

# Forest change detection and monitoring using passive and active remote sensing data (RS4FOR project)

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Institute of Geography and Spatial Management  
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6th Meeting of the Carpathian Convention Working Group on Sustainable Forest Management  
Workshop on balancing bioenergy production and sustainable forest management in Mountains Areas  
Sopron 2017

# Institute Geography and Spatial Management Jagiellonian University

- **Jagiellonian University**  
(founded in Kraków in 1364)
- **Institute of Geography and Spatial Management**  
(founded at the JU in 1849)
  - about 60 researchers
  - human and physical geography, spatial planning and management, GIS&T
  - PhD, MSc BSc students
- **our lab.** (since 2016)
  - GIS&T (e.g. remote sensing, spatial explicit analysis and modelling)
  - application: e.g. forestry, land cover/land use reconstruction and projection, habitat and landscape analysis and modeling, ...



# RS4FOR project – general information

**Implementation period:** 42 months; 2016-2019

**Funding scheme:** National Science Centre Poland – OPUS10 call

„OPUS program” - funding opportunity intended for a wide range of applicants, awarded on the basis of the following criteria:

- proposals form within NCN Panels, involving basic research,
- scientific excellence and the innovative nature of the research project,
- the research portfolio of the Principal Investigator,
- impact on the development of the research discipline,
- justification of the planned costs.



# RS4FOR project – assumptions and expected outcome

RS4FOR project assumption is to test and develop approaches which allow to improve forest cover change detection and monitoring using different types of remote sensing data (optical and radar data, LiDAR); Focus on **Sentinel and Landsat programs**

remote sensing (increasing availability of remotely acquired datasets )

large sets of ground-true data

## Detection and monitoring:

- forest cover types and its changes,
  - forest structure characteristics,
  - tree-stand disturbances (forest health),
  - forest above- and below-ground biomass
- over large areas**

## Outcome of the RS4FOR project:

- set of algorithms, products and metrics for the combine use of optical, radar and lidar data in accurate spatial and temporal forest cover change detection and monitoring at landscape level.

# RS4FOR project – objectives

- **Objective 1:** To develop approaches to incorporate Sentinel 1 and 2 data and LiDAR data into long-term Landsat time series for better **detection and monitoring of forest cover and its change**
- **Objective 2:** To derive and evaluate prediction models, for variety of **forest structure variables and their change (biomass and species composition)**, from Landsat time series, Sentinel 1 time series, Sentinel 2 time series, and LiDAR data and combination of these data series (multi- and inter-year approaches)
- **Objective 3:** To determine the capacity of Landsat time series, Sentinel 1 time series, Sentinel 2 time series, and LiDAR data and combination of these data to map **forest health** (multi- and inter-year approaches)
- **Objective 4:** To conduct an accuracy assessment and evaluate the strength of the developed approaches their potential for operational use in the future studies related to **carbon balance, biodiversity and landscape change assessment**
- **Objective 5:** In addition, the objective of this project is also to assess forest cover conversion and modification in a test area (**the Polish Carpathians**) with a particular focus on **species composition, aboveground tree biomass and forest health change**





**Katarzyna Ostapowicz, PI**



**Anna Zielonka, PhD student**

## **RS4FOR team**



**Ewa Grabska, PhD student**



**Katarzyna Staszyńska, postdoc**

# RS4FOR project team



**Katarzyna Ostapowicz, PI**

## ✓ education background:

PhD in the Earth Science within the Geography (GIS&T spec.),  
Institute of Geography and Spatial Management,  
Faculty of Biology and Earth Science,  
Jagiellonian University, Krakow, Poland

## ✓ research interest:

- Earth Observations (EO) and remote sensing technologies
- spatial explicit analysis and modeling
- land use and land cover change detection, reconstruction and projection
- biodiversity assessment, in particular habitat and landscape fragmentation and connectivity analysis and modeling
- GIS&T education



# RS4FOR project team



Katarzyna Staszyńska, postdoc

## ✓ education background:

PhD in the Forestry Science within the Forest Botany and Nature Conservation,  
Institute of Forest Biodiversity, Forest Faculty, Agriculture University, Krakow (Poland)

## ✓ research interest:

- species and structural diversity of mountain tree-stands, changes in the tree-stands structure
- forest ecosystems conservation and monitoring
- importance of the Natura 2000 network for the conservation of the forest habitats
- application of GIS technology in monitoring of the state and diversity of mountain forests



