

USING SENTINEL-2 DERIVED DEFORESTATION MAPS OF THE PRIMEVAL BIALOWIEZA FOREST TO MAP HABITAT DEGRADATION WITH THE InVEST ECOSYSTEM SERVICE MODEL

Rosalinda Morrone (rm589@le.ac.uk, rosalinda.morrone@mail.polimi.it)
 CLCR, University of Leicester – Polytechnic of Milan



Abstract

Straddling the border of Poland and Belarus, the Natura 2000 site of Białowieża Forest is an irreplaceable area for biodiversity conservation, in particular due to its size, protection status and undisturbed nature. The largest volume of logging since 1988 started in 2017.

The InVEST Habitat Quality model was used to mapping and quantifying the forest's habitat degradation between 2017 and 2018, thus helping to identify areas where biodiversity is likely to be mostly intact or endangered.

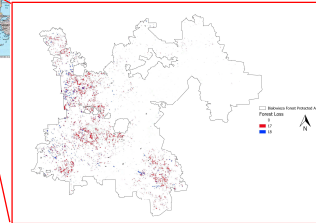
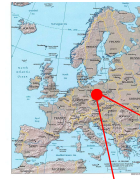


Fig.1: Area of Interest

Methodology: From GIS and Machine Learning to InVEST

Supervised Classification

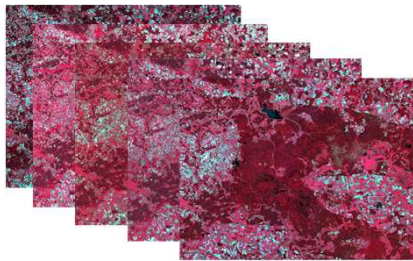


Fig.2: Input: L2A Sentinel-2 Images

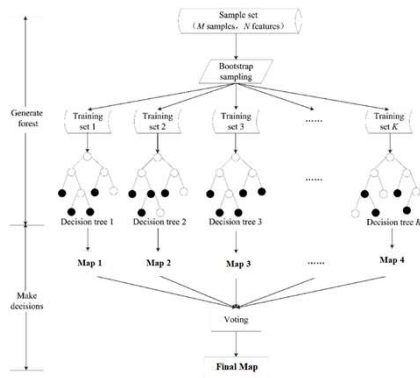


Fig.3: Flowchart Random Forest Classifier

A dynamic training data set is created comparing multiple images of 2017 and 2018. This data set is the input of the meta estimator *Random Forest Classifier*. The best model for the final classification is evaluated thanks to the model selection estimator *GridSearchCV*.

Final Model Accuracy = 72%
Out of Bag Error = 0,03053
Cohen's Kappa = 0.68

Map Accuracy Assessment

		Confusion Matrix Normalized																PA
		Reference data																
Map's prediction		1	3	4	5	7	8	10	11	13	14	16						
	1	0,576	0,000	0	0,004	0	0	0,001	0	0,413	0	0,007					97,43%	
3	0	0,321	0	0,018	0,026	0,035	0	0	0	0	0					95,45%		
4	0,016	0	0,546	0,022	0	0	0,016	0	0	0	0					24,30%		
5	0	0,001	0,274	0,646	0,006	0	0,002	0	0,068	0	0,003					98,19%		
7	0	0,013	0	0,007	0,734	0,195	0,004	0	0	0,022	0,025					54,39%		
8	0	0	0	0	0,206	0,791	0	0	0	0	0,002					91,21%		
10	0,008	0	0,020	0	0	0	0,971	0	0	0	0					98,13%		
11	0	0	0	0	0	0	0	1	0	0	0					100%		
13	0	0	0	0	0	0	0	0	1	0	0					31,70%		
14	0,077	0	0	0,002	0	0	0	0	0	0	0,921					97,54%		
16	0,098	0,020	0	0	0	0	0	0	0,157	0	0,725					48,05%		
UA	57,59%	92,11%	94,57%	64,58%	73,38%	79,13%	97,13%	100%	100%	92,11%	72,55%							

