FSU activity report: 2015 - 2019

Alexander Brenning, Patrick Schratz, Jannes Muenchow
LIFE Healthy Forest Meeting, Vitoria, 26-27 Mar 2019

Outline

1) Action A2 deliverables: "*Optimization of the integrated systems*"

- Assistance for acquistion of hyperspectral imagery
- Database of plot characterization
- Database of possible predisposing factors for spatial modelling

2) Action B1.1 deliverables: "*Spatial mapping using statistical and machine-learning data analysis*"

- Remotely sensed forest health map
- Maps of forest disease potential

3) Action D3: "*Complementary Actions*"

- Summer school Jena March 2017

A2.1.1: Field monitoring and sampling

Pathogen presence/absence

NEIKER provided field sampling data for the following pathogens:

- *Armillaria mellea*: 1016 obs. (395/621) (after cleaning)
- *Diplodia sapinea*: 922 obs. (700/222) (after cleaning)
- *Fusarium circinatum*: 922 obs. (781/141) (after cleaning)
- *Heterobasidion annosum*: 1016 obs. (785/231) (after cleaning)

A2.1.1: Field monitoring and sampling

Defoliation data

NEIKER gathered in-situ information in 2016 and 2017.

2016

- Demonstration plots (Luiando, Oiartzun, Laukiz 1-3, Hernani)
- Sampling of all trees in the plot
- Total amount of sampled trees: ~ 1800

2017

- Sampling of all 28 plots (Total # of obs.: 1400)
- 50 trees per plot
- Sampling scheme from FSU

A2.1.4: Envir. condi. as predisp. factors

The following variables were collected:

- Long-term **precipitation** (1950 - 2000)
- Long-term **temperature** (1950 - 2000)
- Long-term **PISR** (1950 - 2000)
- **Soil** type (at 250 m res.)
- **Lithology** type (at 1 km res.)
- **pH** value (at 1 km res.)
- Probability of **hail damage** at trees (200 m res.)

A2.1.6: Hyperspectral img acquisition

- Hyperspectral imagery was acquired by HAZI in September 2016 for all plots (28 in total)
- Unfortunately, one of the five "demonstration plots" ("hernani") was not covered by the flight mission
- FSU helped with the planning of the flight routes (Marco Pena)

A2.1.6: Hyperspectral img acquisition

- Hyperspectral satellite Hyperion-1 was decomissioned in January 2017 without prior notice
- Hyperspectral Airborne AVIRIS data as a replacement not suitable (price, flights only in US)
- No other spaceborne hyperspectral sensor available

A2.1.6: Hyperspectral img acquisition

→ We acquired spaceborne multispectral **Sentinel-2** data as an alternative for Hyperion-1 data.

Available cloud-free mosaics of the Basque Country for the vegetation period (April - September)

- 2017: 3
- 2018: 8

A2 Deliverables

- [x] Acquisition of hyperspectral imagery
- [x] Database of plot characterization
- [x] Database of possible predisposing factors for spatial modelling

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B1.1: Spatial mapping

Defoliation mapping

1. Training of an **Extreme Gradient Boosting** (xgboost) model

- ~ 7500 Variables
  - 90 Vegetation Indices (VI)
  - 7400 Normalized Ratio Indices (NRI)