# RS4FOR project team



**Ewa Grabska, PhD student**

## ✓ education background:

MSc in Geography (GIS&T),  
Institute of Geography and Spatial Management, Jagiellonian  
University, Krakow, Poland

## ✓ research interests:

- satellite image processing and analysis
- fusion of optical and radar imagery, classification algorithms
- Earth observation, vegetation classification
- land cover change detection with focus on forests and croplands

# RS4FOR project team



**Anna Zielonka, PhD student**

## ✓ education background:

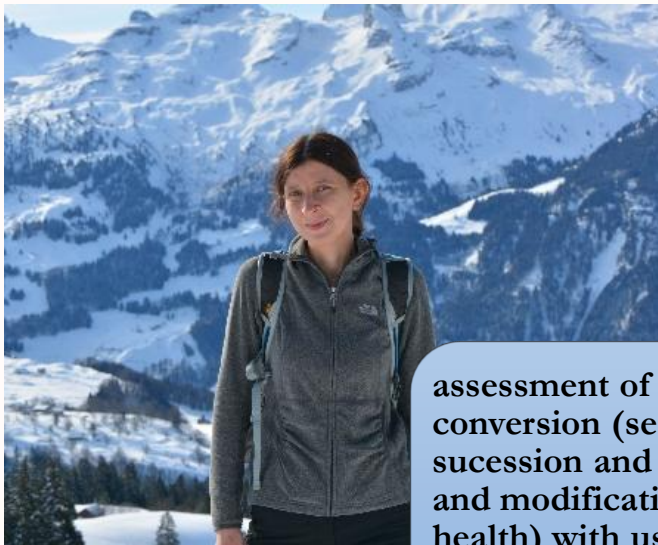
MSc in Geography (geomorphology)

Institute of Geography and Spatial Management, Jagiellonian University, Krakow, Poland

## ✓ research interest:

- functioning of mountain environments, especially in the context of morphogenetic processes and land cover changes
- polar regions functioning and changes as a climate warming effect,
- biomass and carbon estimation from fused remote sensing data and field data collection





Katarzyna Ostapo

assessment of forest conversion (secondary succession and disturbances) and modification (e.g. forest health) with use of dense time series of satellite images



Monika, PhD student

estimation of total forest biomass using various types of RS data (Sentinel 1, 2 and LiDAR)

#### RS4FOR aims

use of remote sensing data in forest characteristics (forest stands species composition, age, condition)

detecting ecologically fragile forests in mountain areas using results of analysis remote and based-ground data



