Tree species classification in temperate forests using airborne hyperspectral data

Krzysztof Stereńczak, Martyna Wietecha
Forest Research Institute, Poland

Motivations & Goals

Motivations

Tree species identification is an important issue in forest management. Despite the fact that airborne hyperspectral data is promising tool to map species distribution, it is still not common to use remote sensing techniques to classify temperate forest. The reason is their complexity.

In this study we try to develop an objective tree species classification method for woodland in the temperate zone which allows to use species information in the assessment of woody biomass and carbon storage in forests as well.

Goals

The aim of the study was to classify tree species of forests belonging to a temperate forest ecosystems, located in the Milicz forest district, Lower Silesia in Poland. There were group of 7 dominant tree species selected.

Methods

Two airborne imaging spectroscopy dataset were acquired with the **HySpex VNIR-1800 and HySpex SWIR-384** sensors. The spectral resolution of the first sensor is 3.26 nm and spatial resolution 2.5 m. For the second one spectral resolution is 5.45 nm and 5 m pixel size. Total spectral range of obtained data is between 400 and 2500 nm (451 bands). Data were acquired in August 2015.

Processing chain adopted in this study.

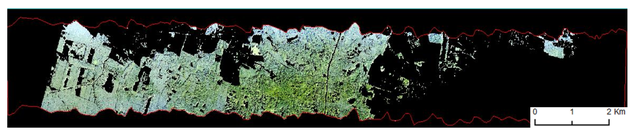
MGGP Aero – provider of the data

- **Radiometric correction - HySpex RAD**
- **Geometric correction - PARGE**
- **Atmospheric correction – MODTRAN5, ATCOR4**

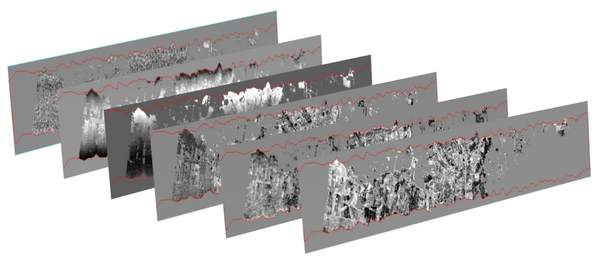
Forest Research Institute - REMBIOFOR

- **Input data selection**
  HySpex SWIR-1800
  416-2510 nm
  451 bands
  5 m
- Basic line selection to develop classification algorithm – with the most mixed forest
- **Mask**
  nDSM – normalized Digital Surface Model, High Vegetation <2.5 m and Vegetation Indices (mNDVI 705)
- **Feature reduction**
  Minimum Noise Fraction (MNF)
- **Choosing the training and verification set**
- **Classification**
  Support Vector Machine (SVM)
- **Post-Classification processes and accuracy assesment**

Forest Digital Map was used to select the most heterogenous line of dataset as a basic scene to develop classification algotithm.

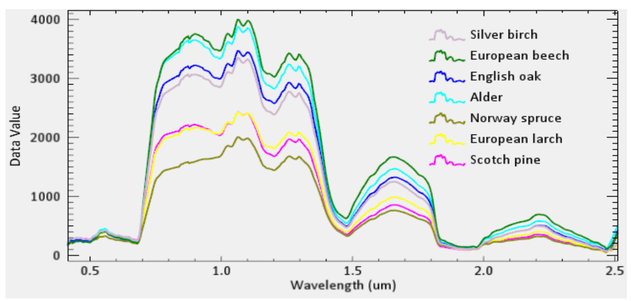


To eliminate non-forest areas Normalized Digital Surface Model (**nDSM**) derived from LiDAR data (ALS) and Vegetation Indices (**mNDVI$_{705}$**) were used.

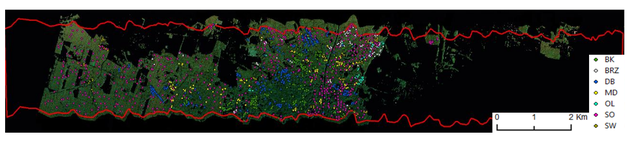


For the feature reduction the last band over 2400 nm were removed. Then the **Minimum Noise Fraction (MNF)** transformation was tested. 36 the most informative MNF bands were used for the further data processing.

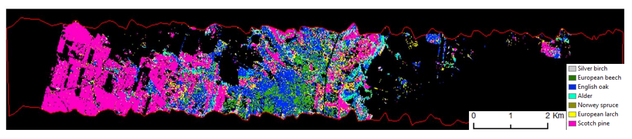
As a training set for 7 class of dominant tree species, shadows and background over **2000 pixels** were selected. ROIs were placed evenly across the line.



