LIFE+ ForBioSensing

Forest Research Institute

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Individual tree detection and species classification in structural diverse forests

Maciej Lisiewicz, Krzysztof Stereńczak, Agnieszka Kamińska, Bartłomiej Kraszewski, Małgorzata Białczak, Miłosz Mielcarek, Aneta Modzelewska, Rafał Sadkowski, Żaneta Piasecka

Forest Research Institute (Poland)

TREE SPECIES

INSTYTUT BADAWCZY LEŚNICTWA
ZAKŁAD GEOMATYKI

Life

Tree Species Project Workshop, Göttingen. 27-28 September 2022

LIFE + ForBioSensing PL Comperhensive monitoring of stand dynamics in Białowieża Forest supported with remote sensing techniques co-funded by Life Plus and The National Fund for Environmental Protection and Water Mangement in Poland, contract number: LIFE 13 ENV/PL/000048; 485/2014/WN 10/OP-NM-LF/D

Motivation for this presentation

Perspectives on tree species classification in Poland

Presentation of a solution for tree species classification and monitoring the condition of individual trees, implemented and tested in LIFE+ ForBioSensing project

Exchange of experience - ideas for the near future

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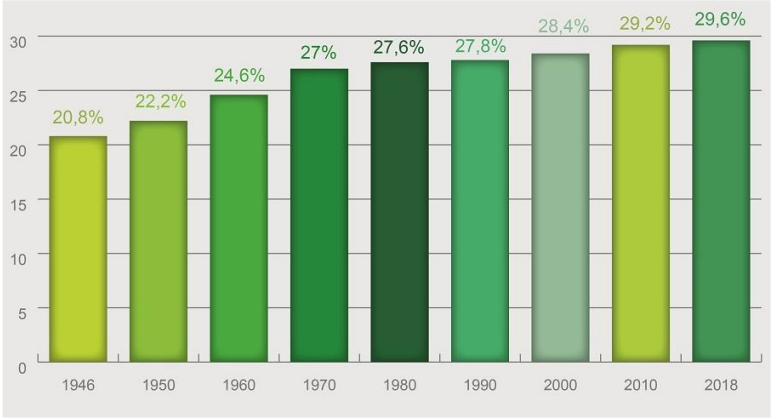
Forests in Poland

Forest cover - around 29.6% (9.260 mln ha)



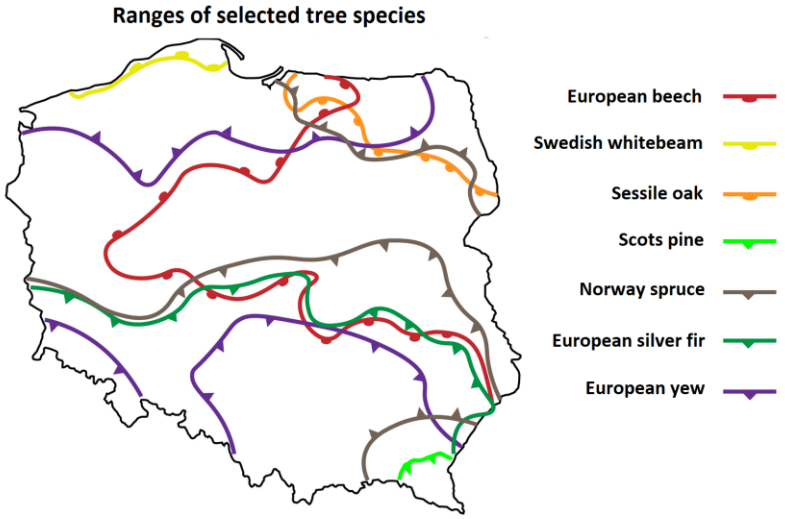
Source: GUS

Ownership:

- public forests 82% of Poland's forests (**State Forests National Forest Holding - 78%**, national park forests - 2%, others - 2%).
- private forests 18%.

Tree species in Poland:

pine - 58.5%
birch - 7.5%
oak - 7.5%
spruce - 6.4%
beech - 5.8%
alder - 5.4%
other deciduous trees - 4.7%
other coniferous trees - 4.2%



Source: ZPE

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General idea for remote sensing-based forest inventory and monitoring (in Poland)

Inventory

Monitoring

dbh/height — statistical methods/ALS — field based/RS

Terrestrial RS — ALS/other RS — RS

ABA — ABA/ITD

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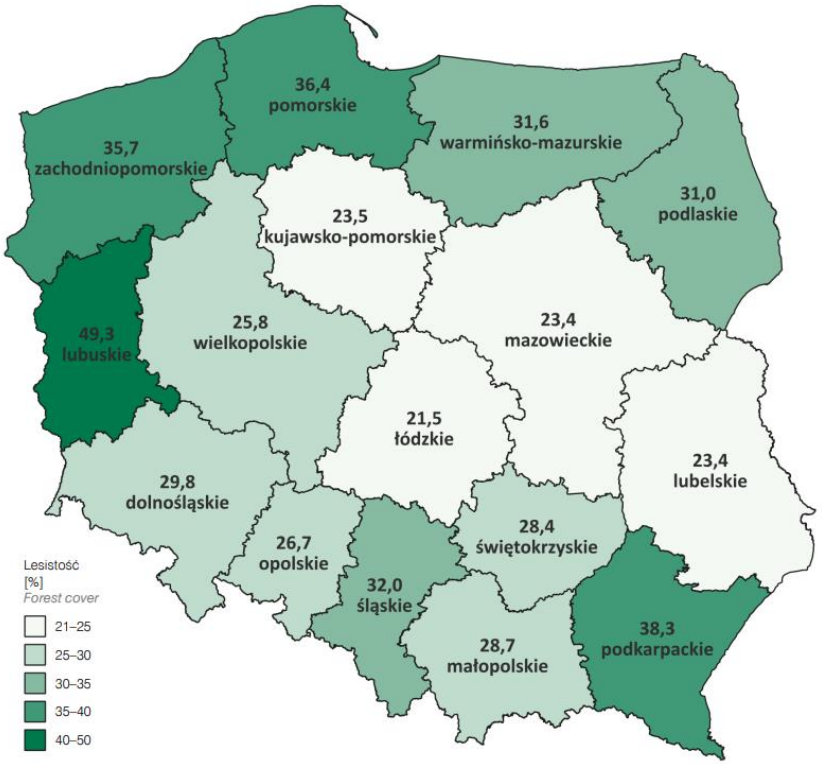
NFI in Poland



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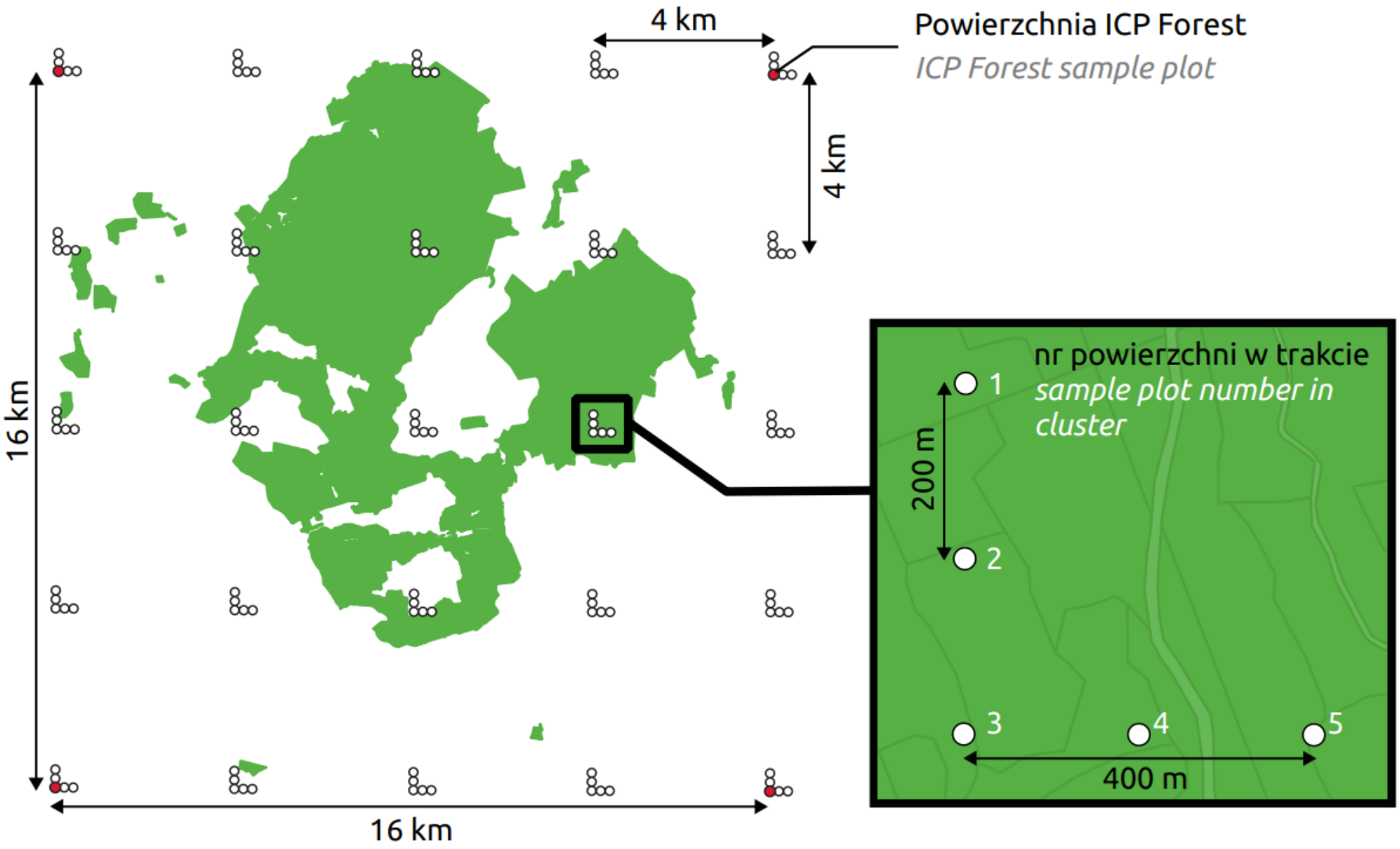