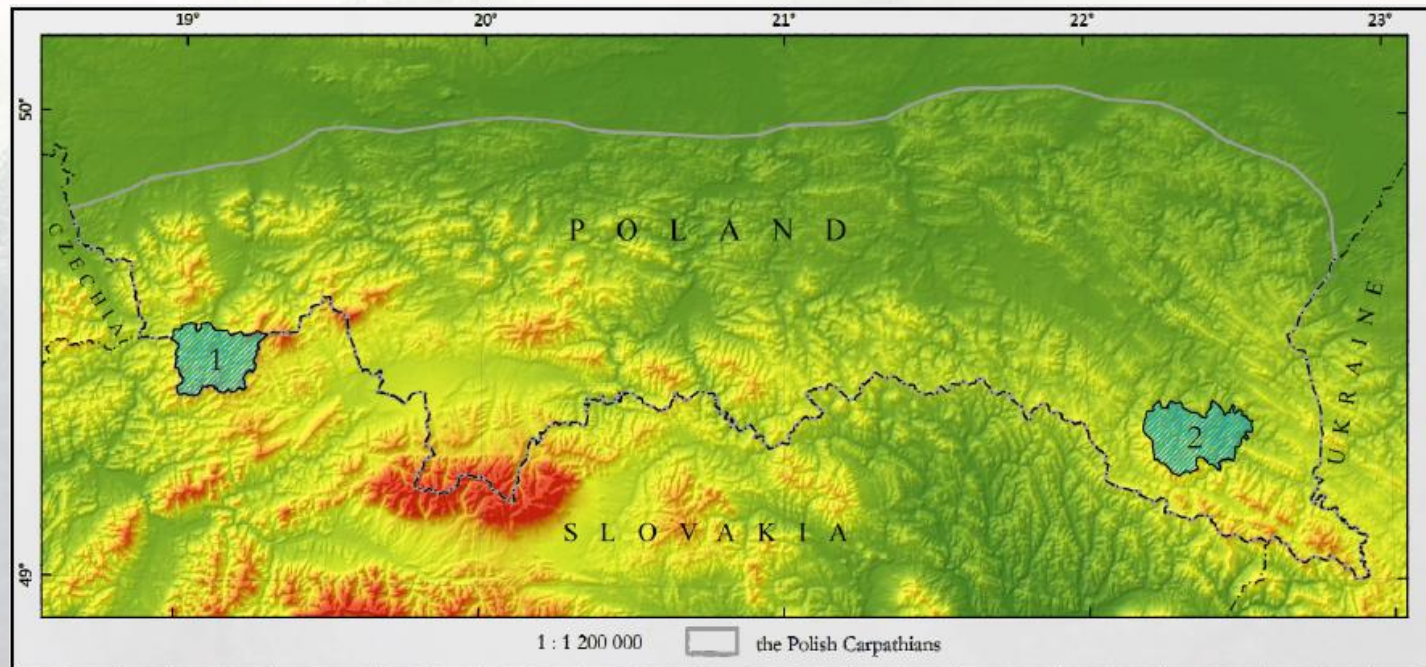
Ewa Grabska, PhD student



Katarzyna Staszyńska, scientific assistant

# RS4FOR project – area of interest

- ✓ temperate forest in the Polish Carpathians
- ✓ two test sites – Ujsoly and Baligród forest districts (sub-study area 1 and 2)






# RS4FOR project – data and forest characteristics

## Different types of remote sensing data:

- optical data (satellite imagery): Landsat 4, 5, 7, 8 (data time series from 1985 to 2017) and Sentinel 2 (data time series from 2015-17)
- radar data: Sentinel 1 (data time series from 2014-17),
- data from airborne laser scanning (ALS) (2013, project ISOK)

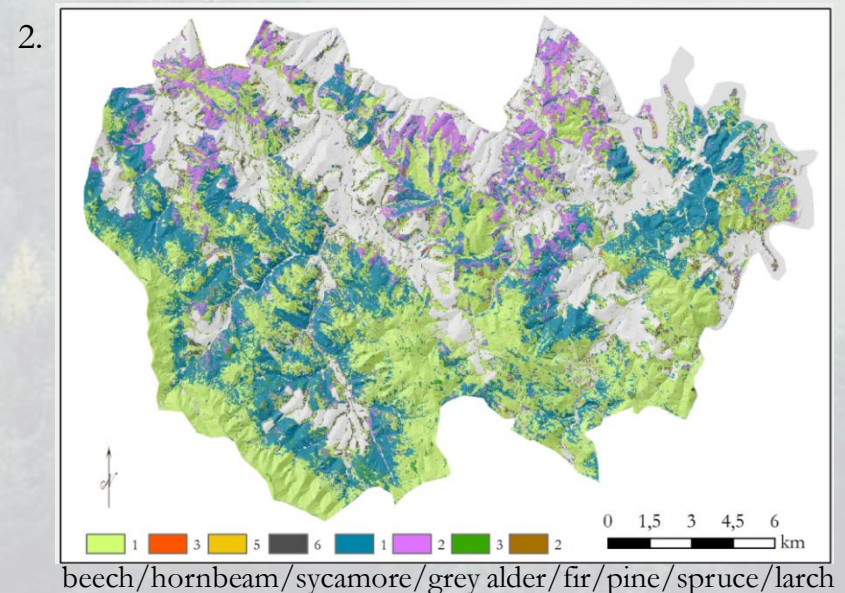
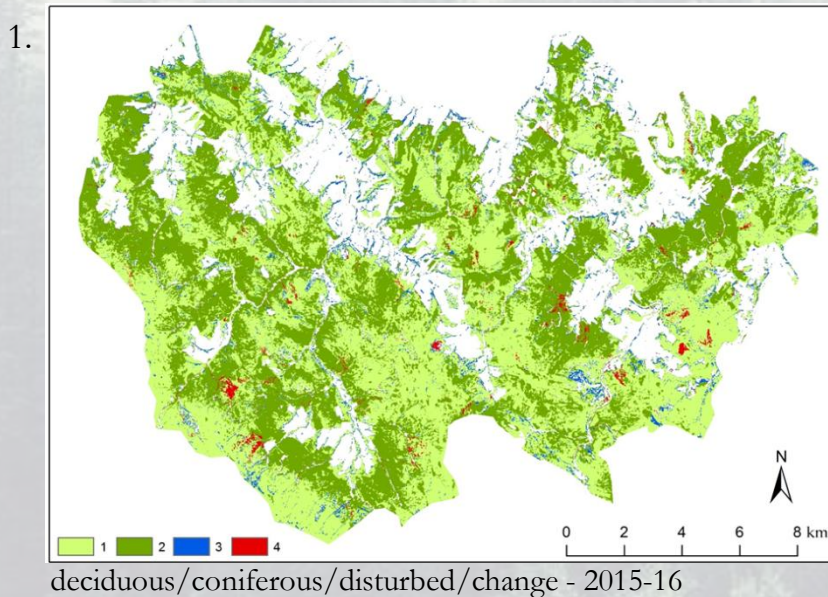
## Reference data:

- Forest Data Bank (2015-16)
- National Forest Inventory Data (cycle I & II, 2006-2009, 2010-2014)
- field measures (30 locations in the Polish Carpathians precise tracking of sample plots)
- soil research
- terrestrial laser scanning

- 
- 1) tree-stands characteristics as: composition, presence of rare tree species, forest disturbances (condition)
  - 2) forest above- and belowground biomass estimating
  - 3) deadwood biomass
  - 4) tree-stands dimensional structure diversity
  - 5) trajectories of forest cover change (disturbances, defoliations)

# Use of remote sensing data in forest characteristics

- exploring the potential of Sentinel 2 data for detail characterization the forests environment (substantial both in forest management and scientific issues), in particular:
  - tree - stand composition
  - forest age
  - forest condition (disturbances)
- methodology: automatic classification using Random Forest algorithm using satellite imagery and reference data (ground-based collected data and terrestrial laser scanning )
- preliminary results (examples):
  - Forest types and the occurrence of disturbed forests in Baligród F.D.
  - Species classification in the Baligród F.D.

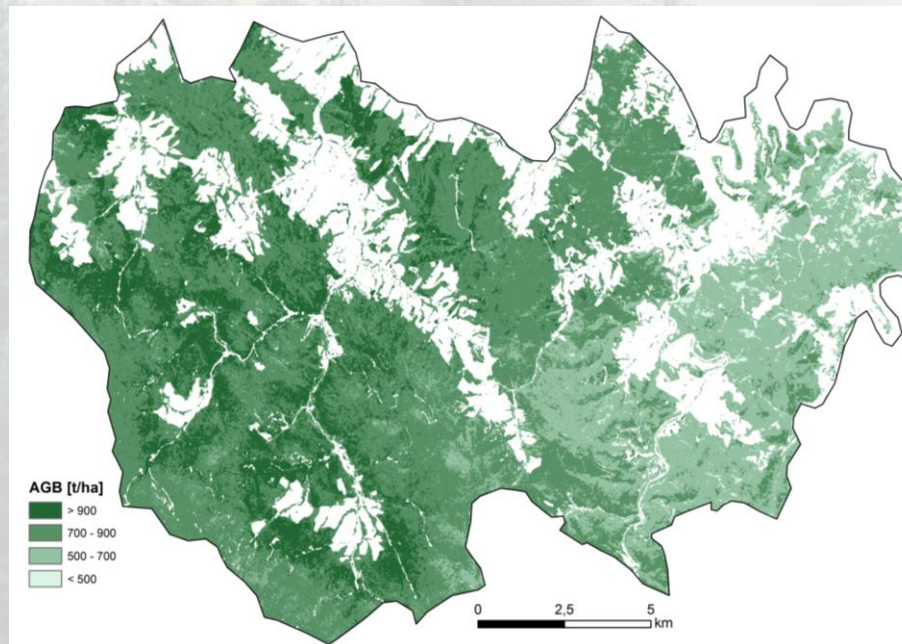




# Use of remote sensing data in biomass and carbon estimation from fused remote sensing data and field data collection

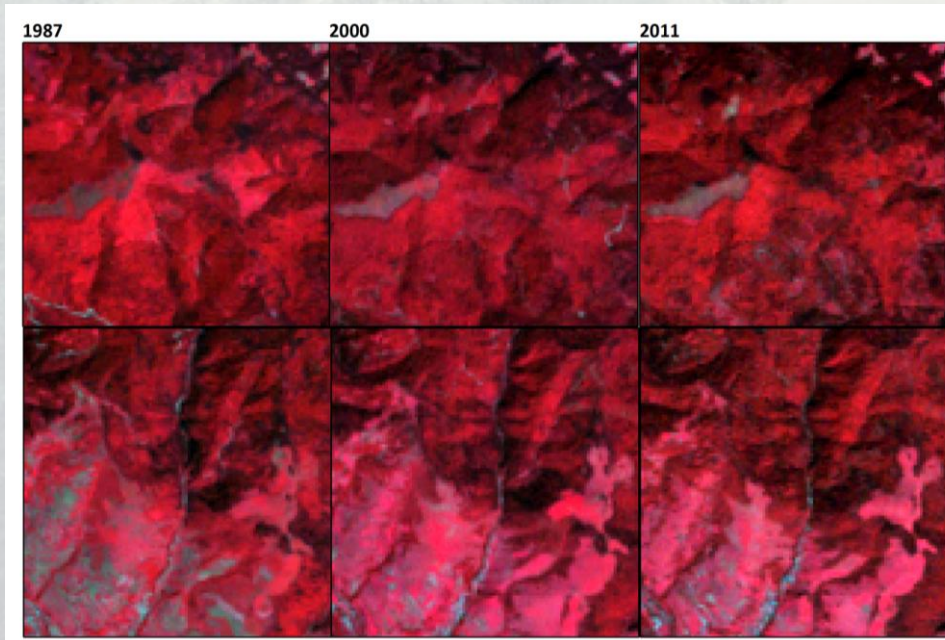
- remote sensing data (including LiDAR, optical and radar data) allow to estimate biomass for large areas with high spatial accuracy, what is important to understand global carbon cycle
