Unlocking Troves of Data

Feature Extraction From Historical Print Maps Through an Object-Based Classification Approach

Capstone Peer Review Presentation

Delphine Khanna - GEOG 596A - May 6, 2019

Outline

- Background
- Goals
- Project Methodology
- Proposed Timeline
- Anticipated Results / Outcome
- Further developments

Background

1. Historical Geospatial Data

Historical geospatial data?

- GIS analysts are used to accessing geospatial datasets from multiple sources
- However, most of that data is relatively recent, from the last 20 to 30 years
- What happens when someone needs access to older historical data?

Why historical data?

There might be different reasons for needing to use geospatial data from previous historical periods:

- Researcher studying a past phenomenon, or interested in the evolution of specific geographic features over time (Madry, 2006)
- Increasingly, as input for computational models and machine learning algorithms (Bidney & Piekielek, 2018)

Historical print maps

- Historical print maps are a great source of data about the past:
  - Related to topography, land cover, urban development, human demographics, environmental dynamics, and more
  - They represent facts from the 18th to 20th century, or even earlier
- However, that data is locked on paper and cannot be leveraged easily in GIS systems

Background

2. Feature Extraction

Feature extraction from historical print maps

- Traditionally: manual feature extraction
  - Digitize the features of interest using digitization tablets or heads-up digitization techniques (Bolstad, 2016)
  - It works, but very expensive and slow

- Automated or semi-automated feature extraction
  - Research in that field for the last 15 years
  - Different approaches have been proposed

Different methods of automation

- First: scan, georeference, crop, pre-process

- Pixel-level classification
- Template-based
- Machine-learning
- Object-Based Image Analysis (OBIA)

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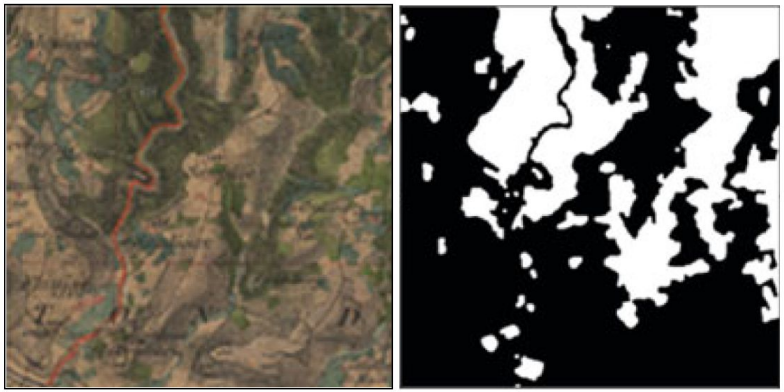

Extracting forested areas from a 19th century map (Herrault et al, 2013).

Good for hue-based areal symbologies.

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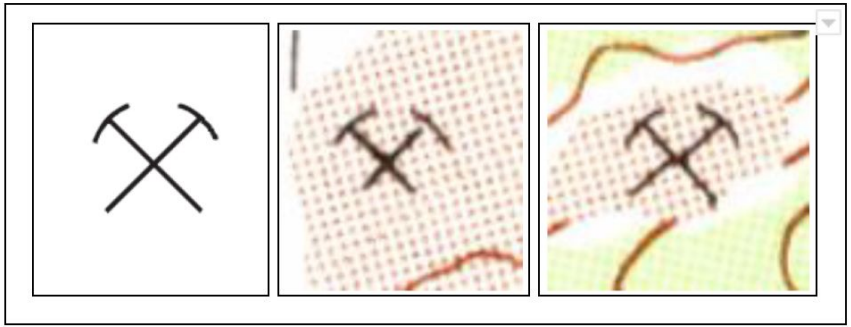

Quarry symbol template & occurrences on a USGS map (Chen, 2015).

Good for individual symbols.

Different methods of automation

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- **Machine-learning**
- Object-Based Image Analysis (OBIA)

Locating individual buildings on a 1966 USGS map with a Convolutional Neural Network (Uhl et al., 2017).

Good for when very large training samples can be secured.

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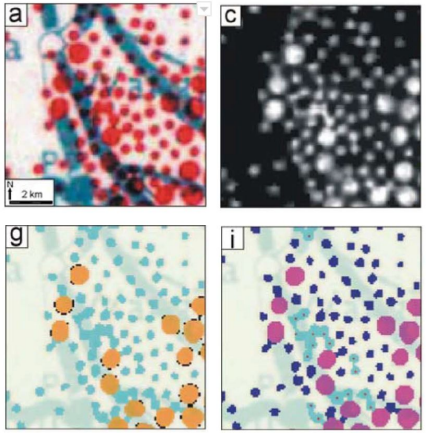


Extracting dots symbolizing population numbers from a 1962 Kenya map (Kerle & de Leeuw, 2009).