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LIFE+ ForBioSensing project

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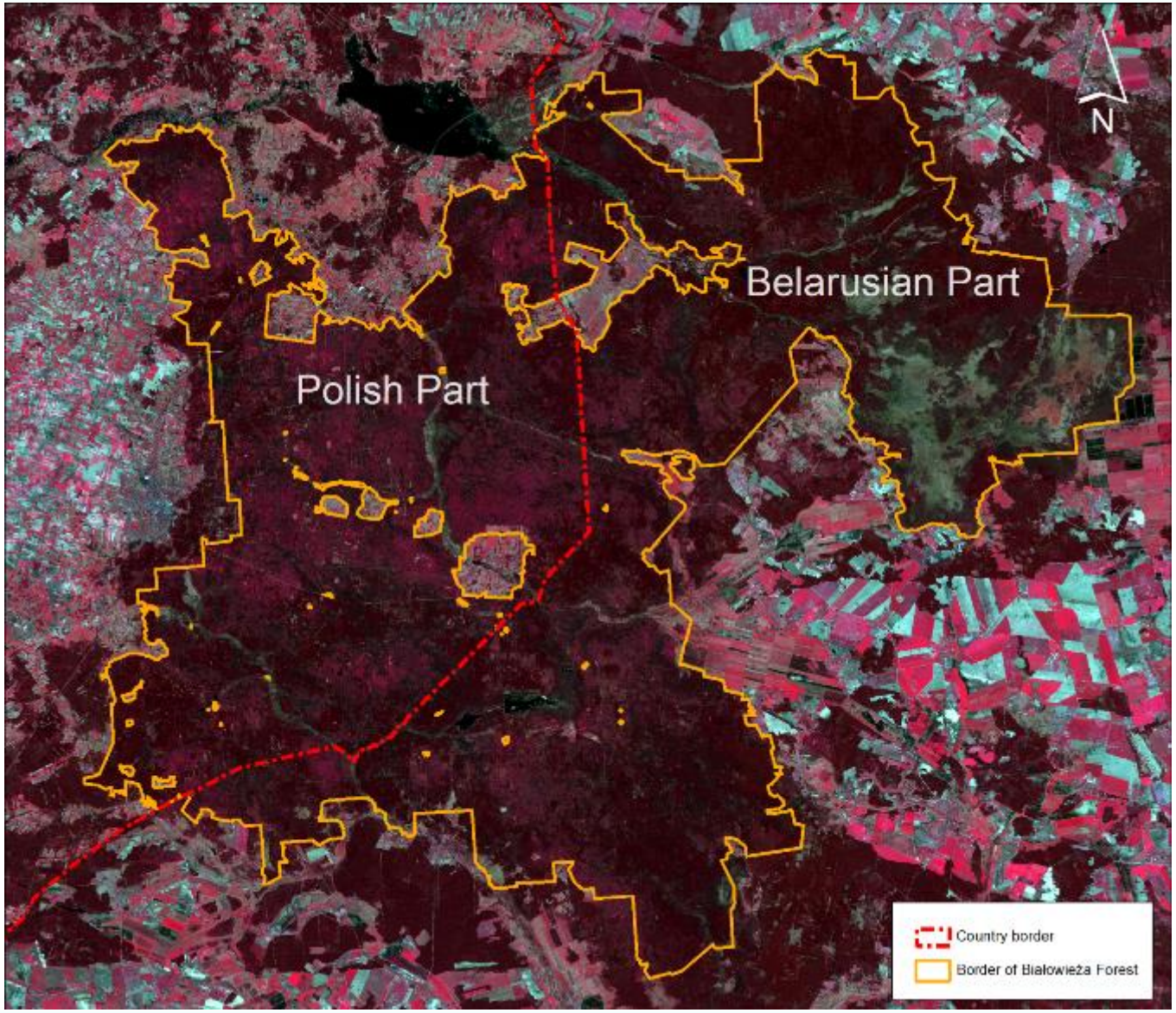
The Białowieża Forest



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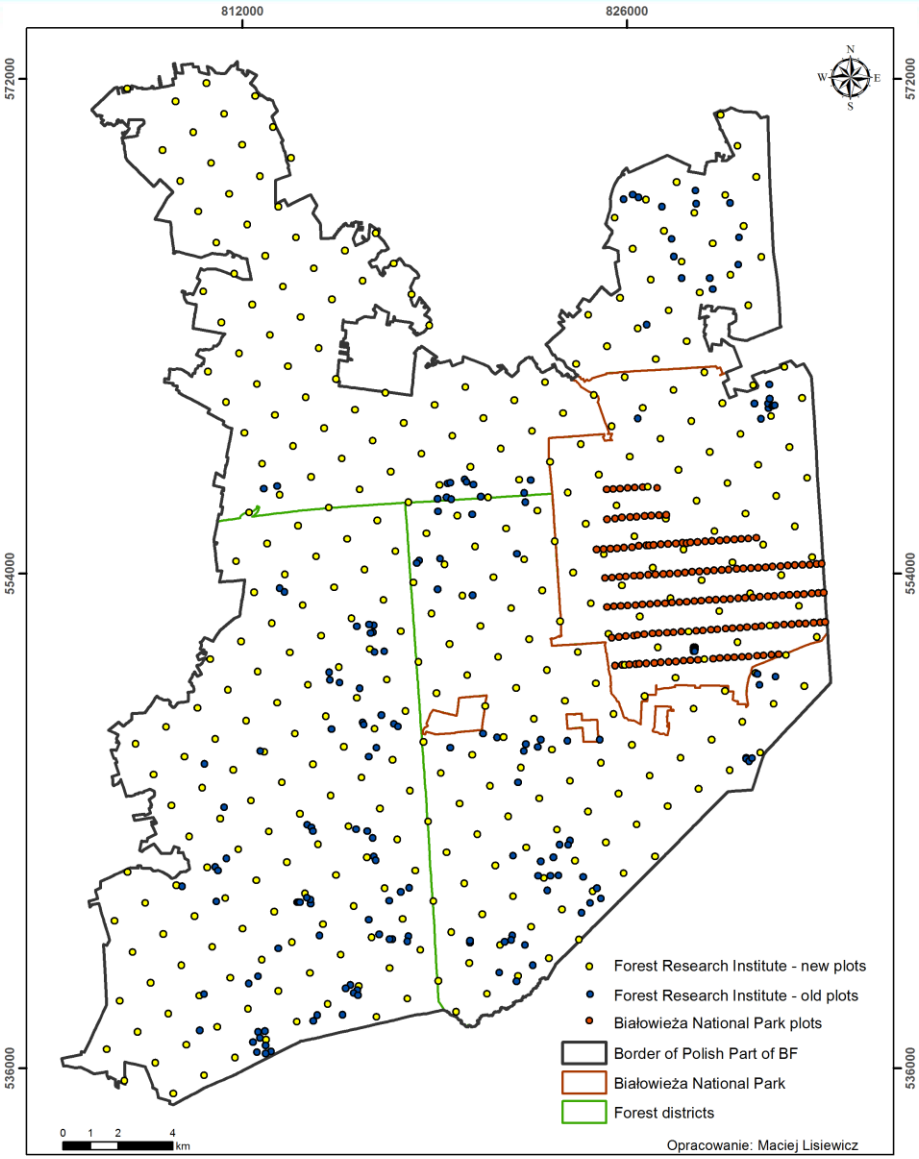
Field-based monitoring plots



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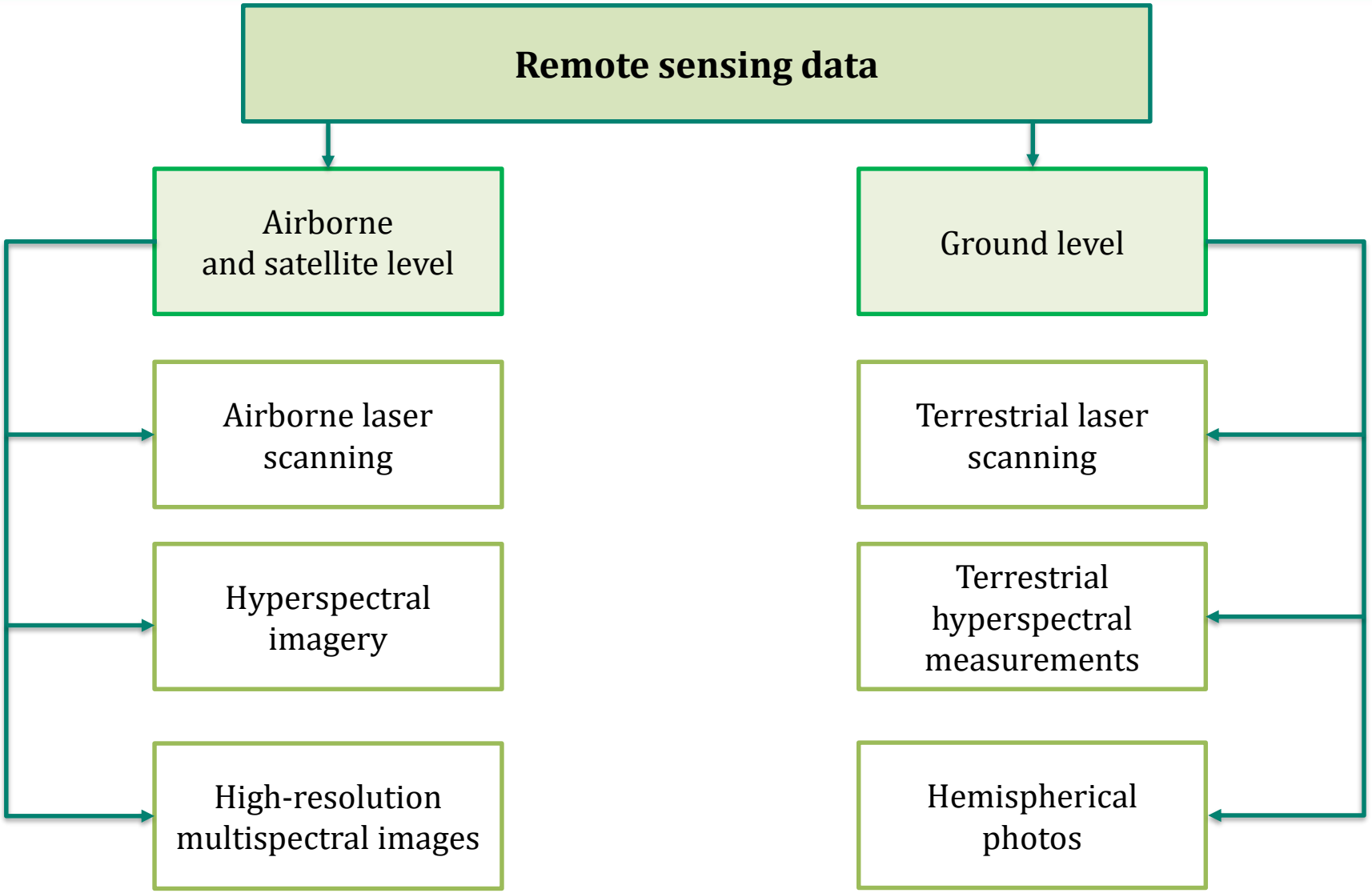
Remote sensing data acquired in the project



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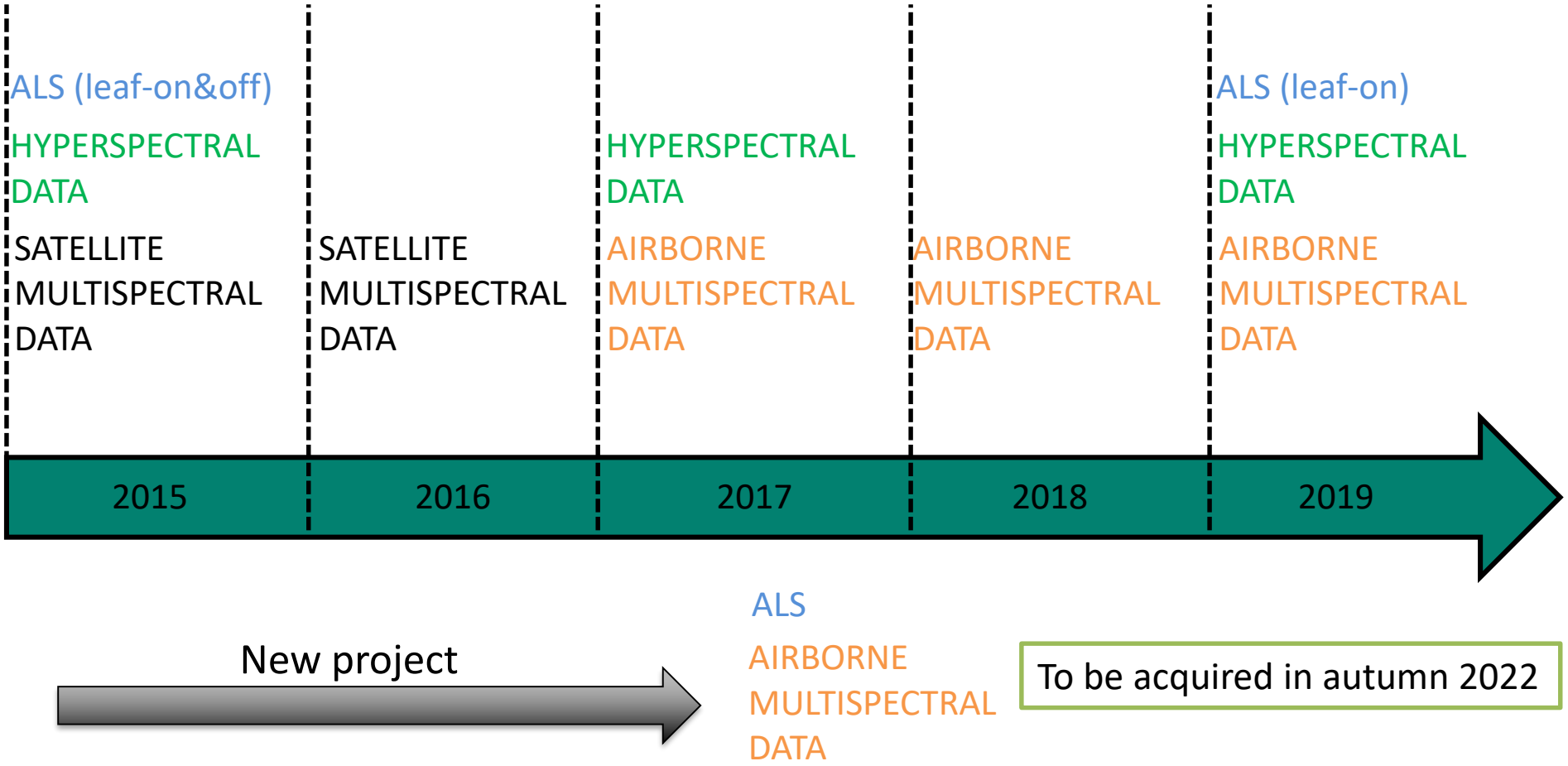
Data collected from airborne and satellite level