1. Extraction of the most important variables → 7

2. Prediction of defoliation (Basque Country; 2017 + 2018)

Defoliation mapping

Model Performance

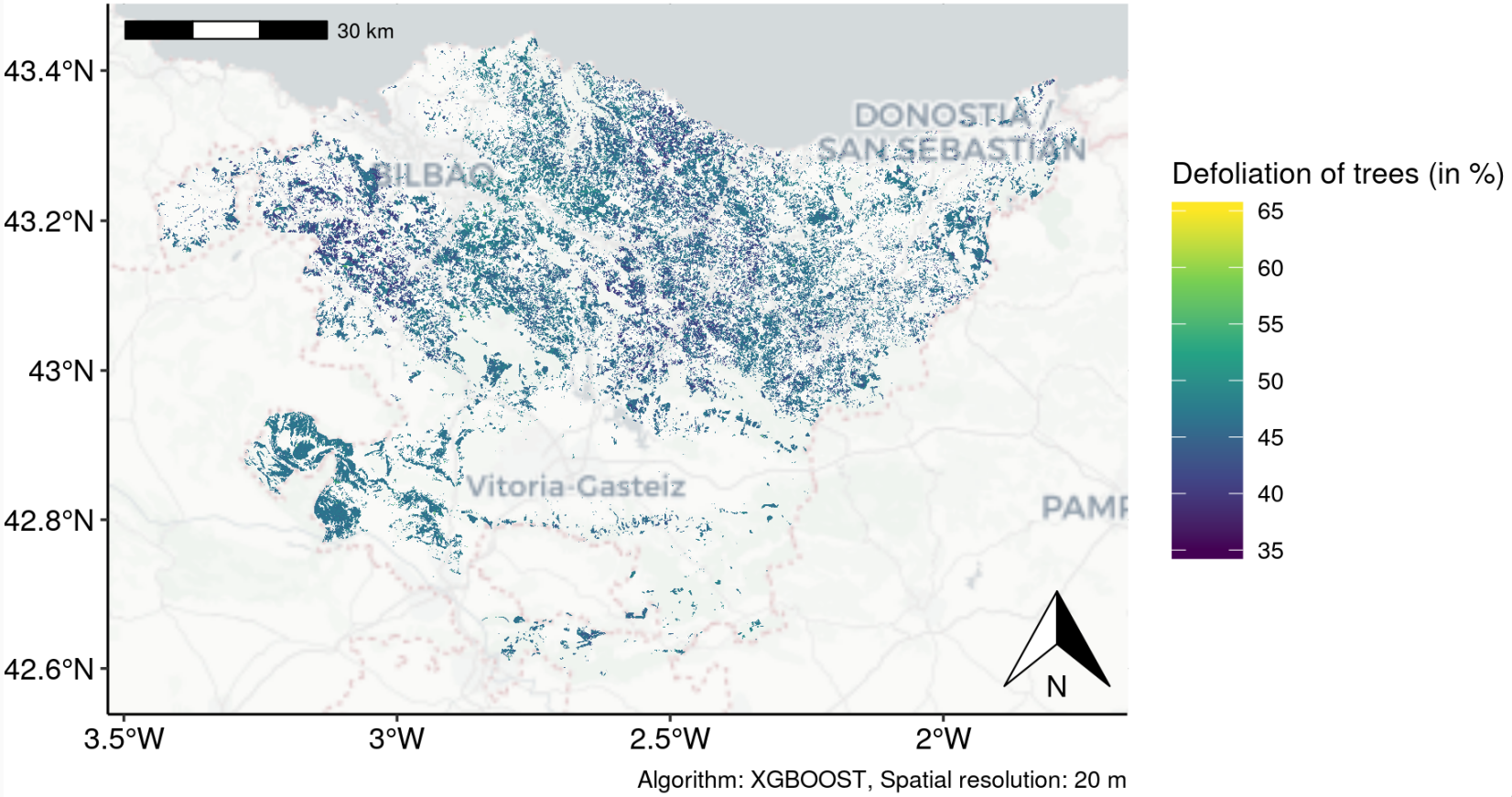
RMSE: ~ 40 (defoliation)

Most Important Vegetation Indices

- "EVI",
- "GDVI_2", "GDVI_3", "GDVI_4",
- "mNDVI",
- "mSR",
- "D1"