Relatively versatile.
Does not require training samples.
Selected for this project.

Background

3. Soviet Military Maps

Large map series

- Automating feature extraction is particularly interesting with large map series
  - Putting in place the workflow is time consuming
  - So, ideally you want to use the workflow many times

- Soviet military maps
  - One fascinating example of large map series
  - My project will focus on some of those maps

1936 Soviet map representing Eastern Azerbaijan at 1:50,000.

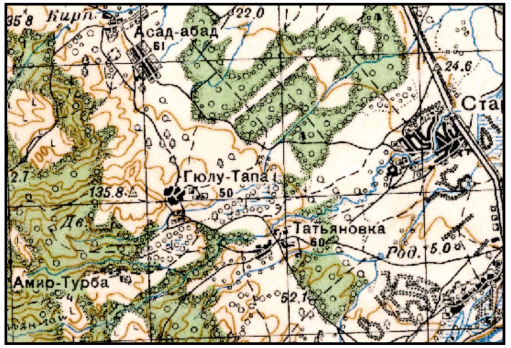
Soviet military maps

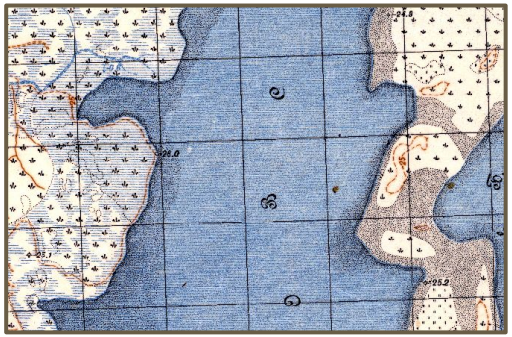
- Military maps were produced in the Soviet Union for most of the 20th century
  - Most were highly classified, and unknown to the public
  - The Soviet army first focused on mapping Russia and countries surrounding it
  - Later on, after World War II went on to map most of the terrestrial earth surface
  - Several series exist at different scales from 1:1,000,000 to 1:10,000
  - Large series using the same symbology consistently
  - (Davies & Kent, 2017)

Details of Washington, D.C. (1975)
At 1:25,000.

Soviet military maps

- After the collapse of the Soviet Union in the early 1990's:
  - More and more of those maps started appearing in the West
  - Thousands of map sheets have already surfaced, and it is suspected that there exist many more that are still unknown to us (Watt, 2005)
  - That cartographic body represents a wealth of valuable historical information
  - Known for their remarkable level of details





Details of Azerbaijan (1936) at 1:50,000.

Goals

Goals

- Build a workflow to extract features semi-automatically
- From Soviet military maps dating from the 1930’s for a region of the Belarus Republic
- Using the Object-Based Image Analysis (OBIA) approach

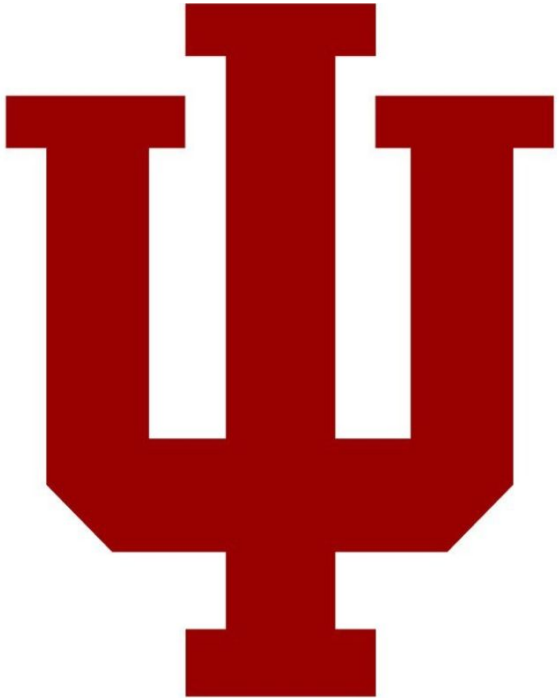
- Strive to create a workflow as streamlined as possible
- Assess the potential for real-life use
- Tackle some complex symbology types
- Help assess the usefulness of OBIA for this type of analysis

Project Methodology

1. Securing the Data

Indiana University's Collection

- Indiana University Bloomington Library
- Started digitizing their collection of Soviet military maps thanks to a grant (Crowe, 2018)
- High resolution GeoTIFFs
  - Not yet public
  - But they gave me access to them
- No complete series
- All files are georeferenced and cropped