- methodology: AGB estimation based on fusion Sentinel-1 and 2, Random Forest classification and allometry equations
- preliminary results of biomass and estimation (example): AGB map - Baligród F. D. test area (3)

3.

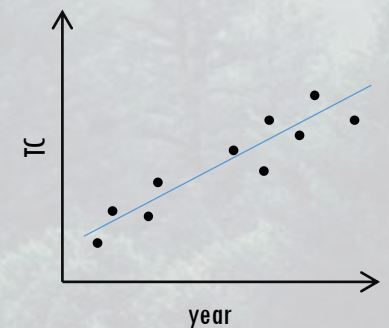
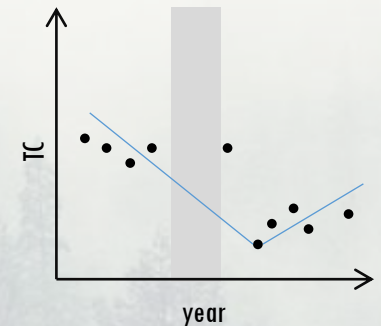


# Detection forest conversion and modification

- development of approaches focus on forest change detection with dense time series of Landsat and Sentinel 2 data
  - secondary succession
  - forest disturbances
  - defoliation
- methodology: dense time serie analysis/trajectories of forest conversion and modification
- preliminary results (examples):
  - secondary sucession on agriculture abandontment areas
  - forest disturbances
  - defoliations



[RGB bands: 4, 3, 2]





# Development of the methods of the ecologically fragile forest ecosystems identification using remote sensing data

## Assessment of the possibilities of using remote data for supporting forest function restoring activities.

### Identification of:

- **sensitive /ecologicaly fragile forest ecosystems**
  - virgin (old-growth) forests remnants of the natural ecosystems that occupied larger areas in the past
  - habitats sensitive to the effects of forest management or to the changes of environment factors (e.g. *Acer pseudoplatanus* communities or swamp and floodplain forest ecosystems)
  - small-area forest habitats of rare occurrence
- **potentially species-rich habitats detecting:**
  - structurally diversified tree-stand patches,
  - large-sized veteran old trees,
  - dead wood abundant forests,