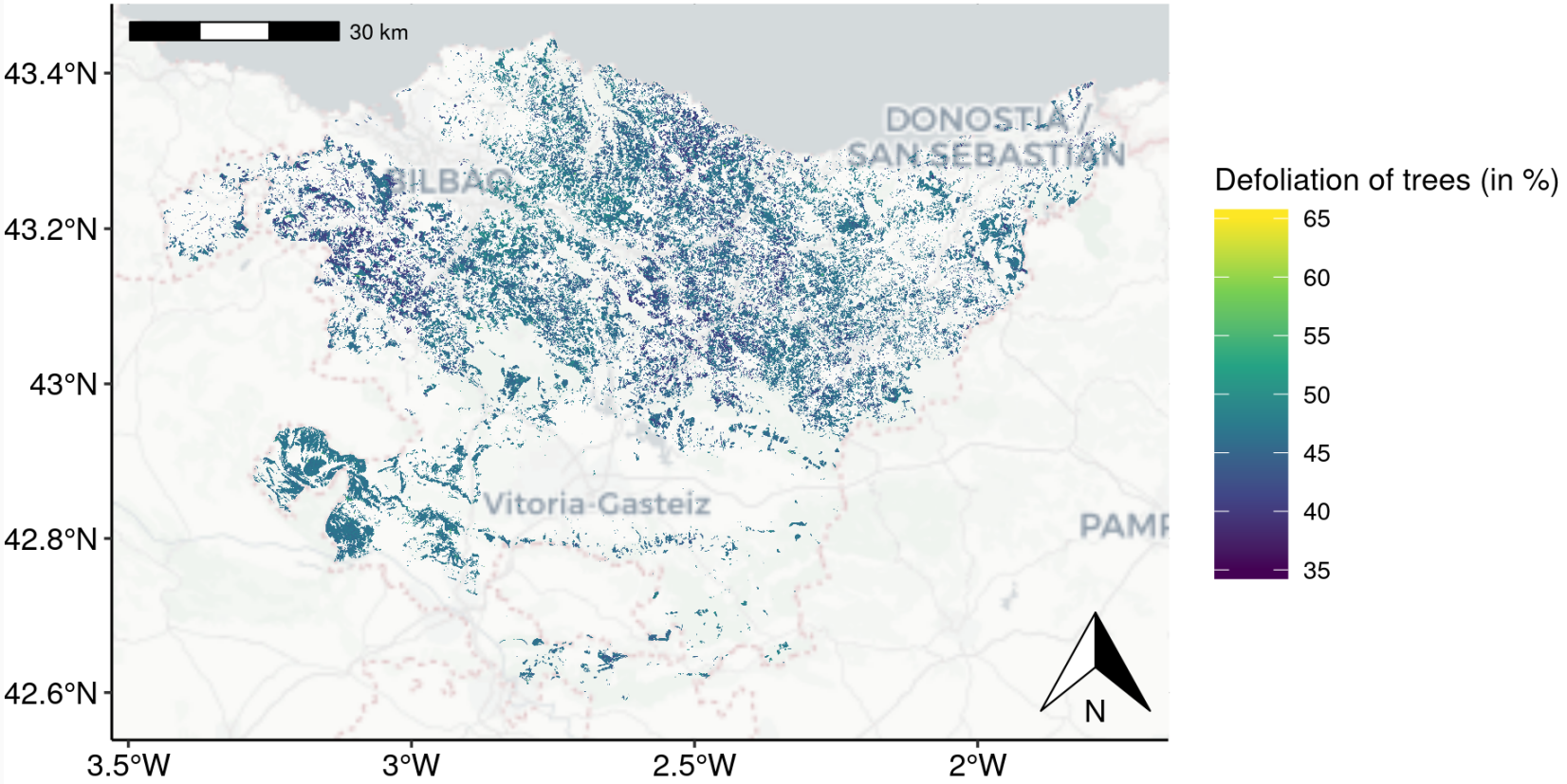
B1.1: Spatial mapping

Defoliation mapping (Prediction 2017)