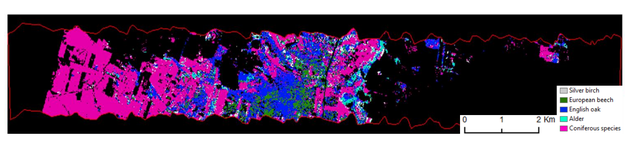
	ROI Class	Pixel Count
1	Scotch pine	842
2	European larch	183
3	Norway spruce	102
4	English oak	392
5	European beech	215
6	Silver birch	168
7	Alder	121



Basing on two orthophotomaps (April 2014, August 2015) and fixed sample plot veryfication set of over **2400** points was created.



To avoid Hughes' phenomenon **Support Vector Machines (SVM)** classifier were used. 7 class of tree species were distinguished at first.



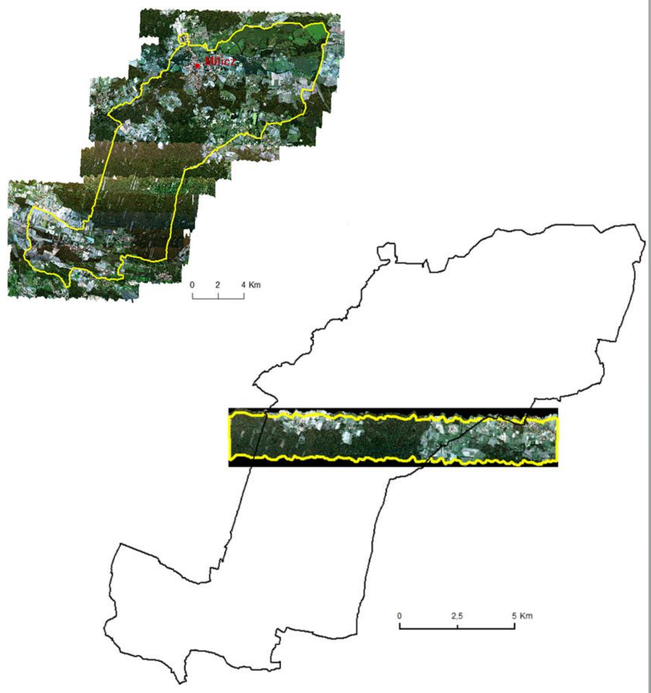
As the Norway spruce and European larch rarely occur within the stands, **combine classes** was used and class of coniferous species was created. Additionally **sieve and clump** processes were aplied to improve classification image.

Study area & Object of research

Study area

The area of research is **Milicz forest district**, located in Lower Silesia, south-westrm Poland. The area limits extend to 181,94 km^2, while forest covers 44%. The dominant forest site types are fresh mixed coniferous forest and fresh mixed broadleaves forest.

In the first attempts, the most heterogeneous line of datasets was classify.

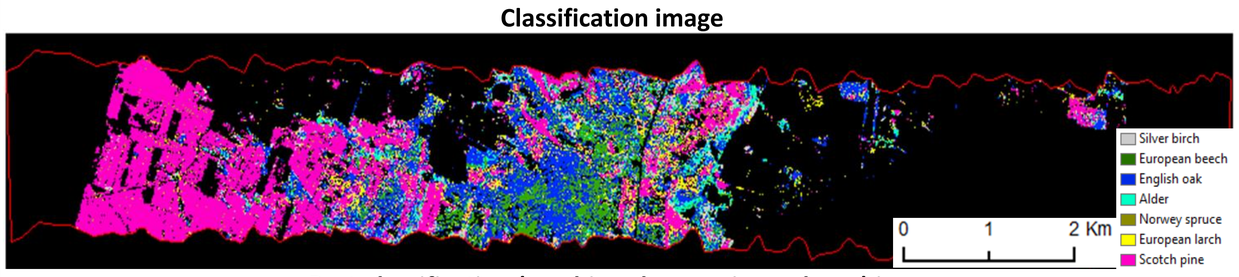


Object of research

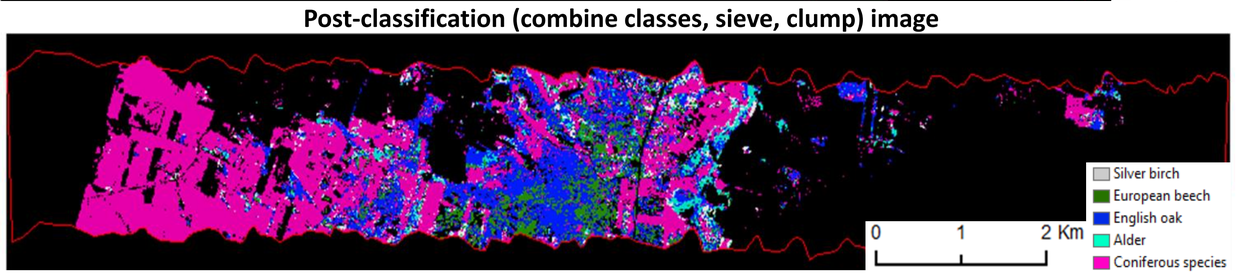
The research focused on the classification of 7 dominant forest tree species for Milicz forest district: **Scotch pine (*Pinus sylvestric*), European larch (*Larix decidua*), Norway spruce (*Picea abies*), European beech (*Fagus sylvatica*), English oak (*Quercus robur*), Silver birch (*Betula pendula*), Alder (*Alnus sp*.)**