New project

ALS

AIRBORNE MULTISPECTRAL DATA

To be acquired in autumn 2022

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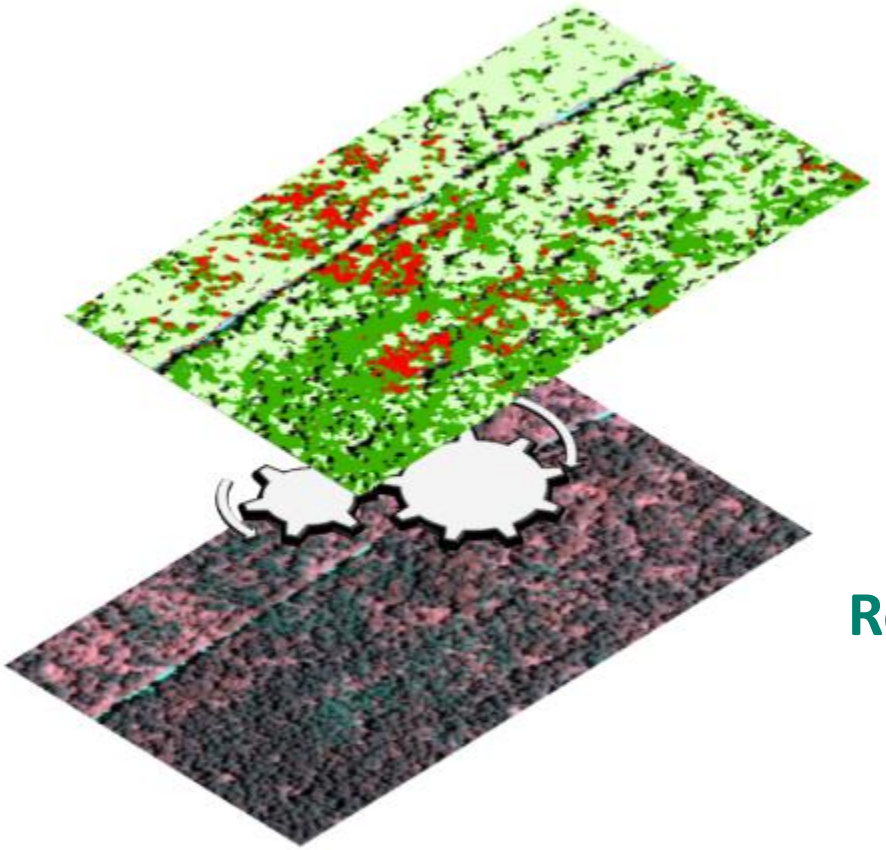

Results of remote sensing analyzes

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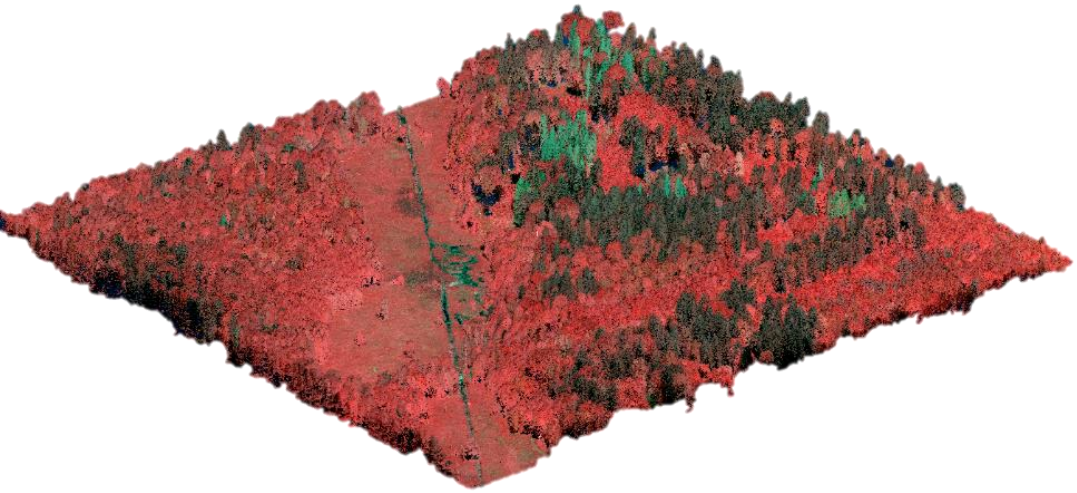
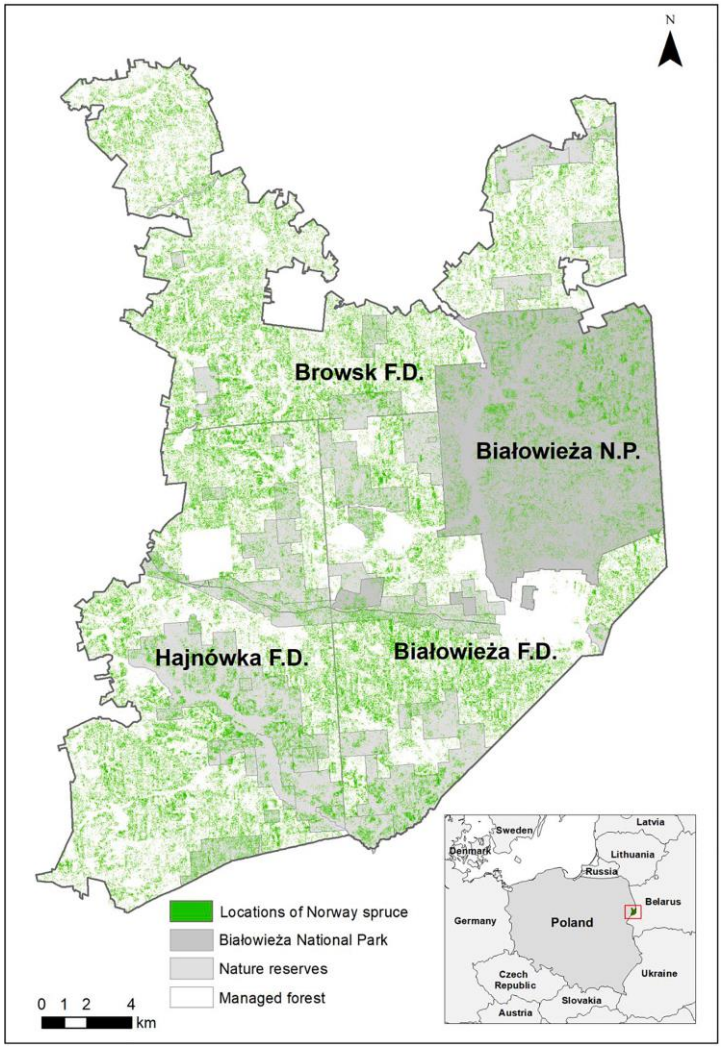
Need for accurate information on alive/dead spruces





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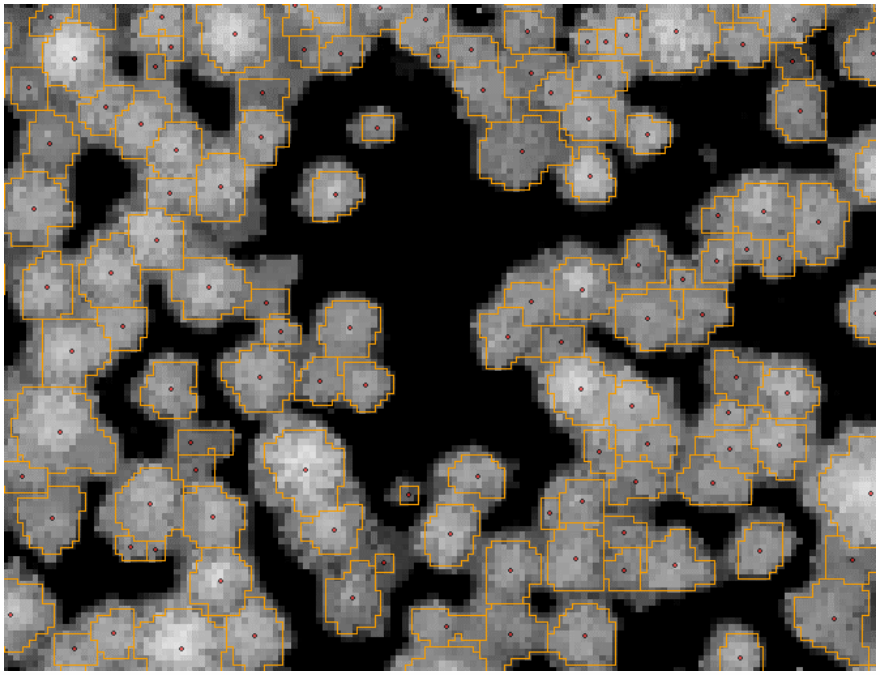
CHM-based Individual Tree Detection method

- The need to implement a method in structurally heterogeneous and species-mixed forests
- Marker-controlled watershed segmentation algorithm with parametrisation into three height ranges
- Resulting segments adjusted using a five-step procedure



Contents lists available at ScienceDirect

Int J Appl Earth Obs Geoinformation

journal homepage: www.elsevier.com/locate/jag

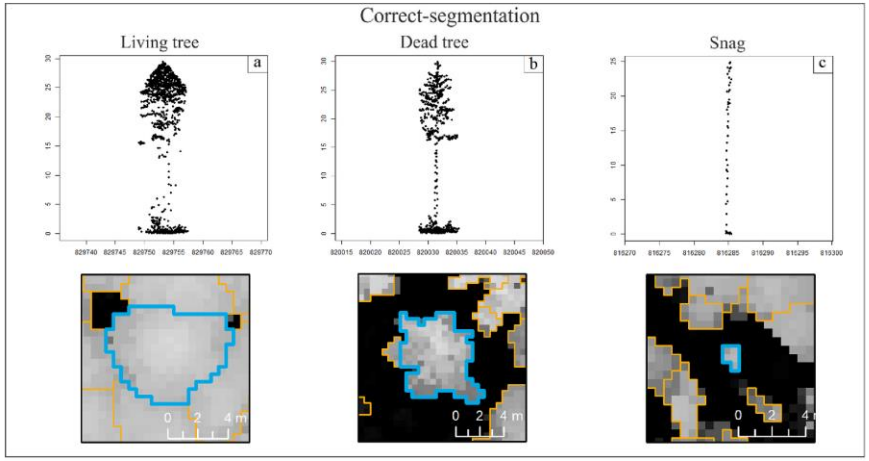
Mapping individual trees with airborne laser scanning data in an European lowland forest using a self-calibration algorithm