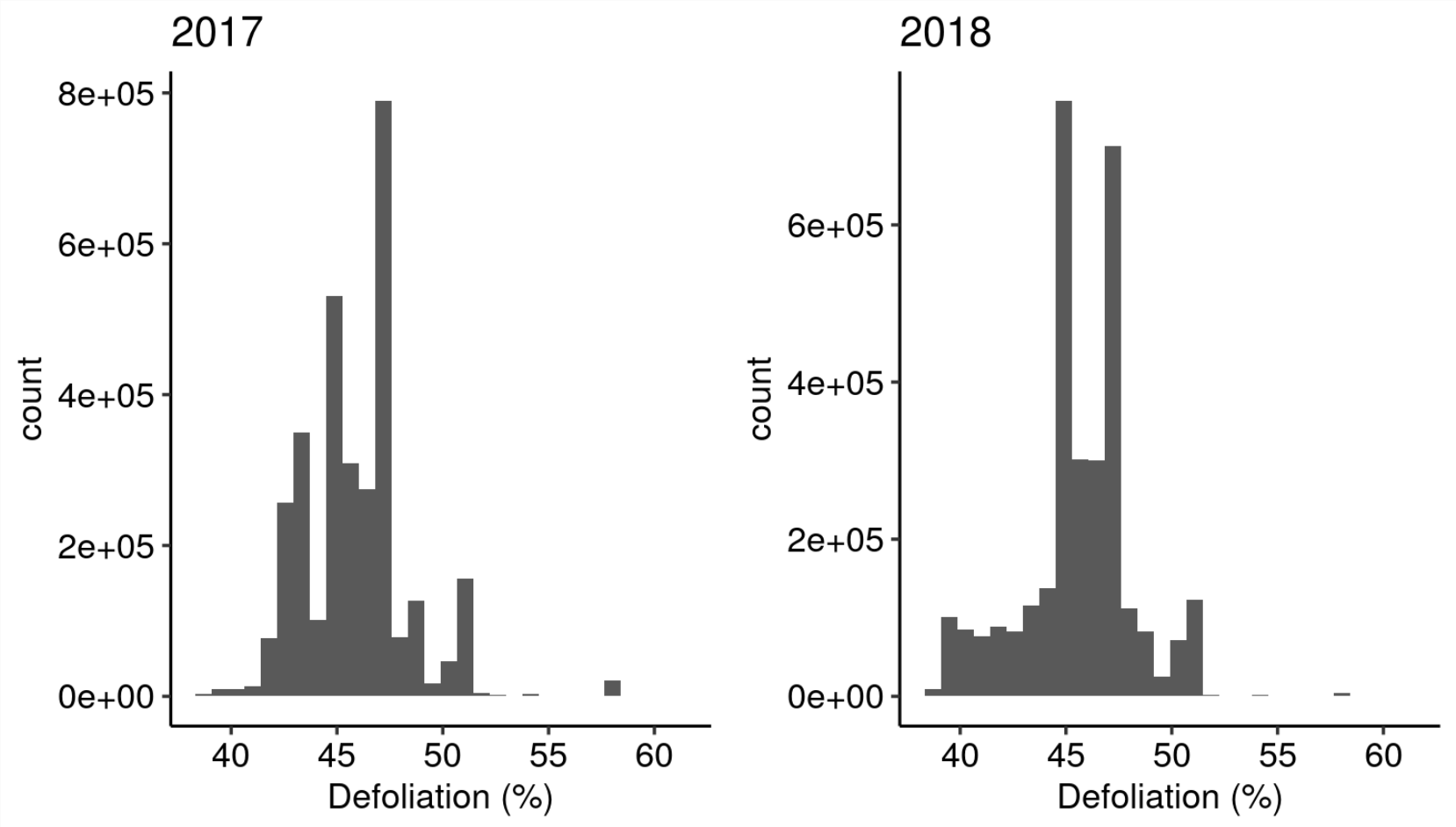
B1.1: Spatial mapping

Defoliation mapping (Prediction 2018)



B1.1: Spatial mapping

Defoliation mapping (Histograms)



B1.1: Spatial mapping

Pathogen modeling

Tuning and training of 7 classifiers for each pathogen

- Random Forest (RF)
- Support Vector Machine (SVM)
- Boosted Regression Trees (BRT)
- Generalized Additive Model (GAM)
- Generalized Linear Model (GLM)
- Extreme Gradient Boosting (XGBOOST)
- k-Nearest Neighbor (KNN)

B1.1: Spatial mapping

Pathogen modeling

- Performance evaluation for all possible combinations (26/28)[1]
- Creation of prediction maps for all possible combinations (24/28)[2]

[1] XGBOOST and GAM did not converge on Armillaria.

[2] XGBOOST cannot predict to data with new factor levels.

