Classification of liana and tree leaves using VIS-NIR or LWIR reflectance

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Since 2002, different studies have shown an increase in liana abundance.

Detrimental effects on the ecosystems.

These trends have cast doubt the accuracy of some productivity models.

Detection!
Several studies have addressed the classification at different levels.

Visible, near and shortwave infrared as regions of interest.

Long-wave infrared region?

Foster et al. 2008
Castro-Esau et al. 2004
Sánchez–Azofeifa and Castro–Esau 2006
Kalacska et al. 2007
Sánchez-Azofeifa et al. 2009
Hesketh and Sánchez-Azofeifa 2012
Martin et al. 2016
Objectives

• To determine which spectral region could improve the discrimination of lianas and trees leaves. (VIS-NIR or LWIR)

• To evaluate which pre-processing approach may enhance the discrimination.

• To evaluate, in combination to data reduction techniques, which classifiers are the most promising to discriminate liana and tree leaves.
Study site and design

- Santa Rosa National Park, Costa Rica

- May-July, 2017

- Full sun exposed leaves

- 5 leaves per individual / 4 individuals = 20 leaves per species
### Species selected

<table>
<thead>
<tr>
<th>Trees</th>
<th>Lianas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Family</strong></td>
<td><strong>Species</strong></td>
</tr>
<tr>
<td>Apocynaceae</td>
<td>Stemmadenia obovata</td>
</tr>
<tr>
<td>Bignoniaceae</td>
<td>Crescentia alata</td>
</tr>
<tr>
<td>Burseraceae</td>
<td>Bursera simarouba</td>
</tr>
<tr>
<td>Dilleniaceae</td>
<td>Curatella americana</td>
</tr>
<tr>
<td>Euphorbiaceae</td>
<td>Jatropha curcas</td>
</tr>
<tr>
<td></td>
<td>Sapium glandulosum</td>
</tr>
<tr>
<td>Fabaceae/Caes</td>
<td>Bauhinia ungulata</td>
</tr>
<tr>
<td></td>
<td>Hymenaea courbaril</td>
</tr>
<tr>
<td>Fabaceae/Pap</td>
<td>Gilricidia sepium</td>
</tr>
<tr>
<td>Fagaceae</td>
<td>Quercus oleoides</td>
</tr>
<tr>
<td>Hippocrateaceae</td>
<td>Semialcarium mexicanum</td>
</tr>
<tr>
<td>Lauraceae</td>
<td>Ocotea veraguensis</td>
</tr>
<tr>
<td>Malpighiaceae</td>
<td>Byronima crassifolia</td>
</tr>
<tr>
<td>Malvaceae</td>
<td>Guazuma ulmifolia</td>
</tr>
<tr>
<td>Meliaceae</td>
<td>Cedrela odorata</td>
</tr>
<tr>
<td></td>
<td>Trichilia americana</td>
</tr>
<tr>
<td>Nyctaginaceae</td>
<td>Pisonia aculeata</td>
</tr>
<tr>
<td>Sapindaceae</td>
<td>Cochlospermum vitifolium</td>
</tr>
<tr>
<td>Simaroubaceae</td>
<td>Simarouba glauca</td>
</tr>
<tr>
<td>Tiliaceae</td>
<td>Luehea speciosa</td>
</tr>
<tr>
<td>Verbenaceae</td>
<td>Rehdera trinervis</td>
</tr>
</tbody>
</table>

**14 species of lianas / 7 families**

**21 species of trees / 17 families**
Data collection: spectral reflectance

**Unispec-SC**
- Leaf clip and light source
- Range 0.31-1.13 μm (0.45-0.95 μm)
- Resolution 3.3 nm (1 nm resample)

**Agilent 4100 ExoScan FTIR**
- FTIR (Fourier transform infrared) spectrometer
- Range 2.5-16 μm (8-11 μm)
- Resolution 1.86 cm⁻¹ (10 nm resample)
Data processing

Samples, resample

VIS-NIR

LWIR

Preprocessing

 RAW

 SG

 D

 CWT
Preprocessing

VIS-NIR

Reflectance

LWIR

Reflectance

SG

D

CWT
Data processing

Samples, resample

VIS-NIR

LWIR

Preprocessing

RAW

SG

D

CWT

Principal components

PC-RAW

PC-SG

PC-D

PC-CWT
Eigenvectors

VIS-NIR

LWIR

Weight

Wavelength (μm)
Principal components analysis

VIS-NIR
- a
- c
- e
- g

LWIR
- b
- d
- f
- h

Legend:
- Liana
- Tree
Data processing

Preprocessing
- RAW
- SG
- D
- CWT

Principal components
- PC-RAW
- PC-SG
- PC-D
- PC-CWT

Classifiers - Training
- T-RAW
- T-SG
- T-D
- T-CWT

Classifiers - Testing
- Test-RAW
- Test-SG
- Test-D
- Test-CWT
Classifiers

Similarity
0.4 0.6 0.8 1.0

RMDA
LDA
MULDA
SLDA
RDA
SDA
RLDA
QDA
RQDA
NN
BGLM
GLM
RF
BC
CART
ST
SR
KNN
SVMLK
SVMPK
SVMRK

Accuracy
Kappa
Sensitivity
Specificity
Conclusions

LWIR region present the highest values of classification.

Spectral bands of importance for classification:
- VIS-NIR: 680-720 nm
- LWIR: several

Random forest, \( k \)-nearest neighbor, SVMRK seems to be the best classifiers to discriminate lianas and trees at the leaf level.

First derived and CWT seems to be better procedures for classification.

Future directions - New perspectives
- Forest mapping?
- Functional traits - spectroscopy
Acknowledgments

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Tropi-Dry

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