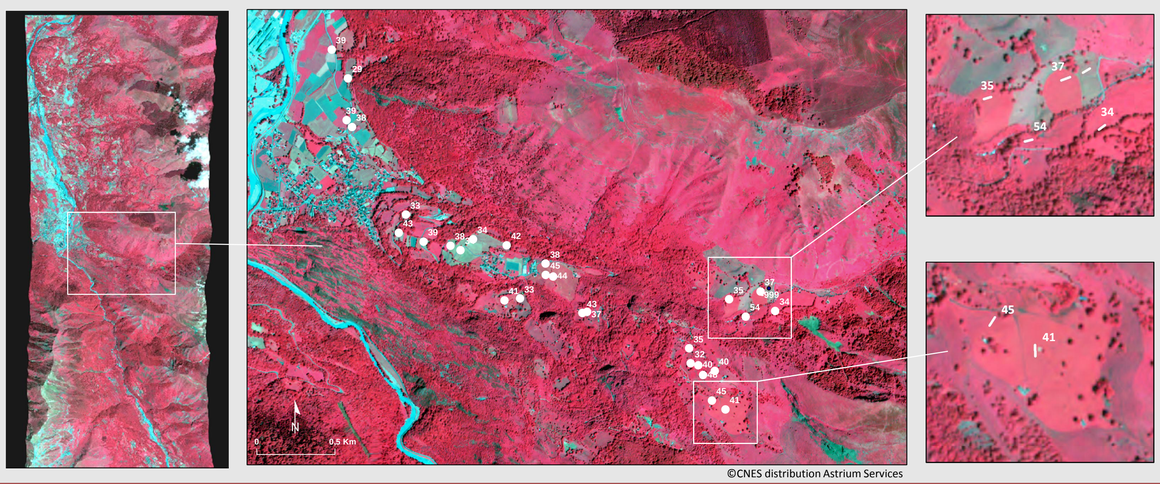
Pléiades image data

- **Acquisition date**: August 10th, 2012
- **Spatial resolution**: 2 meters
- **Spectral resolution**: 4 bands (NIR, R, G, B)
- **Product level**: ortho-imagery (level 2)

Indicators of spectral responses of meadows

NDVI-based variables

mean, max, range, std dev. per meadow



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Statistical analyses

Generalized Linear Models (GLM):

$$g(E(y) = b_0 + b_1X_1 + b_2X_2 \ldots + b_nX_n$$

Plant species response variable (Poisson or binomial distribution) — *Remote Sensing predictor variables*

Productivity models:

1. $Species\ Richness \sim NDVI_{mean} + NDVI_{max}$
2. $\%\ grasses\ of\ Type\ A \sim NDVI_{mean} + NDVI_{max}$
3. $\%\ grasses\ of\ Type\ B \sim NDVI_{mean} + NDVI_{max}$
4. $\%\ grasses\ of\ Type\ C \sim NDVI_{mean} + NDVI_{max}$
5. $\%\ grasses\ of\ Type\ D \sim NDVI_{mean} + NDVI_{max}$

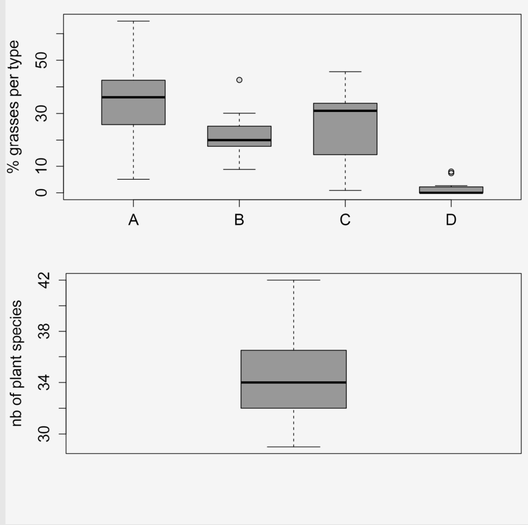
Heterogeneity models:

6. $Species\ Richness \sim NDVI_{stdev} + NDVI_{range}$
7. $\%\ grasses\ of\ Type\ A \sim NDVI_{stdev} + NDVI_{range}$
8. $\%\ grasses\ of\ Type\ B \sim NDVI_{stdev} + NDVI_{range}$
9. $\%\ grasses\ of\ Type\ C \sim NDVI_{stdev} + NDVI_{range}$
10. $\%\ grasses\ of\ Type\ D \sim NDVI_{stdev} + NDVI_{range}$