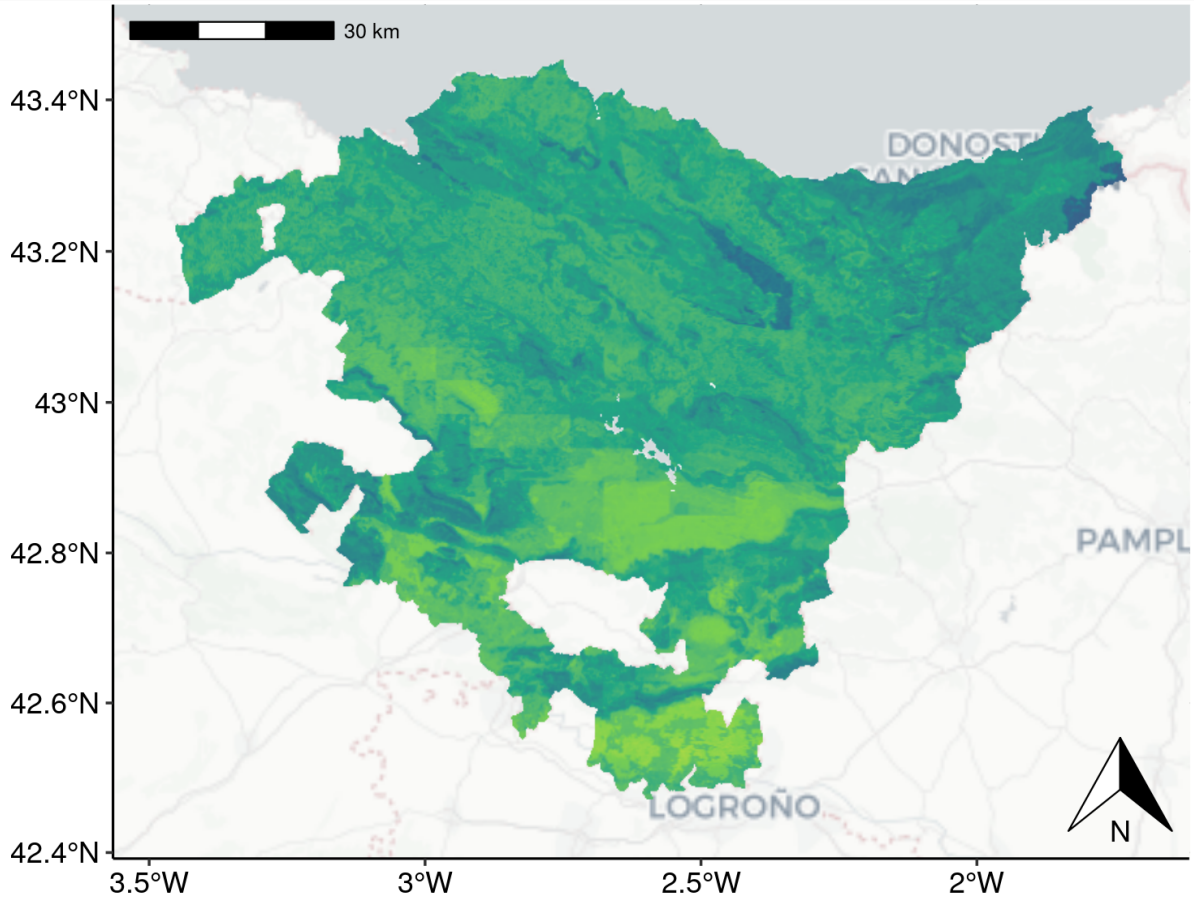
Best classifier (Performance)

Brier Score

- Armillaria: Random Forest (0.243)
- Diplodia: Random Forest (0.165)
- Fusarium: Random Forest (0.128)
- Heterobasidion: Random Forest (0.165)