Fig.4: Confusion Matrix, Producer's Accuracy, User's accuracy

LULC Classified Image

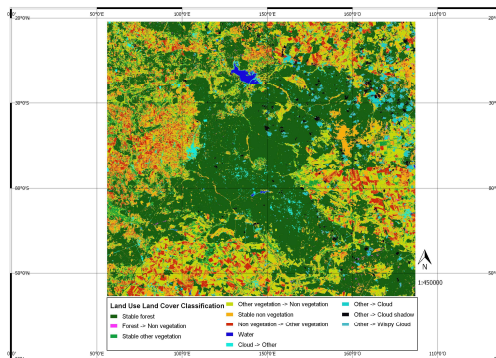


Fig.5: LULC map, InVEST Data Need

InVEST Habitat Quality Model

THREAT	MAX_DIST (km)	WEIGHT	DECAY
primary roads	3	0.5	linear
secondary roads	2	0.3	linear
railway	5	0.3	linear
border	5	0.5	linear
forest loss 2017	10	1	linear
forest loss 2018	10	1	linear
urban area	3	0.6	linear
EWDI (Enhanced Wetness Difference Index)	10	0.9	linear

Table 1: Distance-decay data for the threats [1],[2],[3]

LULC	NAME	HABITAT	L_P_ROADS	S_ROADS	RAILWAY	L_BORDER	F_L2017	F_L2018	L_URBAN	L_EWDI
1	stable forest	1	0.7	0.7	0.7	0.6	1	1	0.9	0.9
3	forest / non-vegetation	0.4	0.55	0.45	0.45	0.4	1	1	0.5	0.9
4	stable other-vegetation	0.75	0.6	0.7	0.55	0.6	1	1	0.65	0.9
5	other-vegetation / non-vegetation	0.4	0.55	0.45	0.45	0.4	1	1	0.5	0.9
7	stable non-vegetation	0.35	0.45	0.35	0.35	0.3	0.8	0.8	0.4	0.6
8	non-vegetation / other-vegetation	0.65	0.5	0.6	0.45	0.4	1	1	0.55	0.9
10	stable	1	0.6	0.6	0.6	0.6	0	0	0.65	0.9
11	cloud / other	0	0	0	0	0	0	0	0	0
12	other / cloud	0	0	0	0	0	0	0	0	0
14	other / cloud shadow	0	0	0	0	0	0	0	0	0
16	other / wetland cloud	0	0	0	0	0	0	0	0	0

Table 2: Relative sensitivity of the habitat type to each threat [1],[2],[3]

How changes in ecosystems are likely to lead to changes in benefits that flow to people?

InVEST models habitat quality and rarity as proxies for biodiversity, ultimately estimating the extent of habitat and vegetation types across a landscape, and their state of degradation:

$$D_{xj} = \sum_{r=1}^R \sum_{y=1}^{Y_r} \left(\frac{W_r}{\sum_{r=1}^R W_r} \right) \tau_{y i_{rxy}} B_{xj} S_{jr}$$

Threat level in grid cell x for LULC type j [4]

Map Accuracy Assessment

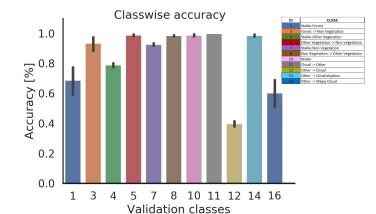


Fig.6: Random data splits for model evaluation

Habitat Degradation

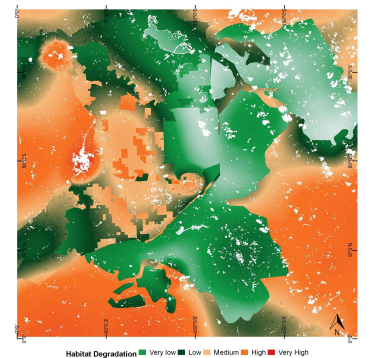


Fig.7: Habitat Degradation Score

High Degradation values inside the forest are mostly influenced by urban areas and by forest loss, and less influenced by EWDI values (related to the bark beetle infestation).

Deforestation Estimate between 2017 and 2018: **0.003% (4.91 ha)**