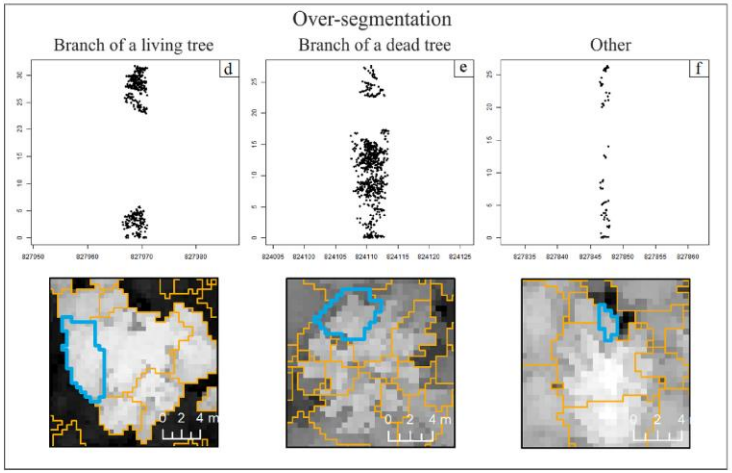
Krzysztof Stereńczak[a,*], Bartłomiej Kraszewski[a], Miłosz Mielcarek[a], Żaneta Piasecka[a], Maciej Lisiewicz[a], Marco Heurich[b,c]

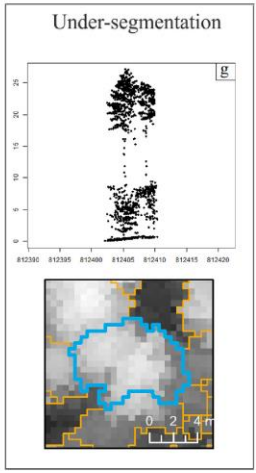
LIFE + ForBioSensing PL Comperhensive monitoring of stand dynamics in Białowieża Forest supported with remote sensing techniques co-funded by Life Plus and The National Fund for Environmental Protection and Water Mangement in Poland, contract number: LIFE 13 ENV/PL/000048; 485/2014/WN 10/OP-NM-LF/D

But some errors still occur…

- Oversegmentation and undersegmentation errors occur in all ITD methods
- Geometry and ALS derived metrics to distinguish between errors
- Machine learning techniques enable to separate errors from correct segments with high precision
- Which tree species are more likely to be incorrectly segmented?







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Remote Sensing Applications: Society and Environment
journal homepage: www.elsevier.com/locate/rsase

Recognition of specified errors of Individual Tree Detection methods based on Canopy Height Model

Maciej Lisiewicz *, Agnieszka Kamińska, Krzysztof Stereńczak

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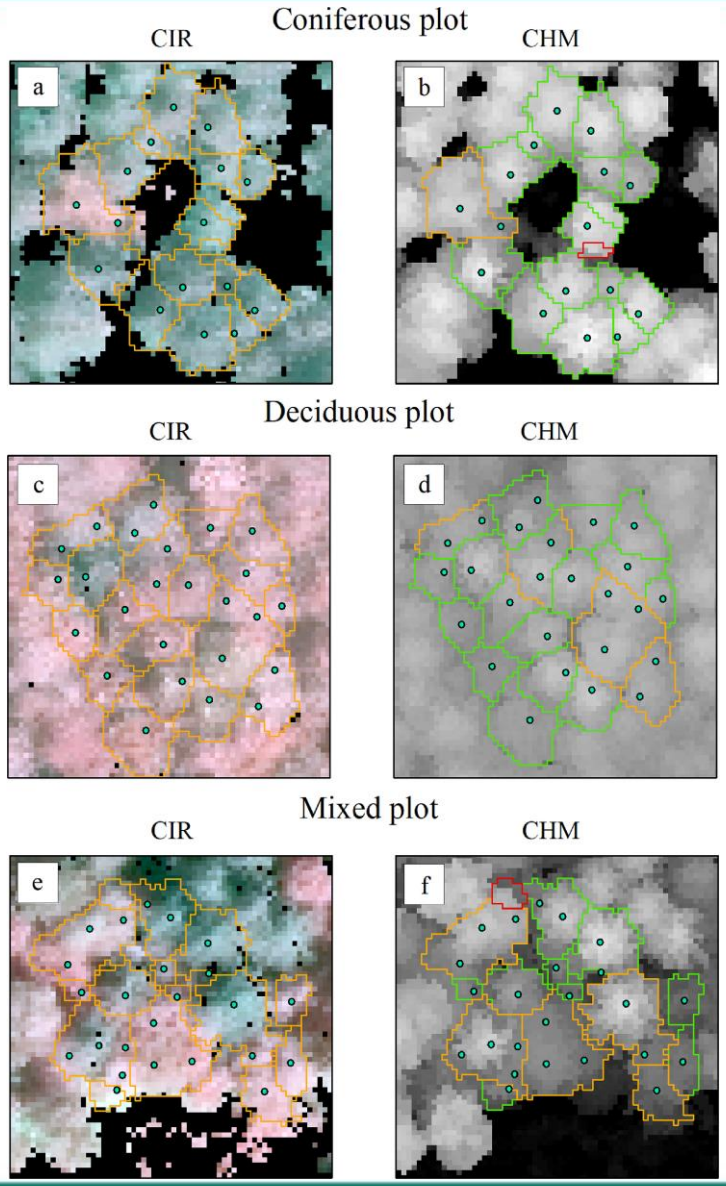
How it looks in the practice



Correct segmentation

Undersegmentation

Oversegmentation

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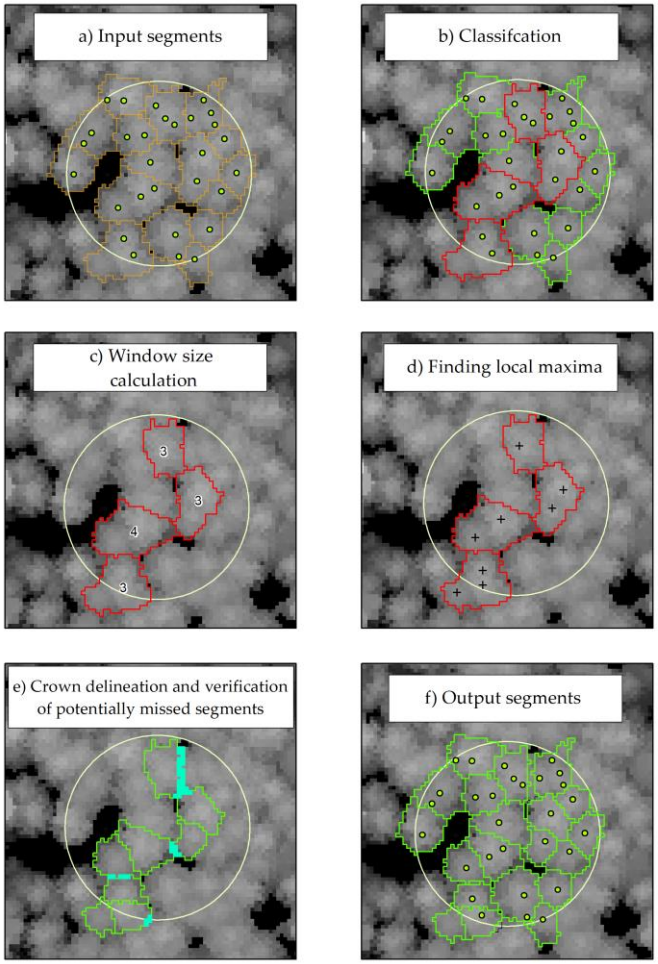
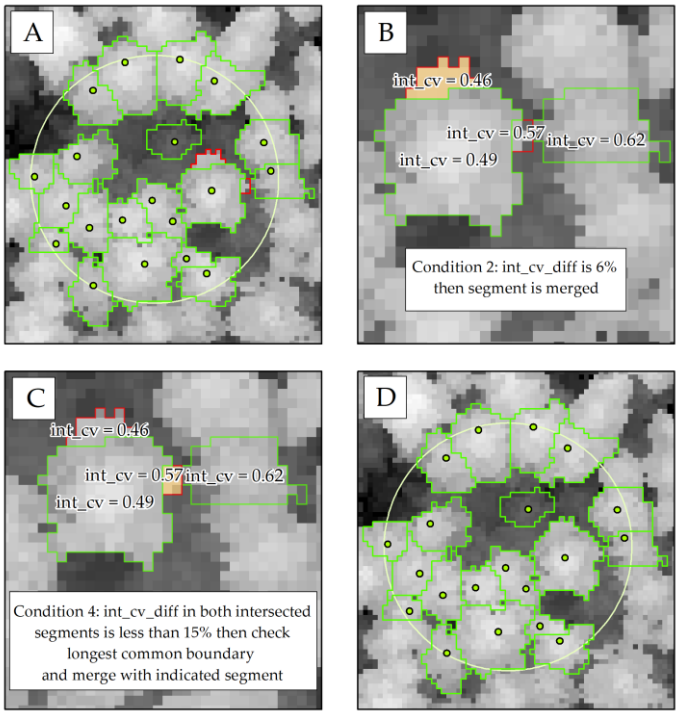
Correction method of CHM-based ITD

Undersegmentation errors refinement



Oversegmentation errors refinement



remote sensing

MDPI

Article

Correcting the Results of CHM-Based Individual Tree Detection Algorithms to Improve Their Accuracy and Reliability

Maciej Lisiewicz *, Agnieszka Kamińska, Bartłomiej Kraszewski and Krzysztof Stereńczak

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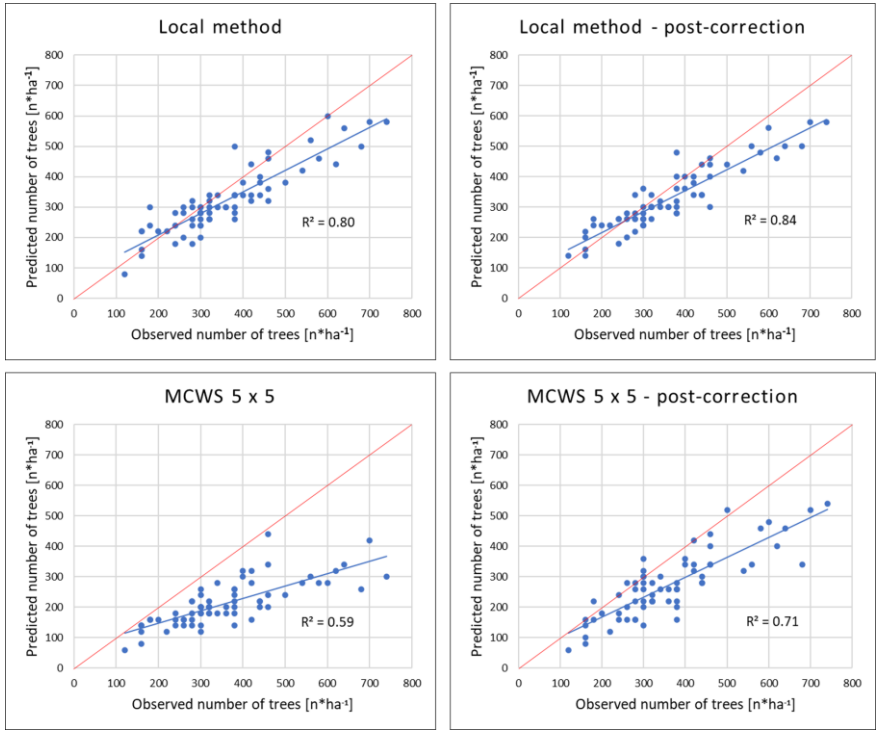
Correction method of CHM-based ITD

- The correction method allows refinement of many segmentation errors
- Method improves the performance of ITD methods in estimating stand parameters
- Correction method is most efficient for mixed stands, for which the lowest segmentation accuracy is initially obtained
- A shortcoming in the context of image data only: method requires ALS point cloud



SYLWAN 166 (6): 362-377, June 2022
https://doi.org/10.26202/sylwan.2022040
Journal homepage: https://sylwan-journal.pl

ORIGINAL PAPER

Influence of the correction method of CHM-based Individual Tree Detection results on the estimation of forest stand characteristics

Maciej Lisiewicz✉, Agnieszka Kamińska, Krzysztof Stereńczak

Department of Geomatics, Forest Research Institute, Sękocin Stary, Braci Leśnej 3 Street, 05-090 Raszyn, Poland