B1.1: Spatial mapping

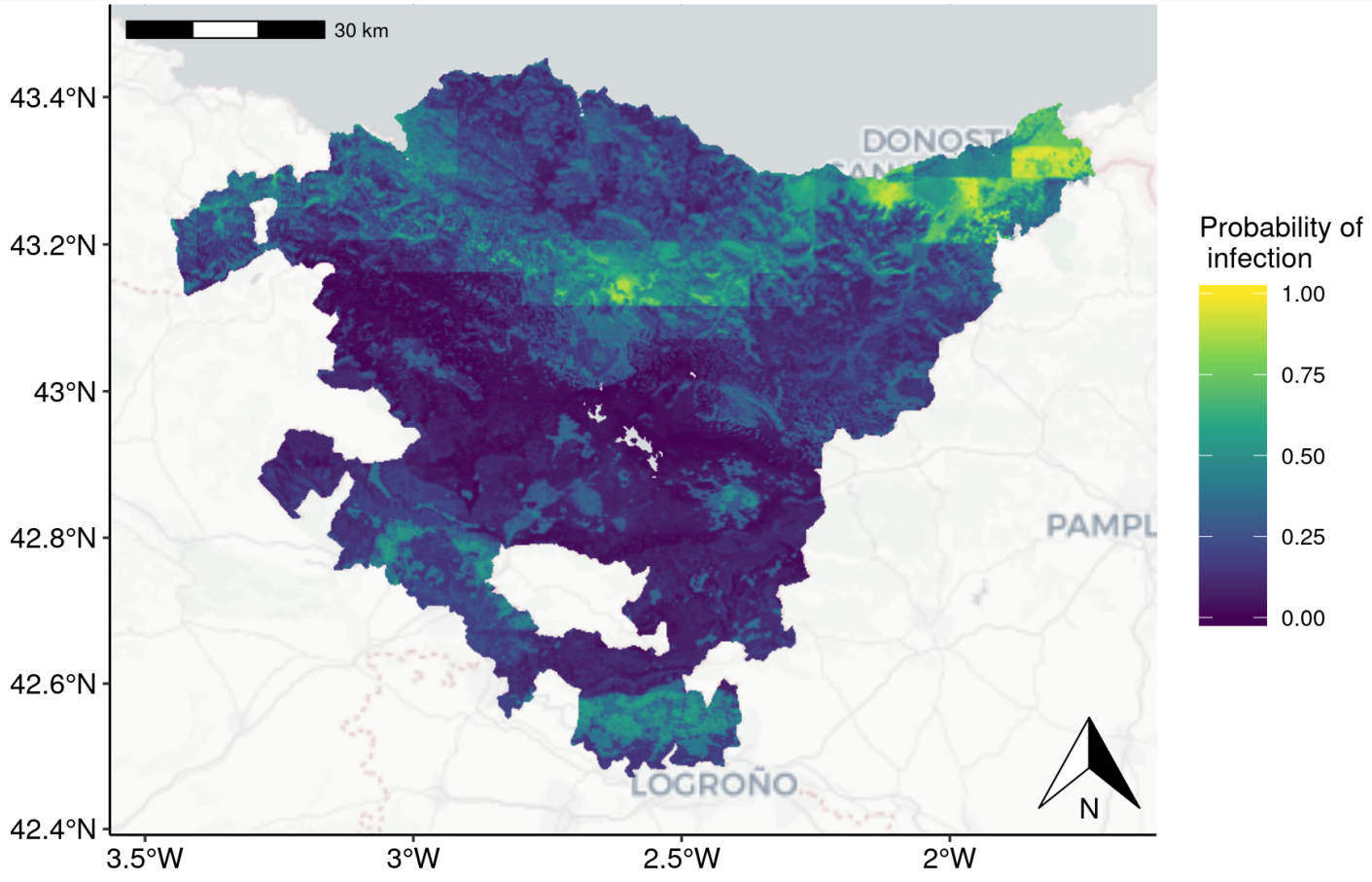
Pathogen modeling (prediction maps)



Pathogen: Armillaria, Algorithm: RF, Spatial resolution: 200 m
Performance: 0.2426 (Brier), Resampling: spatial/spatial

