Evaluation of high-resolution, multi-band imagery for determining proportions of oak and maple LAI in Black Rock Forest, NY

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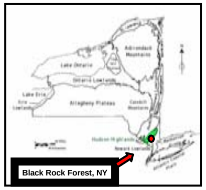
Introduction & Objectives

- Leaf Area Index (LAI) is a crucial metric used in assessing productivity
- Obtaining accurate LAI measurements in the field is difficult and costly
- Remote Sensing
  - Has been used to accurately estimate LAI in simple vegetation systems
  - LAI applications are limited in heterogeneous canopies exhibiting complex structure
  - Most LAI estimates are measured at the forest-level, and fail to account for individual species contributions

APPROACH: Extract spectral reflectance measurements obtained at the scale of the leaf, branch, & forest canopy at two sites exhibiting differences in water availability and topography. These data will be used to spectrally discriminate *Acer rubrum*, *Quercus prinus*, and *Quercus rubra*. A series of canopy maps will be created to investigate proportions of species in comparison to direct measurements of LAI from leaf litter traps.

Site Description



Species	LAI at Each Site Location: Upper	fraction	Lower	fraction
Acer rubrum	0.05	0.01	0.17	0.03
Quercus prinus	1.82	0.43	2.32	0.39
Quercus rubra	1.55	0.37	2.1	0.36
other	0.77	0.18	1.3	0.22
TOTAL LAI:	**4.19**		**5.89**	

	Stand-level characteristics at each site: Upper	Lower
Basal Area (m2 ha-1)	23.7	24.9
Stem Density (trees ha-1)	760	650

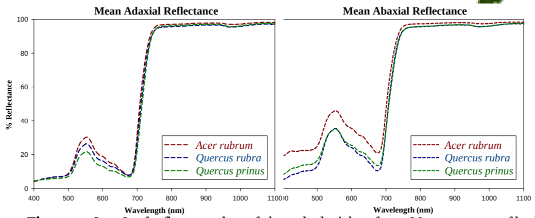
(Turnbull et al., 2001)

- All research was conducted in the Black Rock Forest, NY – a research and educational forest in the Hudson Highlands ecoregion, characterized by oak forests (see Turnbull et al. 2001 for complete site description).
- BRF is an important site for research on *Quercus* dominated forests, due to its location at the edge of the hypothesized expansion zone under changing environmental conditions.

Data Collection

- Images were acquired with a 6-camera composite system, with neutral-density filters in each camera at the following λ: 480, 550, 676, 730, 850, 940 nm.
- Leaf-level spectra were acquired in June 2000 using an LI-1800 spectroradiometer, and were calibrated with a spectralon sample (Li-Cor, Lincoln NE). Adaxial (upper leaf surface) and abaxial (lower leaf surface) were sampled at 5 nm intervals between 400-1100 nm.
- Branch-level images were acquired in late June 2000 from a cherry-picker at 4.8 m above individual crowns . Images were intercalibrated to a reflectance panel located within each of the scenes by the empirical line method.
- Canopy-level images were acquired in late June 2000 from a helicopter.

Laboratory Leaf Analysis



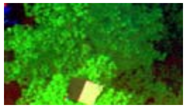
Figures 1 & 2: Leaf reflectance data of ab- and adaxial surfaces. Measurements of both leaf surfaces are important, because structurally complex canopies will display both leaf surfaces. Remotely sensed data will be an integration of all elements and their spectral reflectance signals.

λ (nm)	*A. rubrum*	*Q. prinus*	*Q. rubra*	P-Value
480	.141	.102	.089	.156
550	.371 a	.282 b	.306 b	.038
676	.133	.103	.093	.132
730	.849 a	.785 b	.808 c	<.0001
850	.976 a	.965 b	.962 b	.006
940	.977 a	.968 b	.966 b	.006

Table 1: Mean leaf-level reflectance values (n≥10 leaves/species). Significant differences between species were derived from one -way ANOVA analyses; letters indicate among-mean differences (α = .05).

• Significant differences between oaks and maples were observed at 550, 850, 940 nm. Differences between all three species at 730 nm indicate the ability to spectrally discriminate at the species-level.

Branch Analysis



Images 1 & 2: Branch-level images of *Acer rubrum* (left) and *Quercus rubra* (right).

λ (nm)	*Acer rubrum*	*Quercus prinus*	*Quercus rubra*	P-Value
676	759.589 a	420.516 b	282.52 c	< .0001
730	49.2 a	359.864 b	332.87 c	< .0001
850	32.162 a	268.09 b	499.32 c	< .0001
940	29.826 a	178.02 b	312.3 c	< .0001

Table 2: Mean branch-level reflectance values (n=256 pixels/species). Significant differences between species derived from one-way ANOVA analyses; letters indicate among-mean differences (α = .05).

• Significant differences between all three species were observed at 676, 730, 850, & 940 nm.

Canopy Analysis

Images 3 & 4: Canopy-level RGB images for the low (left image) and high site (right image). Data was obtained at both sites at 300 feet above the forest canopy. Species canopy dominance at the low site is mostly *Quercus rubra* and emergent *Acer rubrum*. Canopy dominance at the high site is primarily *Quercus prinus* and *Quercus rubra* and is more patchy in the distribution of species than the more dense lower site.

λ (nm)	*Acer rubrum*	*Quercus rubra*	P-Value
480	14.4	13.55	0.01
550	76.733	52.75	< .0001
676	82.483	78.9	0.055
730	137.85	89.883	< .0001
850	91.45	77.9	< .0001
940	131.5	115.8	< .0001

Table 3: Canopy-level spectra were extracted from a low-site image (n=60/species). Significant differences between red maple and red oak were derived from one-way ANOVA analyses (α= .05).

Conclusions & Future Research

- Performing a rank normalization on canopy-level images to suppress erroneous illumination issues.
- Employing the Dempster-Shafer algorithm in a fuzzy classification of canopy-level images.
- Using species variations in image texture to enhance spectral classification efforts.

References

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