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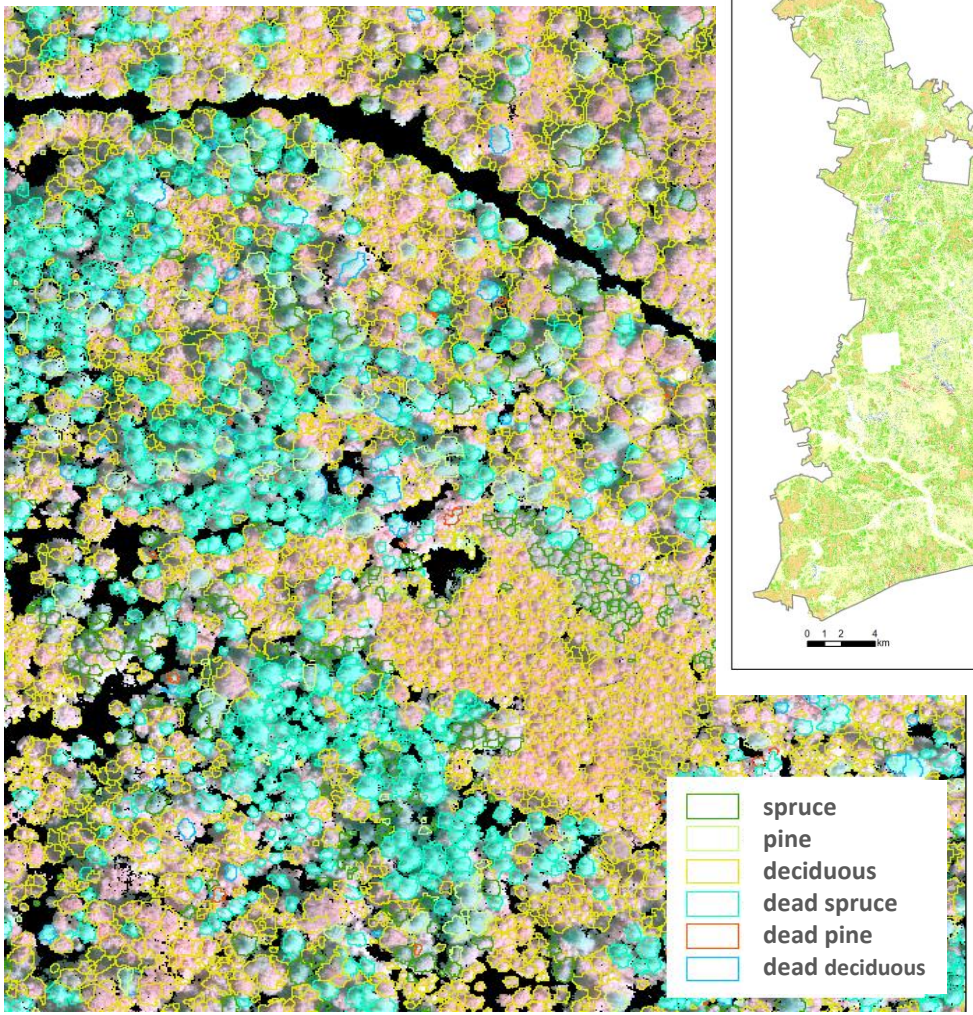
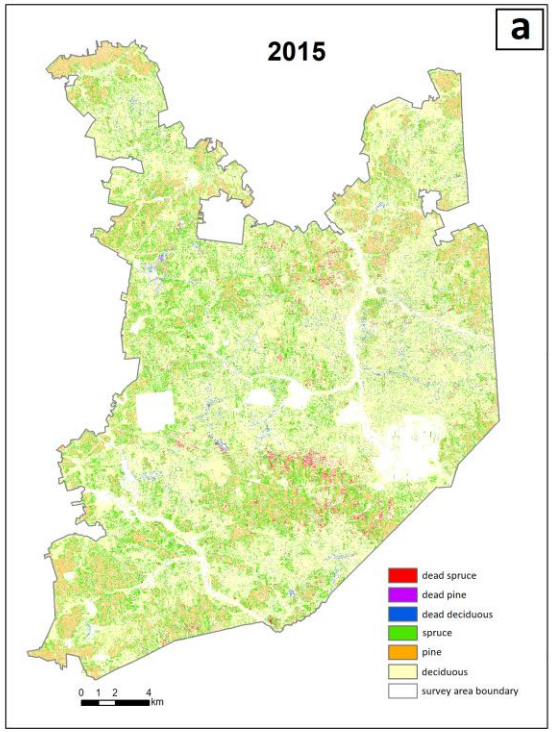
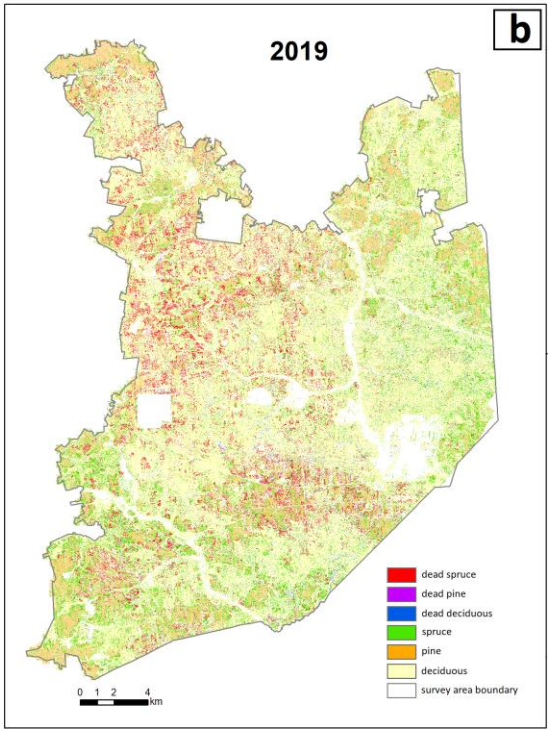
Species composition - ALS







Remote Sensing of Environment 219 (2018) 31–43

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Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

Species-related single dead tree detection using multi-temporal ALS data and CIR imagery

Agnieszka Kamińska, Maciej Lisiewicz, Krzysztof Stereńczak*, Bartłomiej Kraszewski, Rafał Sadkowski

Laboratory of Geomatics, Forest Research Institute, Sekocin Stary, 3 Braci Leśnej Street, 05-090 Raszyn, Poland

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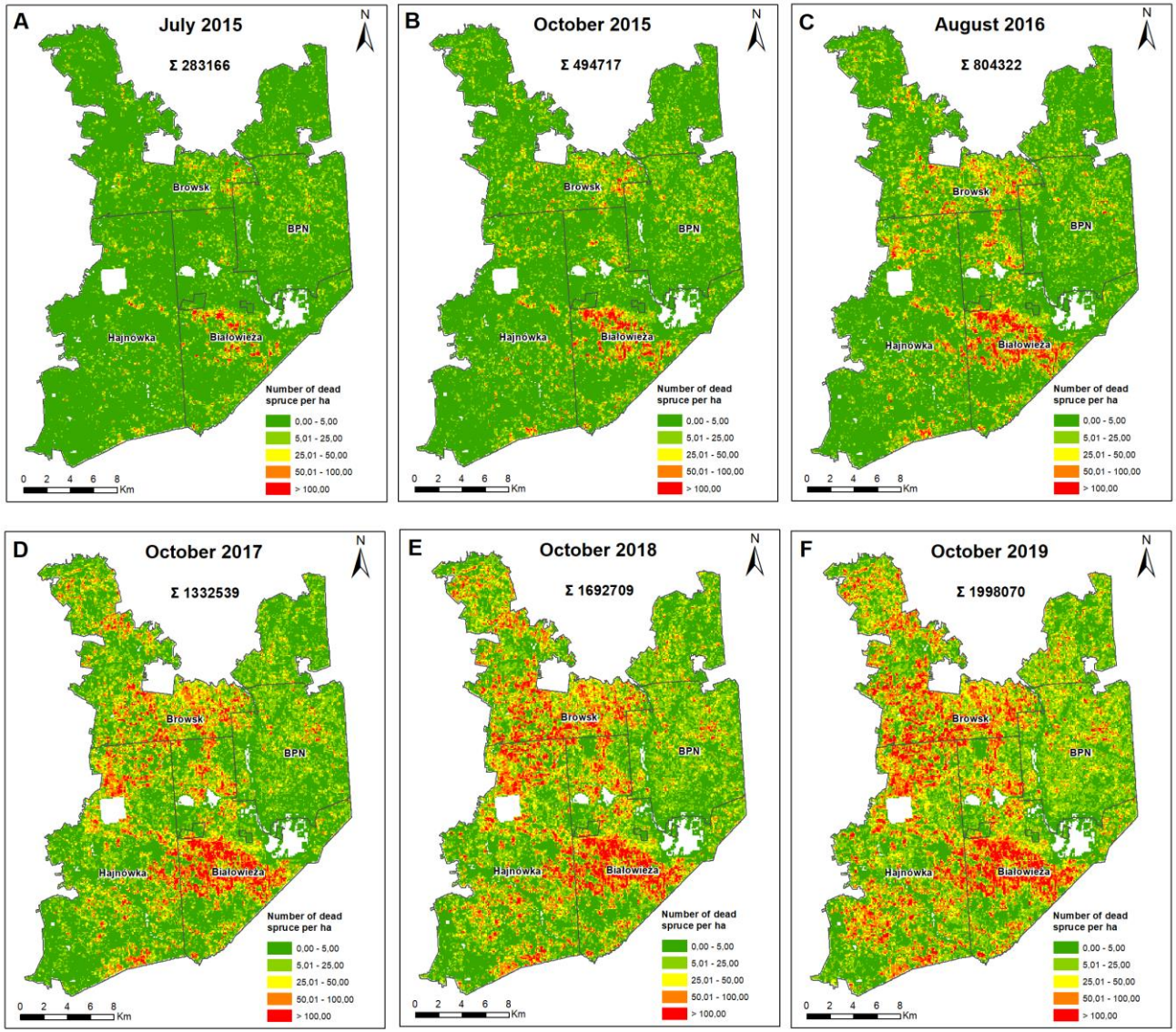
The dynamics of spruce dieback in 2015-2019



- Stereńczak et al. 2019, doi: 10.1016/j.foreco.2019.03.064
- Kamińska et al. 2020, doi: 10.1016/j.foreco.2020.118432
- Stereńczak et al. 2020, doi: 10.1016/j.foreco.2019.117826
- Kamińska et al. 2021, doi: 10.1016/j.foreco.2021.119530

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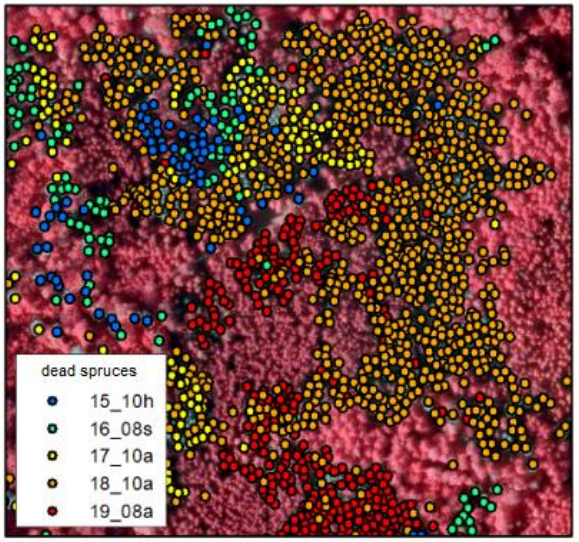
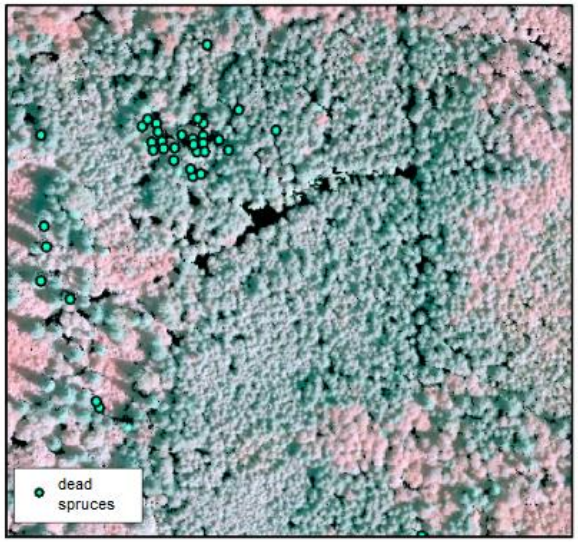
ALS vs MS data