B1.1: Spatial mapping

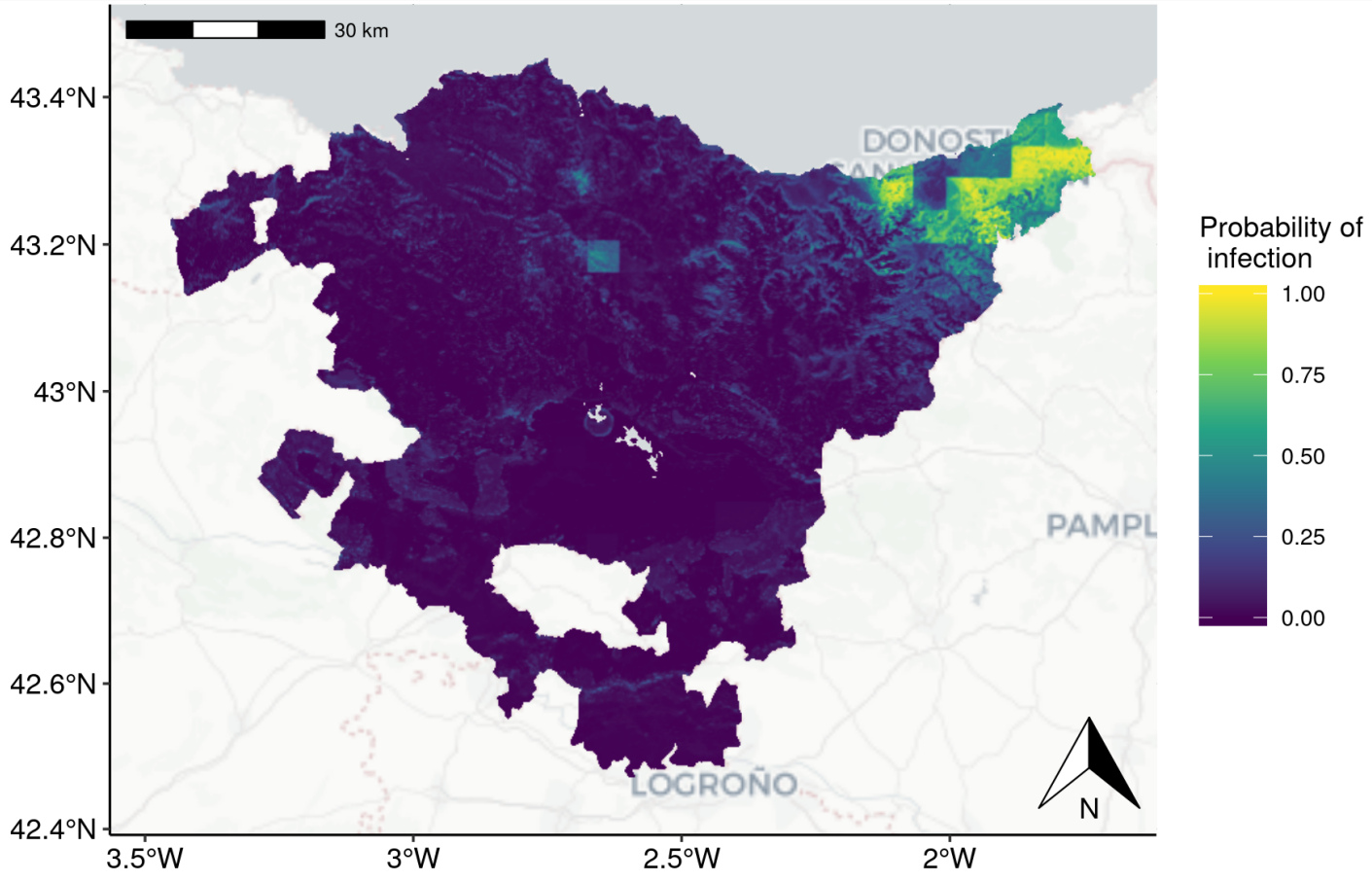
Pathogen modeling (prediction maps)



Pathogen: Diplodia, Algorithm: RF, Spatial resolution: 200 m
Performance: 0.165 (Brier), Resampling: spatial/spatial

