INPLANT

PLANT OPTICAL TYPES TO PREDICT ECOSYSTEM IMPACTS OF PLANT INVASIONS

Elisa Van Cleemput, Hannes Feilhauer, Olivier Honnay, Ben Somers
Invasives are a major problem: Currently 13,000 plant species (3.9% of the extant flora) have become naturalized somewhere as a result of human activity.
Invasive plant species also strongly affect the *functioning of ecosystems*.

Mean effect size (*Hedges d*) of impacts of invasive species.

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Vila et al. (2011) *Ecol. Letters*
*Predicting* the effects of new exotic species on ecosystem functions would allow to set up an *early warning system*

- Predictions have been not successful so far;

- The typical approach among plant ecologists is based on the framework of the *plant traits* (or plant characteristics).
**Processes/Functions**

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plant functional types
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**Functional Traits**
- growth form
- life form
- nutrients
- biomass
- leaf size/shape
- rooting depth
- seed mass
- vegetation height

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**PLANT FUNCTIONAL TYPES**

**Functional Traits**
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**Plant Trait Database**

**The LEDA Traitbase**
**FUNCTIONAL TRAITS**
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**PLANT FUNCTIONAL TYPES**
- Processes/Functions
  - drivers

**PLANT FUNCTIONAL TYPES**
- Functional Traits
  - Functional Types
  - Processes/Functions
  - drivers

**Gradient**

**Diagram**
- Vegetation types
- Functional traits
- Scatter plot
- Diagram of plant functional types
**Processes/Functions**

**Drivers** → ? → **Plant Functional Types**

**Functional Traits**
- Growth form
- Life form
- Nutrients
- Biomass
- Leaf size/shape
- Rooting depth
- Seed mass
- Vegetation height

**Plant Functional Types**

**Processes/Functions**

**Plant Functional Types**
Spectral Information?

Ligth Capture & growth
(pigments, nutrients, leaf mass)

Foliar defense & longetivity
(cellulose, lignin, phenols, tanins)
PLANT FUNCTIONAL TYPES

FUNCTIONAL TRAITS
- growth form
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drivers

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\[ FUNCTIONAL\ T Raits \]

\[ FUNCTIONAL\ TYPES \]

\[ PROCESSES/FUNCTIONS \]

gradient

\[ PLANT\ FUNCTIONAL\ TYPES \]


**Processes/Functions**

- Drivers

**Plant Optical Types**

**Spectral Information**

**Optical Traits**

- Inliggende wecconstaart
- Inopdruw
- Overwelk gras
- Veldbies
- Grote gate leer

**Plant Optical Types**

**Gradient**
Overall objective and vision

Develop and examine a functional-trait-based framework, founded on optical data, that enables us to better monitor and understand invasion impacts on the functioning of grassland ecosystems.
gradient

PROCESSES/FUNCTIONS

drivers

PLANT OPTICAL TYPES

SPECTRAL INFORMATION

OPTICAL TRAITS

PLANT OPTICAL TYPES
How well can we estimate functional traits in grass- and shrubland ecosystems, based on hyperspectral remote sensing?

Empirical non-parametric regression techniques (Zhao et al., 2013)

Spectral indices for chlorophyll (Ustin et al., 2009)

Mean pigment accuracy retrieval ($R^2$) for a wide range of vegetation types (Huang et al., 2015)

Empirical prediction accuracy for a wide range of vegetation types (Homolová et al., 2013)

Spectranomics database: 5000 tree species (Asner & Martin, 2016)

What do we know?
Review

The functional characterization of grass- and shrubland ecosystems using hyperspectral remote sensing: trends, accuracy and moderating variables

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Meta-analysis: A synthesis of studies

R² and nRMSE of trait estimation model

Weighted mean R²
Weighted mean nRMSE
Three-level meta-analysis

3 sources of variation

\[ R^2_{\text{study } i} = \overline{R^2} + v_i + u_{ik} + e_{ik} \]

- \( v_i \): random deviation due to differences between studies
- \( u_{ik} \): random deviation due to differences between samples within studies
- \( e_{ik} \): Residual due to random sampling variation

Overall mean ES
Mean $R^2$

95% confidence interval (# effect sizes)

- Lignin: 0.64 (9)
- Water: 0.69 (42)
- Nitrogen: 0.74 (129)
- Phosphorus: 0.75 (45)
- Chlorophyll: 0.77 (83)
- Leaf Area Index: 0.79 (73)
- Carotenoids: 0.80 (14)
Overall objective and vision