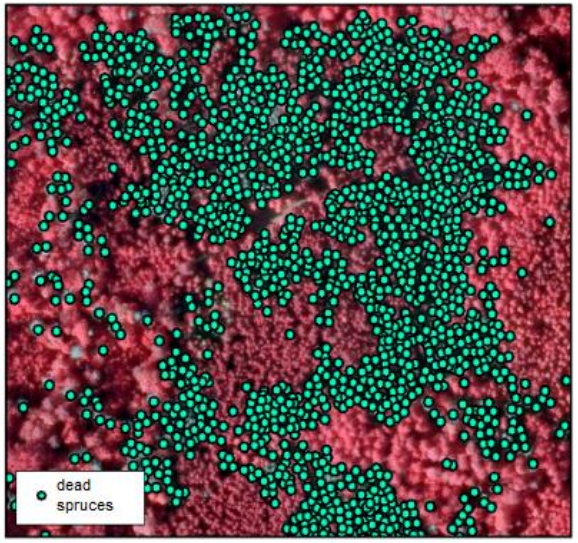
Incremental layer



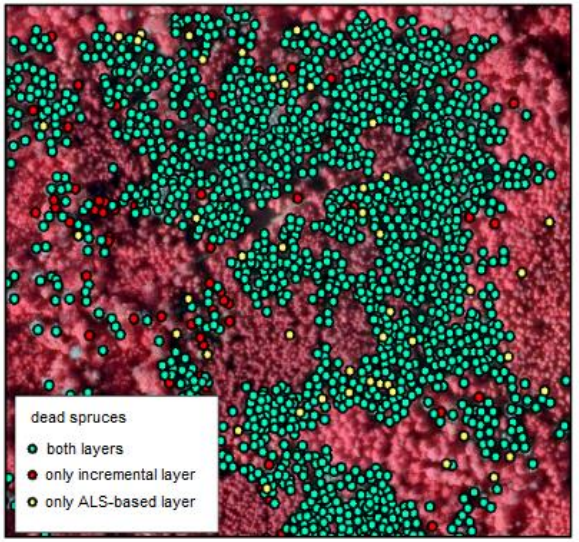
Initial layer



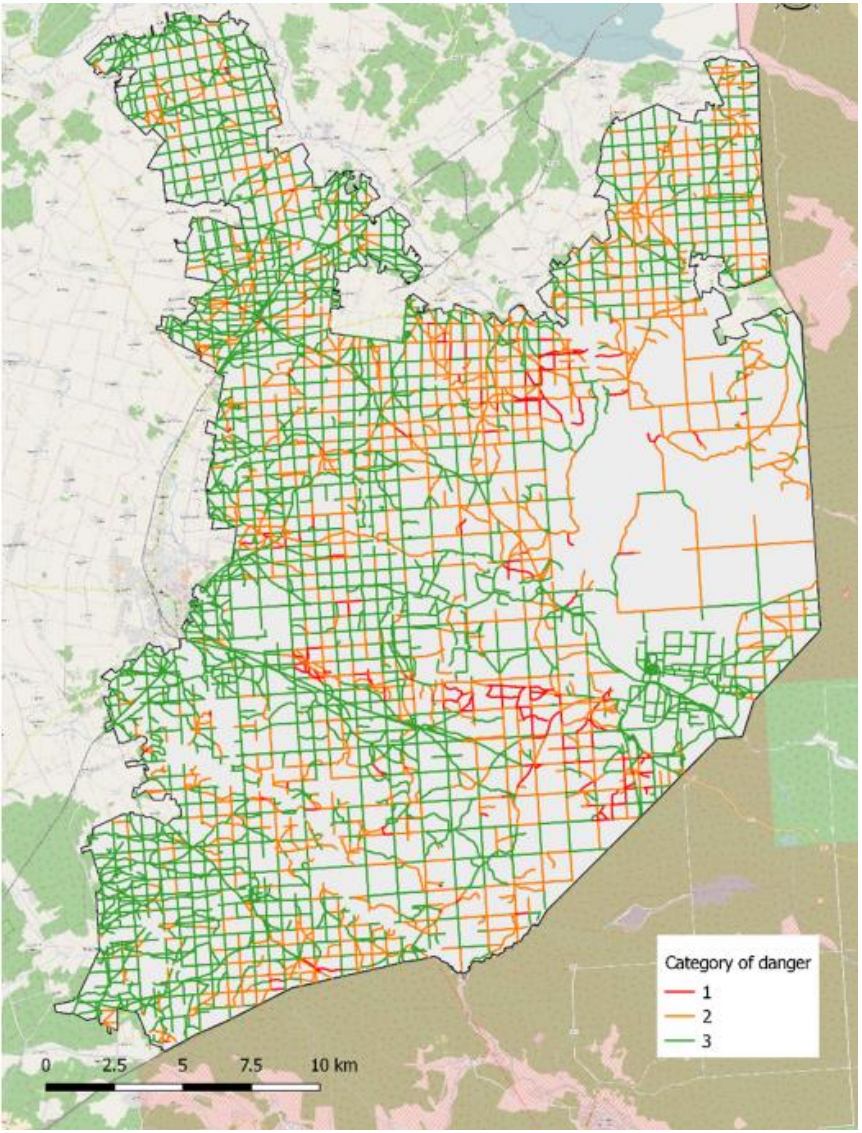
ALS-based layer

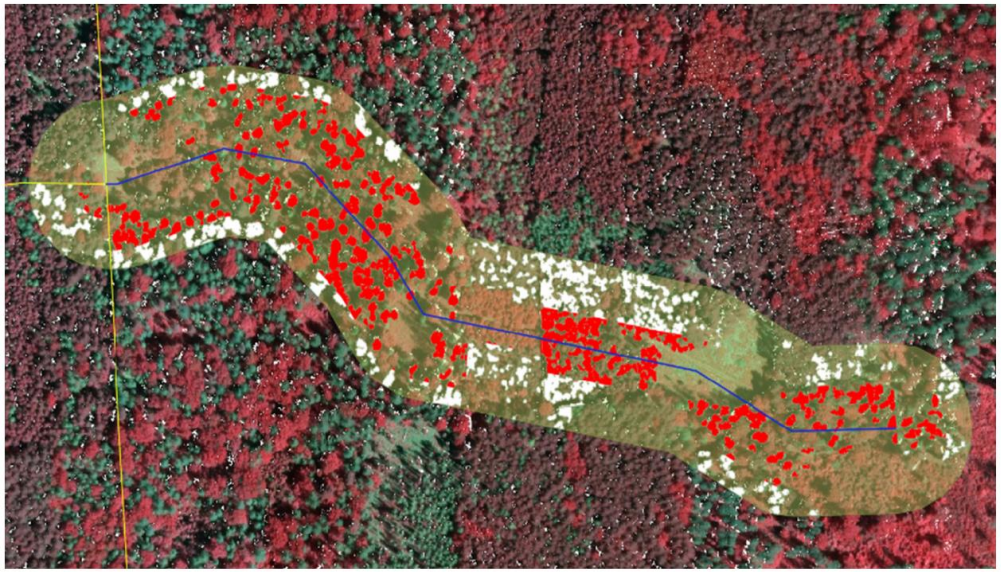


Comparison of resulting layers



Example of application





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Inventory of standing dead trees in the surroundings of communication routes – The contribution of remote sensing to potential risk assessments

Krzysztof Stereńczak *, Bartłomiej Kraszewski, Miłosz Mielcarek, Żaneta Piasecka

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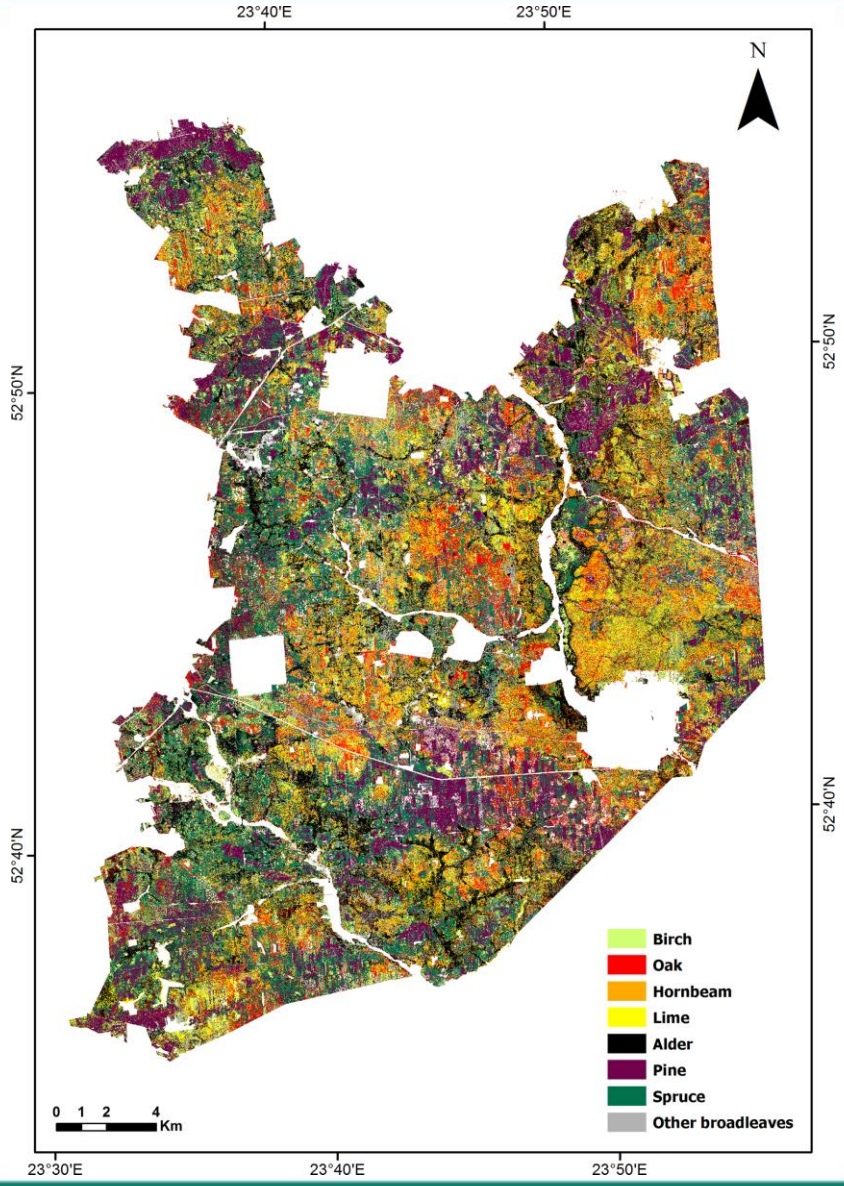
Tree species classification – hyperspectral data



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Int J Appl Earth Obs Geoinformation

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Tree species identification within an extensive forest area with diverse management regimes using airborne hyperspectral data

Aneta Modzelewska[a,*], Fabian Ewald Fassnacht[b], Krzysztof Stereńczak[a]

[a] Department of Geomatics, Forest Research Institute, Sękocin Stary, Braci Leśnej 3 Street, 05-090, Raszyn, Poland
[b] Institute of Geography and Geoecology, Karlsruhe Institute of Technology, Kaiserstraße 12, 76131, Karlsruhe, Germany

Forestry An International Journal of Forest Research

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Forestry 2021; 1–13, doi:10.1093/forestry/cpaa048

Multitemporal hyperspectral tree species classification in the Białowieża Forest World Heritage site

Aneta Modzelewska[1], Agnieszka Kamińska[1], Fabian Ewald Fassnacht[2] and Krzysztof Stereńczak[1]

