Response of hyperspectral indices to architecture and soil

The study aims to investigate whether the estimation of the leaf area index (LAI) from hyperspectral reflectance measurements is significantly affected by soil type and/or plant architecture (e.g., leaf shape and size). Four different plant species with different leaf shapes and sizes were selected for sampling (figure 1). We artificially induced variations in LAI and canopy chlorophyll content as well as variations in background brightness. Narrow band vegetation indices were computed from the canopy spectra using all possible two band wavelength combinations involving 2000 wavelengths between 401 nm and 2400 nm for narrow band SR, NDVI, PVI, TSAVI and SAVI2.

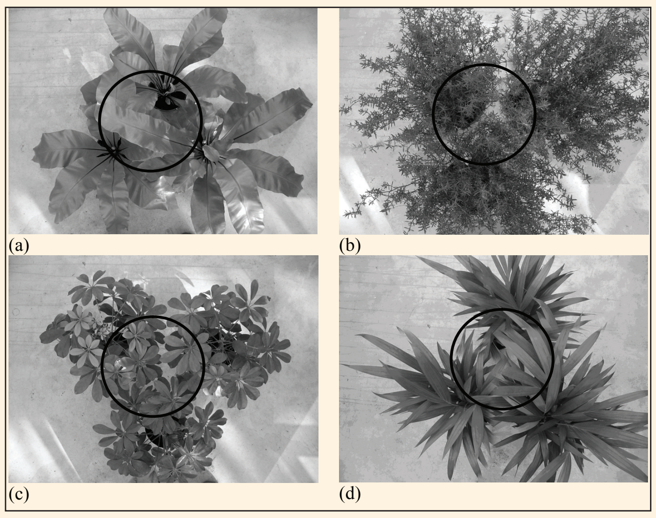

Figure 1: The four plant types at maximum coverage. (a) Asplenium nidus, (b) Halimium umbellatum, (c) Schefflera arboricola Nora and (d) Chrysalidocarpus decipiens. Approximative FOV at soil level are indicated with black circles.

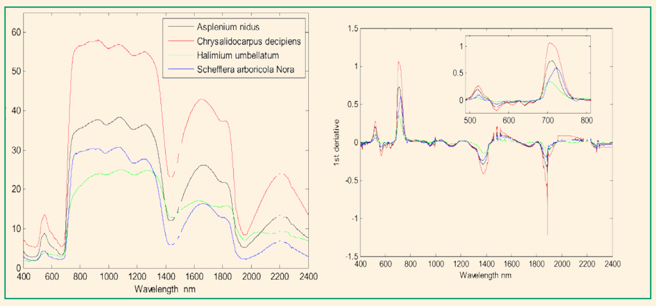

Figure 2. Canopy spectral reflectance characteristics of the four plant species over dark soil with an LAI of 1.5, (a) canopy reflectance, (b) the 1st derivative.

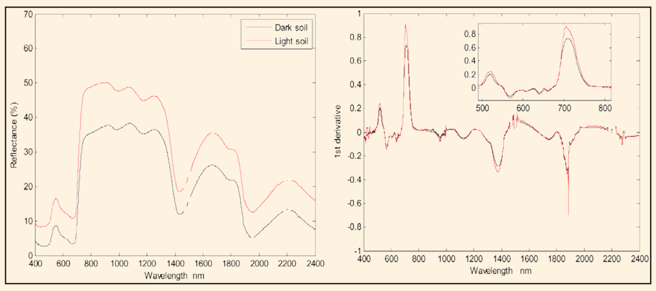

Figure 3. Spectral reflectance (a) and 1st derivative reflectance (b) of Asplenium nidus, with an LAI of 1.5, in dark and light soil.

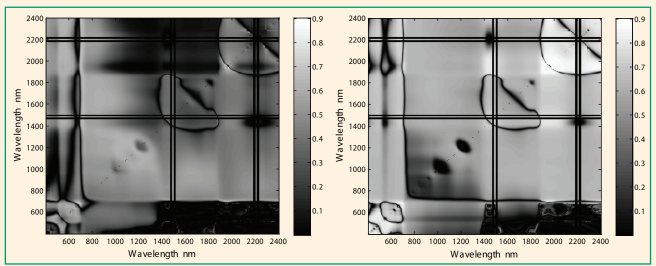

Figure 4. 2-D correlation plots illustrating the coefficient of determination (R2) between LAI and narrow band TSAVI in: (a) dark soil and (b) light soil. The data of the four plant species have been pooled together. Note that the 2-D correlation plots are not symmetrical. The straight (black) lines correspond to wavelengths which have not been measured.