Develop and examine a **functional-trait-based framework, founded on optical data**, that enables us to better monitor and **understand invasion impacts** on the functioning of grassland ecosystems.
STUDY SITES AND SAMPLING DESIGN

**Impatiens glandulifera**
*Himalayan balsam*
*Reuzenbalsemien*

Himalayas
19th century
Annual forb

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**Solidago gigantea**
*Giant goldenrod*
*Late guldenroede*

North America
Mid-1700s
Perennial forb, rhizomes

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STUDY SITES AND SAMPLING DESIGN

Impatiens glandulifera
Himalayan balsam
Reuzenbalsemien

40 plots

Solidago gigantea
Giant goldenrod
Late guldenroede

44 plots

Plots:
- Space-for-time substitution
- 2m x 2m
- Vegetation survey (Londo)
- Quantification of ecosystem functioning
- Functional and spectral characterization of dominant species
ECOSYSTEM FUNCTIONING

1. Peak live aboveground biomass
2. Soil elements: available P, N, C
3. Decomposition rate of standard material:
   Tea bag Index

Mass loss of green tea
~ Stabilisation of labile fraction into recalcitrant fraction

Mass loss of Rooibos tea
~ decomposition rate
FUNCTIONAL AND SPECTRAL CHARACTERIZATION OF DOMINANT SPECIES

39 dominant herbaceous species → 73 observations

Functional traits

Leaf Economic Spectrum: SLA, LDMC, LNC, LPC, Chlorophyll
Size traits: plant height, leaf area
Decomposition related traits: LCaC, LMgC, carotenoids
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Reflectance

Intermezzo
COMMON METHODS

Measuring the spectral signatures of individual herbaceous species is a challenge

Lab measurements of *Poa pratensis* (Bayat et al., 2016)

Lab measurements of *Halimium umbellatum* (Davishvile et al., 2008)

Point measurements, hand-held (Thulin et al. 2012)

Leaf measurements with leaf clip or integrating sphere (ASD)

3 mm pixels with AISA + Eagle spectrometer (Lopatin et al. 2017)
Linear signal unmixing:

\[ \text{spectrum}_{\text{vegetation}} = \frac{\text{spectrum}_{\text{measured}} - f_{\text{black table in FOV}} \cdot \text{spectrum}_{\text{black table}}}{f_{\text{vegetation in FOV}}} \]
COMMON METHODS

Lab measurements of *Poa pratensis* (Bayat et al., 2016)

Lab measurements of *Halimium umbellatum* (Darvishzadeh et al., 2008)

Leaf measurements with leaf clip or integrating sphere (ASD)

3 mm pixels with AISA + Eagle spectrometer (Lopatin et al. 2017)

**PRACTICAL TOOL**

A novel procedure for measuring functional traits of herbaceous species through field spectroscopy

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FUNCTIONAL AND SPECTRAL CHARACTERIZATION OF DOMINANT SPECIES

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Reflectance
Two specific approaches and RQs

Develop and examine a functional-trait-based framework, founded on optical data, that enables us to better monitor and understand invasion impacts on the functioning of grassland ecosystems

1. Can we delineate meaningful PFT’s in a herbaceous context, and to what extent are they spectrally deductible?

2. What are the mechanisms through which invasive alien species alter ecosystem functioning?
Emergent PFTs vs. Emergent POTs

7 groups 8 groups

Entanglement = 0.13
Two specific approaches and RQs

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Processes/Functions

Drivers

Plant Functional Types

Functional Traits

Plant Functional Types

Processes/Functions

'STEREO III' CALL 2015 - INPLANT
I. glandulifera leads to more nutrient-rich plant communities.

S. gigantea shifts the community towards more conservative traits.

Similar pattern were observed both for the optical and functional traits space (Procrustes r = 0.46, p ≤ 0.001)
Two specific approaches and RQs

Develop and examine a functional-trait-based framework, founded on optical data, that enables us to better monitor and understand invasion impacts on the functioning of grassland ecosystems.

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SCHEDULED FLIGHT AND FIELD CAMPAIGN SUMMER 2017 2018

Boom
26/06/'18
5 lines

Wichelen
27/06/'18
3 lines

Lier
02/07/'18
2 lines

Mechelen
02/07/'18
3 lines

Additional flight on 02/09/2018 over all sites
FIELD SURVEY

Vegetation survey

Sunphotometer: aerosols
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INPLANT

https://inplant-project.weebly.com/

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