[1]Department of Geomatics, Forest Research Institute, Sękocin Stary, Braci Leśnej 3 Street, 05-090 Raszyn, Poland
[2]Department of Geography and Geoecology, Karlsruhe Institute of Technology, Kaiserstraße 12 76131 Karlsruhe, Germany

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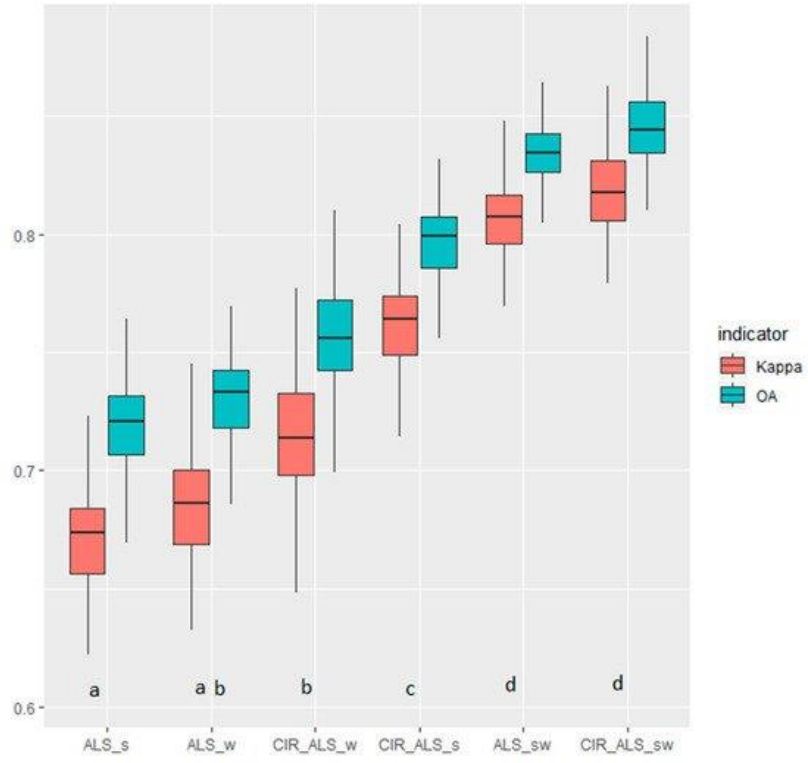
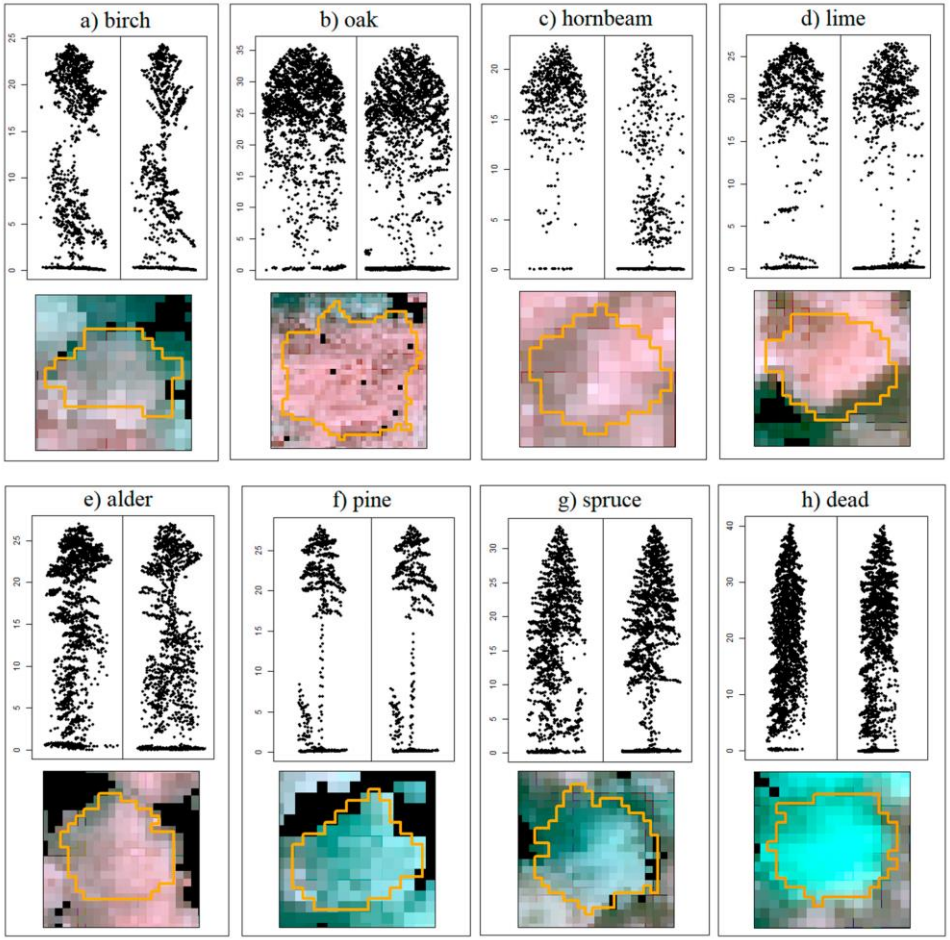
Multi-temporal ALS (leaf on and leaf-off) + CIR imagery





remote sensing

MDPI

Article

Single Tree Classification Using Multi-Temporal ALS Data and CIR Imagery in Mixed Old-Growth Forest in Poland

Agnieszka Kamińska *, Maciej Lisiewicz and Krzysztof Stereńczak

Department of Geomatics, Forest Research Institute, Sękocin Stary, 3 Braci Leśnej Street, 05-090 Raszyn, Poland; m.lisiewicz@ibles.waw.pl (M.L.); k.sterenczak@ibles.waw.pl (K.S.)
* Correspondence: a.kaminska@ibles.waw.pl

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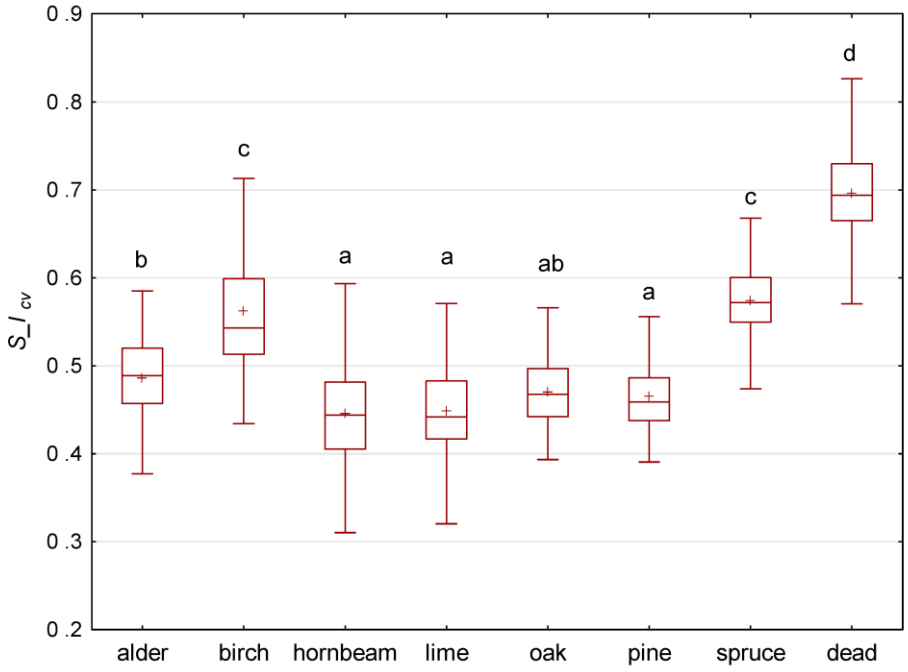
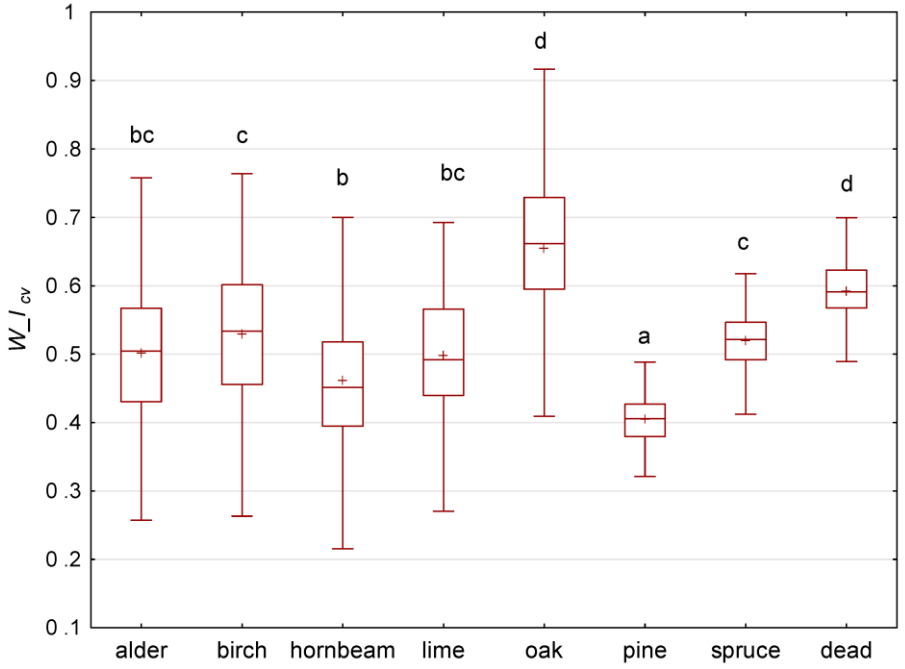
ALS leaf-on vs leaf-off metrics





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ALS leaf-on vs leaf-off metrics

F1-scores of the classification results for different sets of features

	Birch	Alder	Oak	Hornbeam	Lime	Pine	Spruce	Dead
ALS_S	0.51	0.69	0.58	0.67	0.51	0.84	0.83	0.88
CIR_ALS_S	0.80	0.74	0.59	0.68	0.53	0.93	0.92	0.98
ALS_W	0.53	0.67	0.68	0.39	0.34	0.95	0.94	0.94
CIR_ALS_W	0.58	0.69	0.76	0.40	0.37	0.95	0.95	0.98
ALS_{SW}	0.86	0.78	0.72	0.66	0.53	0.96	0.95	0.96
CIR_ALS_{SW}	0.87	0.78	0.75	0.68	0.55	0.96	0.96	0.98

s – leaf-on, w – leaf-off

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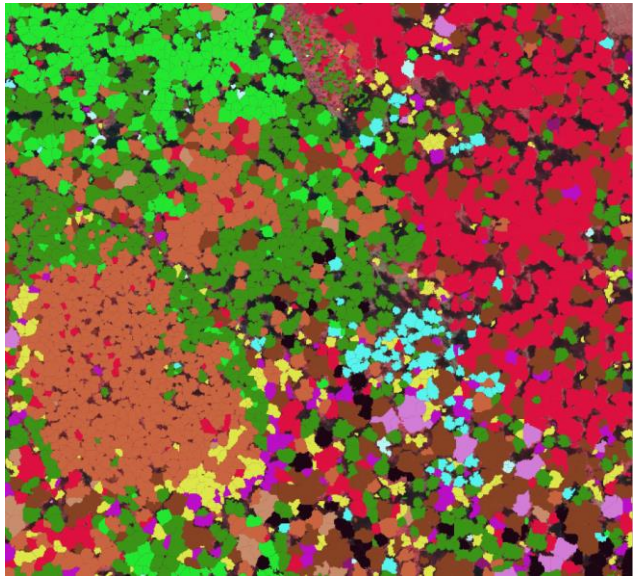
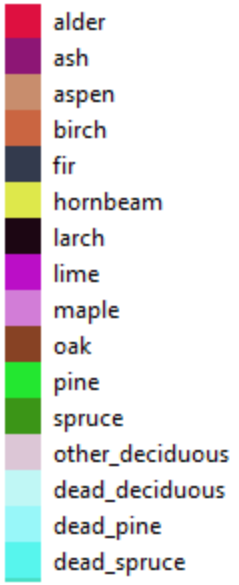
Work in progress - maximum ALS data exploration