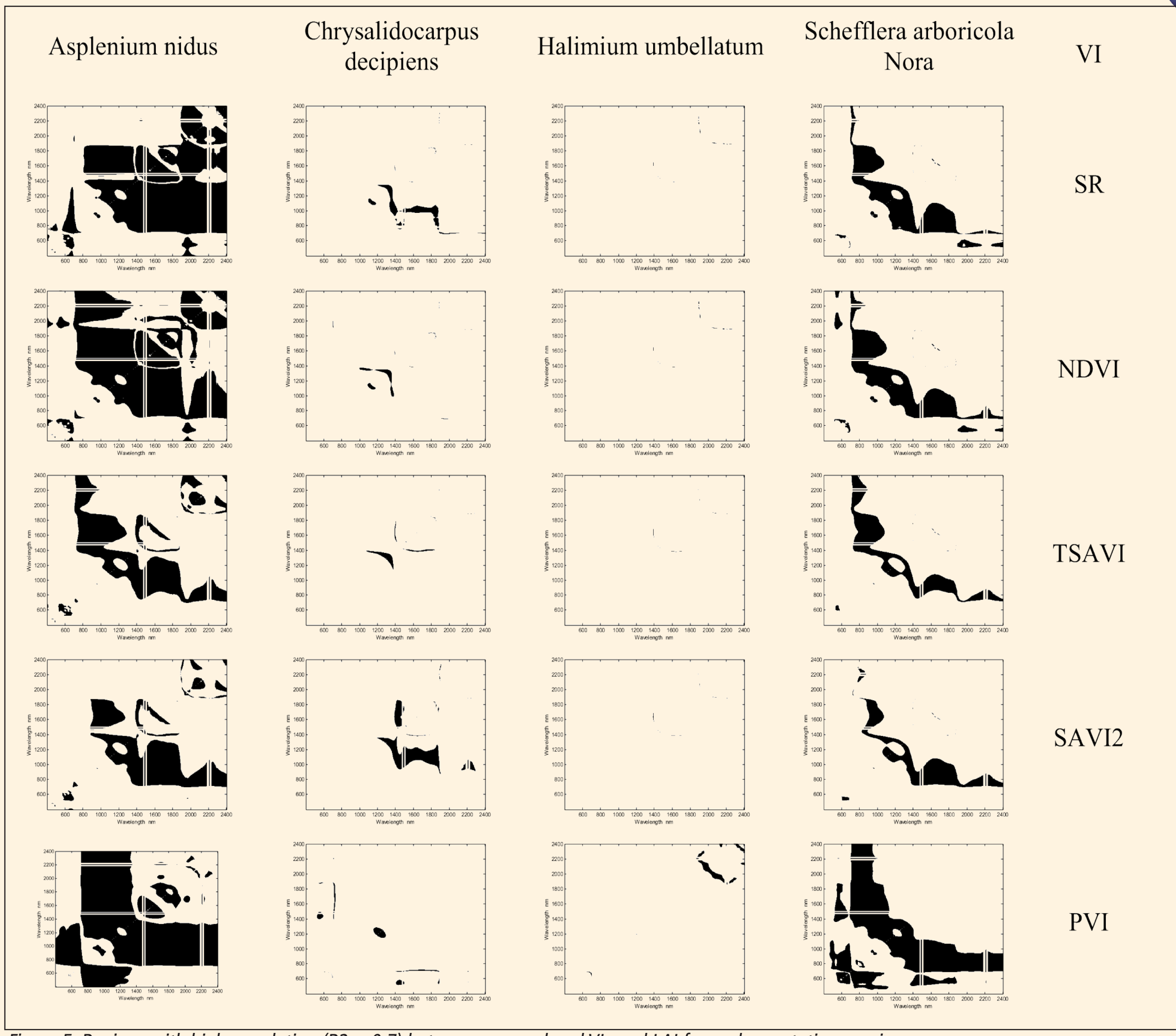

Figure 5. Regions with high correlation (R2 > 0.7) between narrow band VIs and LAI for each vegetation species.

VI	Dark soil (n=48)			Light soil (n=47)		
	R^2	λ1	λ2	R^2	Λ1	λ2
SR	0.78	2228	2141	0.87	741	493
NDVI	0.78	2228	2141	0.85	1904	1903
TSAVI	0.73	1939	1968	0.89	1979	1941
SAVI2	0.77	728	1966	0.89	1942	1977
PVI	0.76	1075	1074	0.73	1244	1134

Table 1. Band positions and R^2 values between LAI and the best narrow band VI in dark and light soils with data of the four plant species pooled together.

VI	Asplenium nidus (n=23)			Chrysalidocarpus decipiens (n=24)			Halimium umbellatum (n=24)			Schefflera arboricola Nora (n=24)		
	R^2	λ1	λ2	R^2	λ1	λ2	R^2	λ1	λ2	R^2	λ1	λ2
RVI	0.91	1480	1414	0.77	1318	1319	0.76	2205	1885	0.89	725	1389
NDVI	0.90	1480	1414	0.77	1319	1318	0.76	2203	1886	0.85	1108	1107
TSAVI	0.91	1480	1414	0.79	1318	1317	0.77	2205	1883	0.87	1954	710
SAVI2	0.91	885	1416	0.79	1317	1319	0.76	1883	2205	0.89	719	2023
PVI	0.92	1265	1263	0.89	717	1713	0.90	1873	2205	0.96	713	1723

Table 2. Band positions and maximum R^2 values between LAI and narrow band VI for different vegetation species. The data of the two contrasting soils have been pooled together.

In general the relationship between LAI and VIs deemed to be stronger in light soil than in dark soil. The study showed that by carefully selecting appropriate wavelengths, a high sensitivity of VIs to LAI variations can be maintained even for high LAI values. The optimal narrow bands forming the best vegetation indices for each soil type were located in different spectral regions. This indicates that relevant information for LAI estimation depends on soil brightness. It seemed difficult to define the most appropriate VI for estimating LAI in each soil type.

The study confirmed that the strength of the relationships between VI and LAI differs for different vegetation species. We found that for each vegetation species, the optimum spectral region (band combinations) for LAI estimation was similar across the investigated VIs, except for PVI. The PVI appears to be less sensitive to brightness variations in the soil background and adapts well to different plant species with different plant architectures and leaf sizes, etc. This index was thus recognized as the most appropriate VI for LAI estimation under conditions of unknown soil reflectance.

Our results also showed that LAI estimates of plants with small and more randomly distributed leaves allow higher estimation accuracies. Probably, the mutual shading of large and highly clumped leaves deteriorates the relation between LAI and canopy reflectance.

For more information:

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