B1.1: Spatial mapping

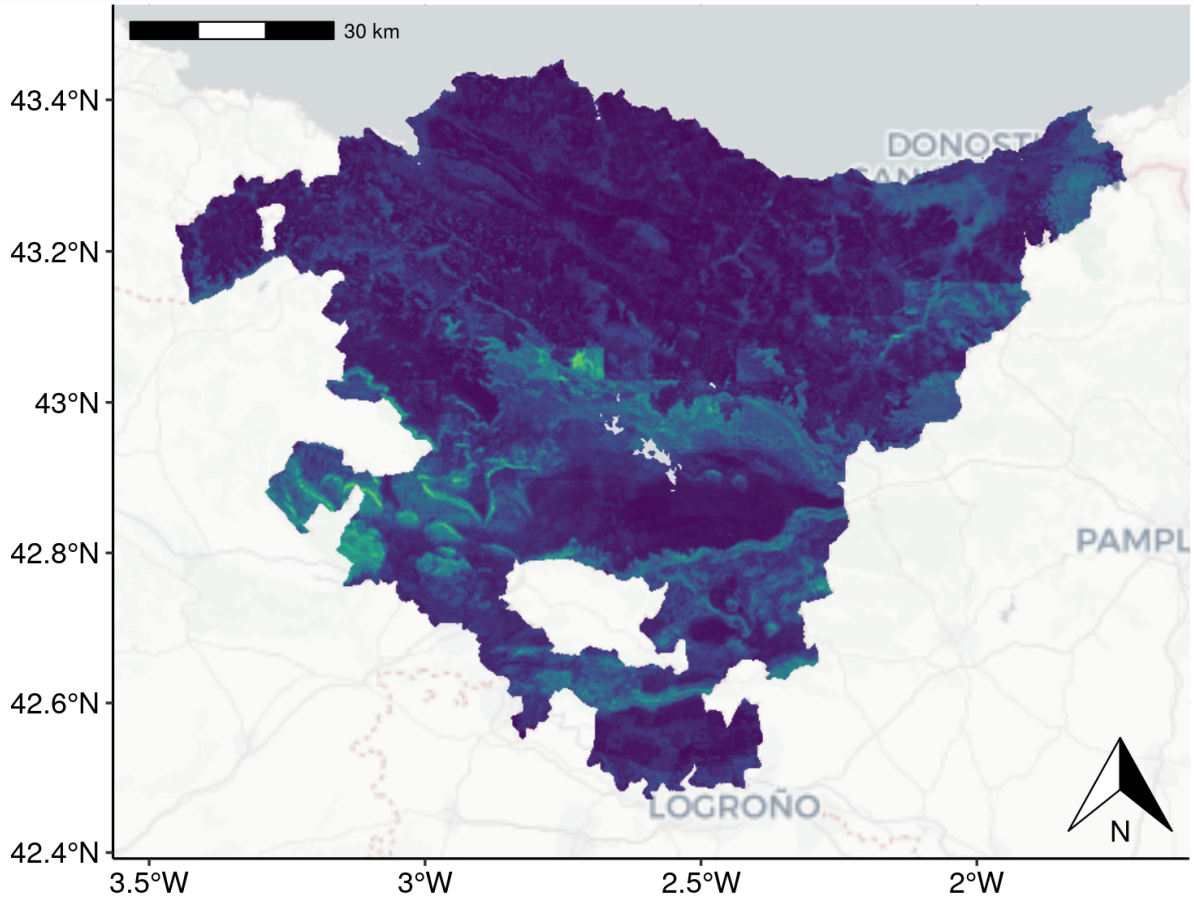
Pathogen modeling (prediction maps)



Pathogen: Fusarium, Algorithm: RF, Spatial resolution: 200 m
Performance: 0.1284 (Brier), Resampling: spatial/spatial

B1.1: Spatial mapping

Pathogen modeling (prediction maps)



Pathogen: Heterobasidion, Algorithm: RF, Spatial resolution: 200 m
Performance: 0.1657 (Brier), Resampling: spatial/spatial

B1.1: Deliverables

- [x] Remotely-sensed forest health map
- [x] Map of forest disease potential

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D3: Complementary Actions

FSU hosted a training school on "**statistical analysis of hyperspectral data**".

Date: March 2017

Duration: 5 days (full-time)

Statistics

- 54 applications
- 28 (international) participants

Participant report: https://www.r-spatial.org/r/2017/03/25/spring-school-jena.html

D3: Complementary Actions

Speaker list

- Marco Peña (Alberto Hurtado University, Chile)
- Aneta Modzelewska (Forest Research Institute, Raszyn, Poland)
- Dr. Henning Buddenbaum (University of Trier, Germany)
- Dr. Tim Appelhans (University of Marburg/GfK Geomarketing Nürnberg, Germany)
- Dr. Thomas Bocklitz (IPC Jena, Germany)
- Prof. Dr. Alexander Brenning (FSU)
- Dr. Jannes Muenchow (FSU)
- Patrick Schratz (FSU)

D3: Complementary Actions