- Further exploration of the potential for multi-temporal ALS
- Additional field surveys for rare species
- Classification into 16 classes
- Implementation of the method throughout the research area (time consuming)





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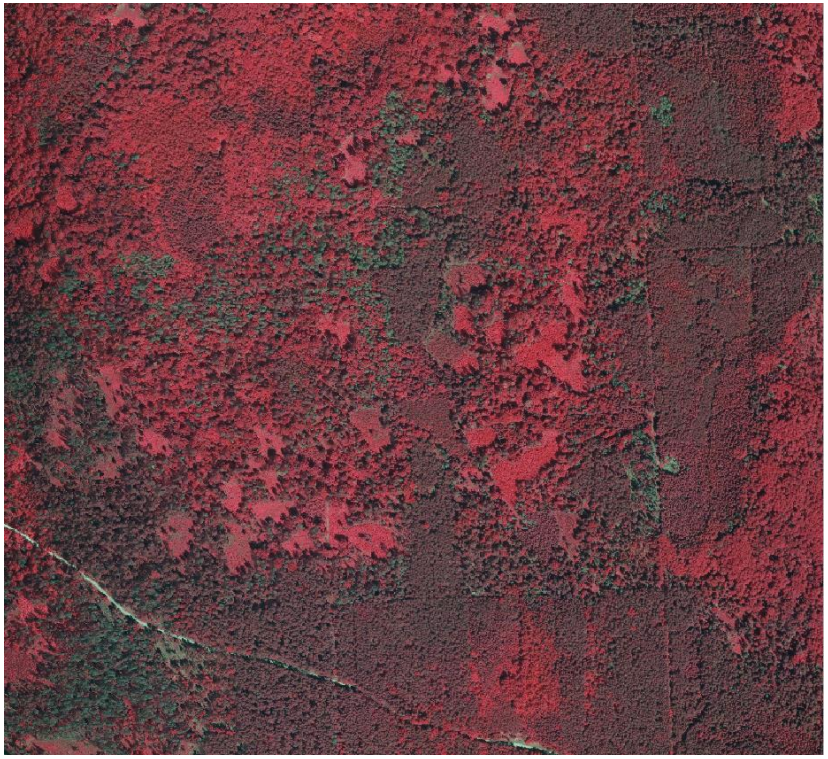
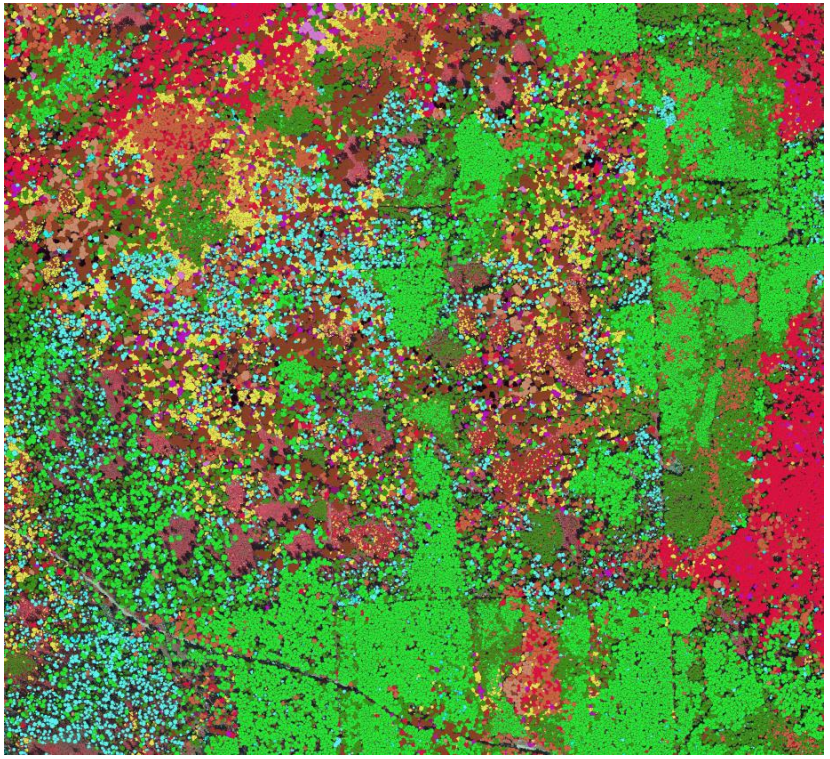
Maximum ALS data exploration





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Preliminary results

Species	Field measurements	Classification
alder	17,0	19,3
ash	0,8	0,8
aspen	1,2	0,9
birch	8,5	11,0
fir	0,0	0,1
hornbeam	15,4	14,9
larch	0,0	0,2
lime	6,0	2,6
maple	1,0	0,5
oak	5,6	7,1
pine	16,0	17,9
spruce	25,2	20,1
other_deciduous	0,5	0,0
dead_deciduous	0,9	2,6
dead_pine	0,3	0,3
dead_spruce	1,6	1,6

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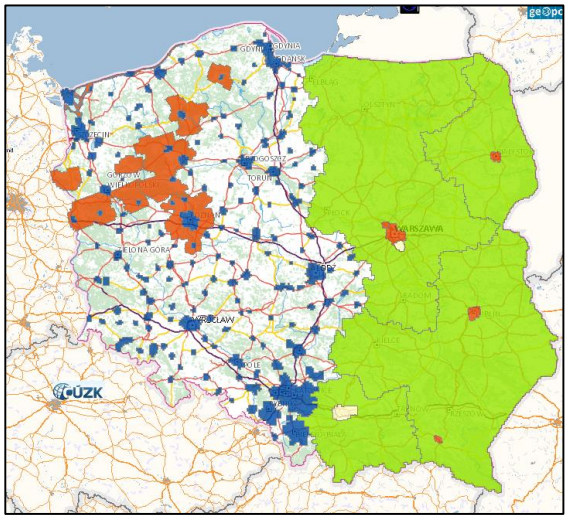
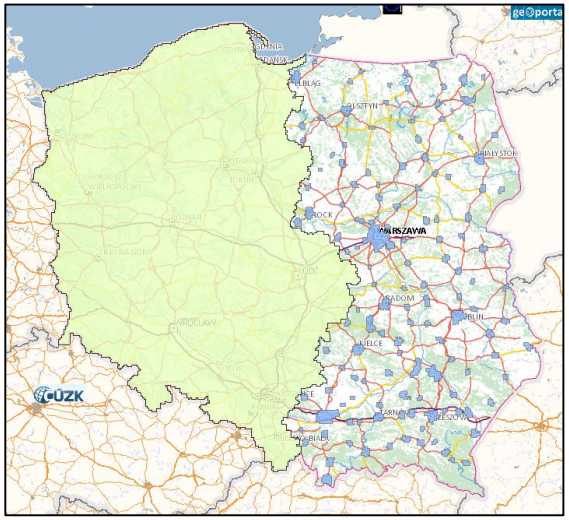
Outlook for the near future

- Open access to country-wide data
- Plan to acquire orthophotos every 2 years and ALS every 5 years
- Possibility to integrate with satellite data
- A detailed tree species map of the whole country?

2022 - ortophotos



2023 plans - ortophotos



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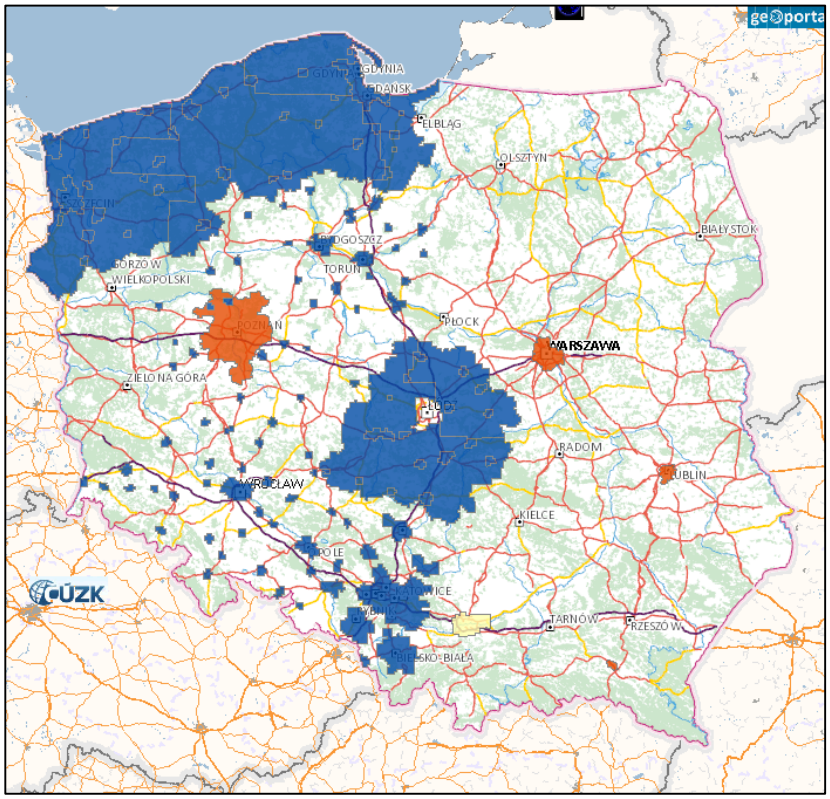
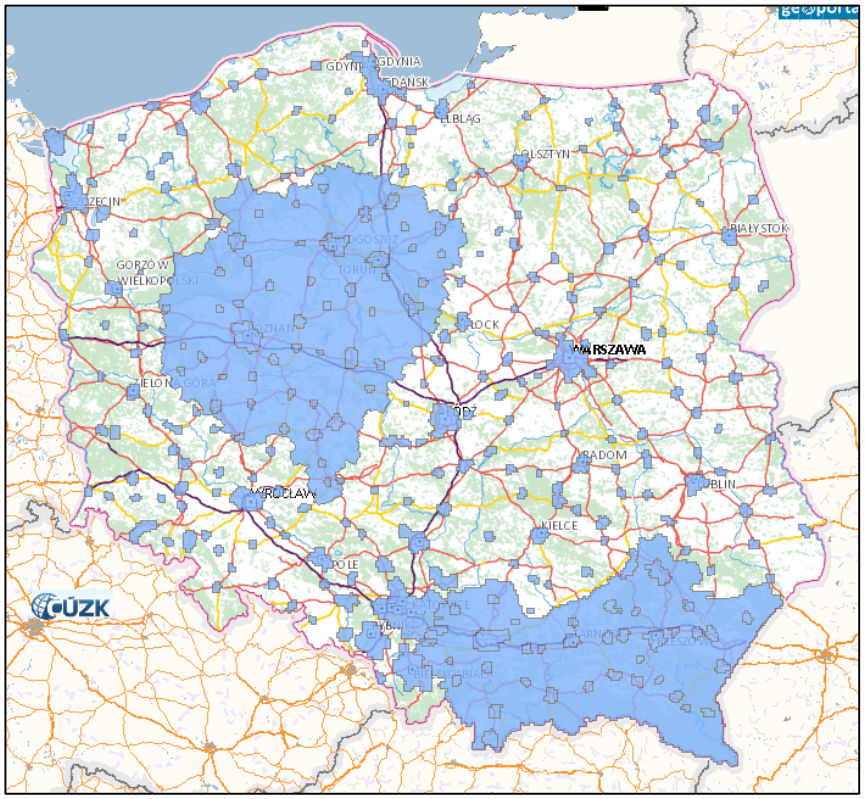
Outlook for the near future

2022 – ALS



2023 and 2024 plans - ALS



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Conclusions

- Multi-temporal RS data brings huge benefits in species classification, especially in temperate forests
- The developed ITD method and correction method can be locally calibrated, therefore it can be used in the analysis of other stands
- Multi-temporal analyses provide large-scale detailed information on the number of dead trees and allow spatial analyses of the outbreaks
- The method of predicting forest stand characteristics based on ALS is currently being introduced in the Polish state forests
- We believe that we can already significantly support Forest Management Plans performed every 10 years using available remote sensing data

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Other projects carried out by our department

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Thank you for your attention!

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