- tree-stands composition and diversity

- above- and below-ground biomass estimation

- information on the vertical and horizontal structure of habitat

### Assessment of the possibilities of restoring the natural functions in degraded or disturbed forest analysing:

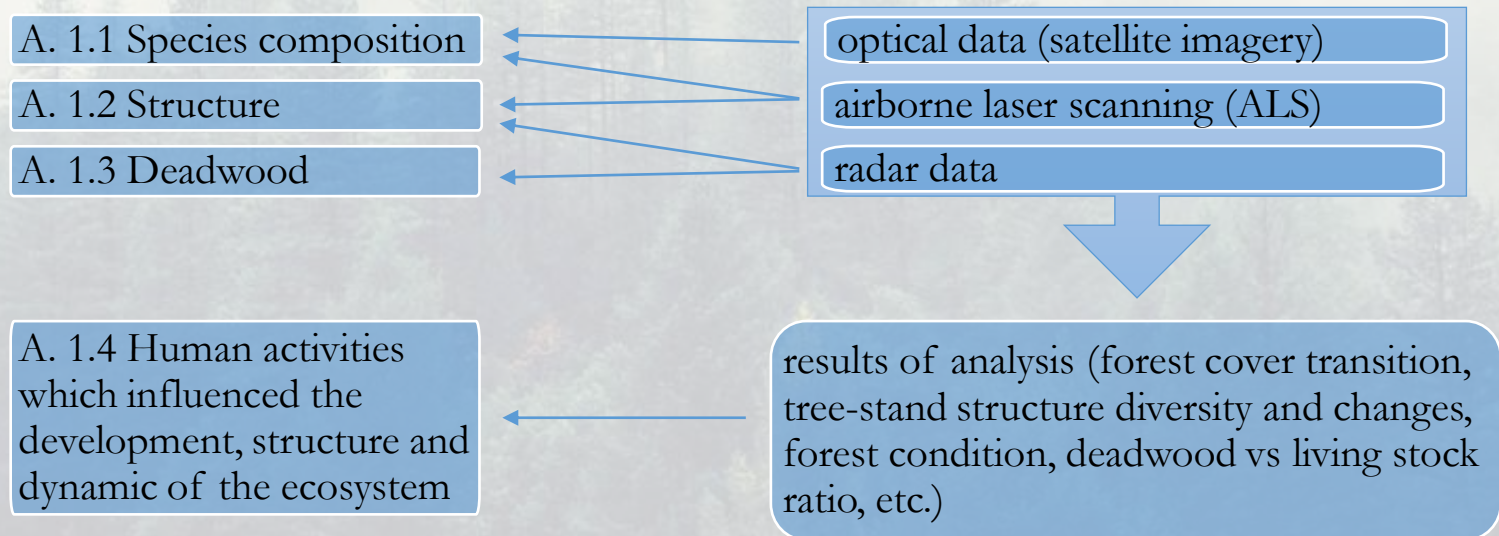
- the characteristics of canopy layer, understorey and litter,
- distance to the old-growth forest patches (possibilities of tree and understorey species seed dispersal)

# RS4FOR project for the Carpathian Convention Working Group on Sustainable Forest Management

According to the “Protocol on Sustainable Forest Management to the Framework Convention on the Protection and Sustainable Development of the Carpathians” “virgin forests” means natural forests, which:

- have not been influenced directly by human activities in their development
- are composed of tree species indigenous to the area with most of the principal characteristics and key elements of native ecosystems, such as complexity, structure and diversity

Due to identification of „virgin forests” particular criteria & indicators have been defined. Most of them are likely to have being identified in mountainous temperate forests with use of the remote sensing data and algorithms and methods obtained by the RS4FOR project





## Related projects in our lab.:

- **CON@SK.PL** project: Transboundary ecological connectivity – modelling landscapes and ecological flows (2017-2018; Visegrad Fund)
  - focus on the Northern Carpathians (Poland and Slovakia)
  - collaboration with SAS (PI), WSL, Humboldt University, PAS
  - more information: <http://www.geography.sav.sk/conskpl/index.php/>
- **LIM** project: Integration of categorical- and gradient-based approaches in landscape fragmentation and connectivity modelling using GIS&T (2012-2015; National Science Centre Poland)
  - focus on the Polish Carpathians and two species: brown bear and European bison
  - collaboration Humboldt University, Madison University, PAS
  - more information: <http://www.gis.geo.uj.edu.pl/LIMProject/index.html>

**In case of interest in the project or cooperation don't  
hesitate to contact us!**

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# Thank you for your attention!

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More information:  
<http://www.geo.uj.edu.pl/project/rs4for/index.php/pl/>