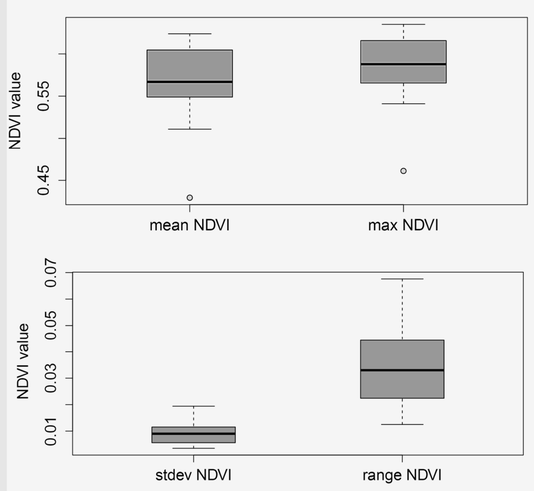
Hybrid models:

11. $Species\ Richness \sim NDVI_{mean} + NDVI_{stdev}$
12. $\%\ grasses\ of\ Type\ A \sim NDVI_{mean} + NDVI_{stdev}$
13. $\%\ grasses\ of\ Type\ B \sim NDVI_{mean} + NDVI_{stdev}$
14. $\%\ grasses\ of\ Type\ C \sim NDVI_{mean} + NDVI_{stdev}$
15. $\%\ grasses\ of\ Type\ D \sim NDVI_{mean} + NDVI_{stdev}$

Summary statistics of plant species variables



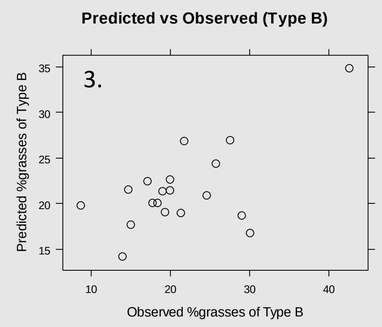
Summary statistics of remote sensing variables



Results

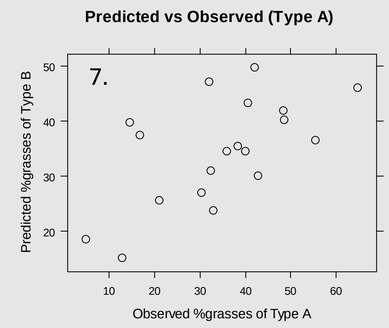
Productivity Models (GLM)

Response variable	%D²	Sign.	RMSE
1. Species Richness	16.98	n.s.	3.05
2. % grasses of Type A	30.79	n.s.	12.19
3. % grasses of Type B	35.44	n.s.	5.70
4. % grasses of Type C	15.38	n.s.	12.09
5. % grasses of Type D	2.60	n.s.	2.37



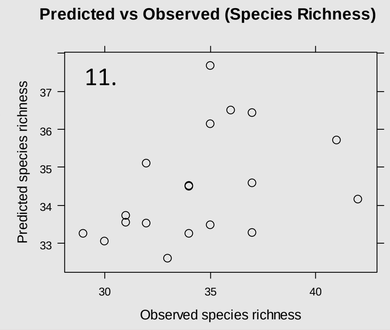
Heterogeneity Models (GLM)

Response variable	%D²	Sign.	RMSE
6. Species Richness	13.69	n.s.	3.15
7. grasses of Type A	37.16	n.s.	11.85
8. % grasses of Type B	9.46	n.s.	6.88
9. % grasses of Type C	23.78	n.s.	11.25
10. % grasses of Type D	0.5	n.s.	2.38



Hybrid Models (GLM)

Response variable	%D²	Sign.	RMSE
11. Species Richness	17.28	n.s.	3.04
12. % grasses of Type A	15.26	n.s.	13.53
13. % grasses of Type B	20.49	n.s.	6.49
14. % grasses of Type C	16.36	n.s.	11.98
15. % grasses of Type D	1.61	n.s.	2.37



Conclusions

- **No significant relationships** between plant species response variables and remote sensing predictors
- Results are **contradictory to similar studies** (e.g. Levin et al. 2007, Parviainen et al. 2010)
- The acquisition date of the Pléiades image (August 10th, 2012) could explain the non-conclusive results: **time delay with the plant survey, mowing of meadows**
- In the next step, the study will evaluate the effect of the date of the image by using reflectance spectra obtained during the vegetation surveys. Relationships with other vegetation indices will also be explored.

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