Results

Classification image



Post-classification (combine classes, sieve, clump) image



Accuracy assesment

SVM – 7 class

Verification set \ Classification	Birch	Beech	Oak	Alder	Spruce	Larch	Pine	
Birch	269	3	12	27	0	7	41	359
Beech	7	300	64	12	0	7	1	391
Oak	6	24	353	28	1	14	2	428
Alder	9	12	30	107	0	3	3	164
Spruce	5	10	23	2	40	40	112	232
Larch	3	2	38	2	5	228	43	321
Pine	21	6	28	10	24	63	415	567
	320	357	548	188	70	362	617	1712

SVM – Post-classification, 5 class

Verification set \ Classification	Birch	Beech	Oak	Alder	Coniferous	
Birch	269	3	12	27	48	359
Beech	7	300	64	12	8	391
Oak	6	24	353	28	17	428
Alder	9	12	30	107	6	164
Coniferous	29	18	89	14	970	1120
	320	357	548	188	1049	1999

	Tree species	Training set Polygons	Training set Pixels	Verification	UA	PA
1	Silver birch	9	168	359	84,1	74,9
2	European beech	8	215	391	84,0	76,7
3	English oak	13	392	428	64,4	82,5
4	Alder	9	121	164	56,9	65,2
5	Norway spruce	4	102	232	57,1	17,2
6	European larch	13	183	321	63,0	71,0
7	Scotch pine	28	842	567	67,3	73,2
8	Background	2	280	-	-	-
9	Shadows	11	204	-	-	-
Sum		84	2023	2462		
OA		70%				
Kappa		0.64				

	Tree species	Training set Polygons	Training set Pixels	Post-Classification	Verification	UA	PA
1	Silver birch	9	168	1. Silver birch	355	89,7	71,3
2	European beech	8	215	2. European beech	387	90,3	74,4
3	English oak	13	392	3. English oak	425	66,0	87,5
4	Alder	9	121	4. Alder	161	66,7	79,5
5	Norway spruce	4	102				
8	European larch	13	183	5. Coniferous species	1118	91,6	89,3
9	Scotch pine	28	842				
6	Background	2	280	-	-	-	-
7	Shadows	11	204	-	-	-	-
Sum		84	2023	2446			
OA		83%					
Kappa		0.77					

- **Classification into 7 class**: OA=70%, Kappa=0.64
- **Classification into 5 class**: OA=83%, Kappa=0.77
- **Coniferous species with the highest accuracy**: Scotch pine (67.3 UA, 73.2 PA)
- **Broadleaves species with the highest accuracy**: Silver birch (89.2 UA, 72.0 PA), European beech (90.0 UA, 74.4 PA)
- **Species with the lower accuracy**: Alder, Norwey spruce, European Larch (low participation in the stand)

Conclusion & Futher steps

Conclusion

For tree species and species group classification airborne hyperspectral data and selected processing algorithm were effective. The highest overall classification accuracies (83%) were provided for the four forest decidous species (birch, beech, oak, alder) and one class of coniferous species with post-classification processes sieve and clump. It provided higher user's and producer's accuracies for almost all decidous classes analyzed and high for coniferous species. Low accuracies of larch and spruce are caused by rare occurrence within the stands in Milicz forest district. Obtaining higher overal accuracy and Kappa coeficient is limited by spatial resolution of the data and mixing of species (e. g. oak and beech, birch and pine).

Futher steps

- Automation of all lines classification process separately
- Mosaicking image classification
- Integration of classification results with ALS data and adding species information to estimate of woody biomass and carbon storage in forests

Forest Research Institute – Project Office
Sękocin Stary, ul. Braci Leśnej 3, 05-090 Raszyn
Tel. +48 22 71 50 300; Fax +48 22 72 00 397
e-mail: rembiofor@ibles.waw.pl
www.rembiofor.pl

Project REMBIOFOR „Remote sensing based assessment of woody biomass and carbon storage in forests", supported by The National Centre for Research and Development, as „Environment, agriculture and forestry" BIOSTRATEG program, agreement no. BIOSTRATEG1/267755/4/NCBR/2015