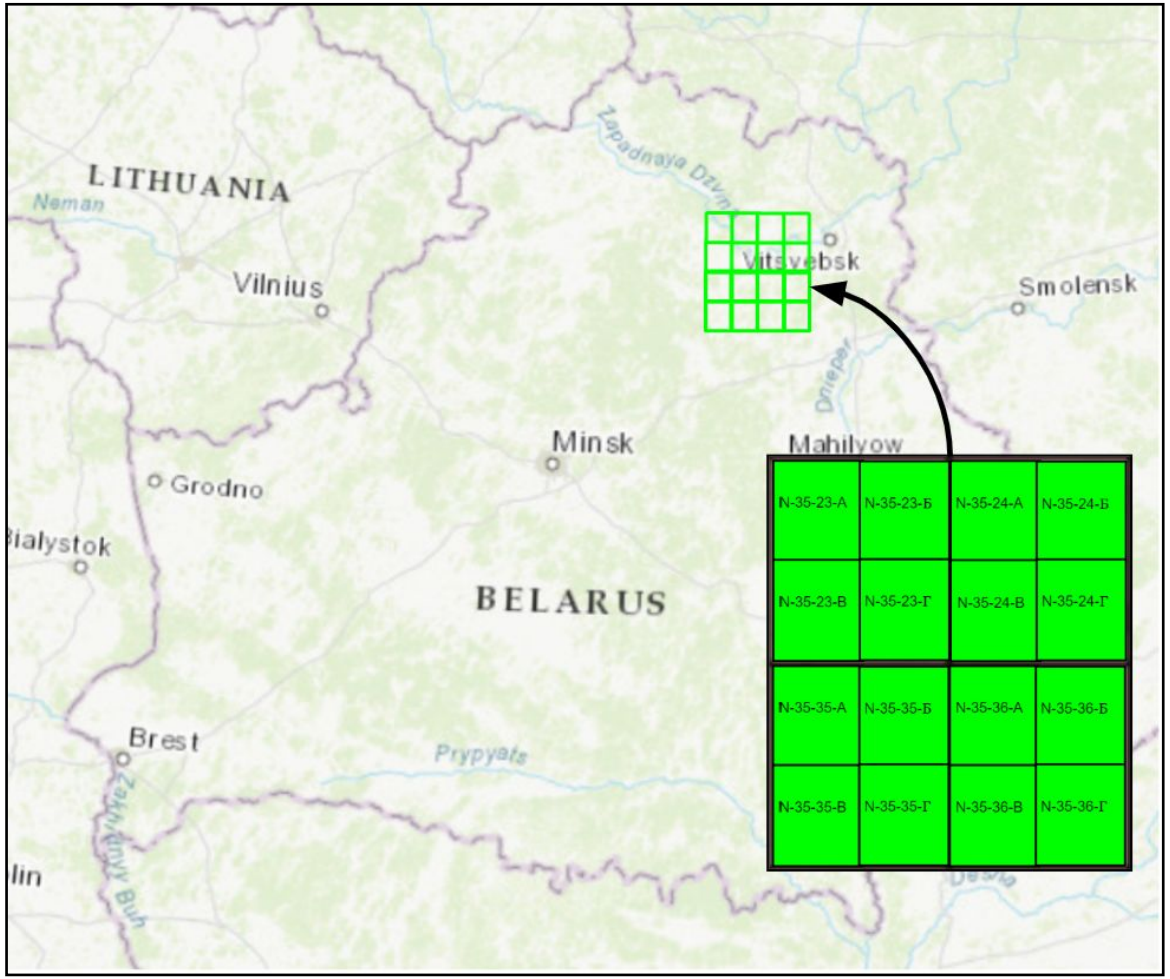


IU Logo

Area of Interest

- **Type:** 16 topographic 1:50,000 map sheets
- **Location:** region East of Viciebsk, Belarus Republic.
- **Years:** 1936 & 1937
- **Coordinate system:** Pulkovo 1942 3 Degree GK Zone 16
- **Datum:** Pulkovo 1942
- **Unit:** meter
- **IDs:**

N-35-23-А, N-35-23-Б, N-35-23-В, N-35-23-Г, N-35-24-А, N-35-24-Б, N-35-24-В, N-35-24-Г, N-35-35-А, N-35-35-Б, N-35-35-В, N-35-35-Г, N-35-36-А, N-35-36-Б, N-35-36-В, N-35-36-Г.



Area of Interest

Each raster:

- 18 by 15 km
- 1 file ≅ 770 Mb

Total of the 16 rasters:

- 72 by 60 km
- ≅ 12.3 Gb

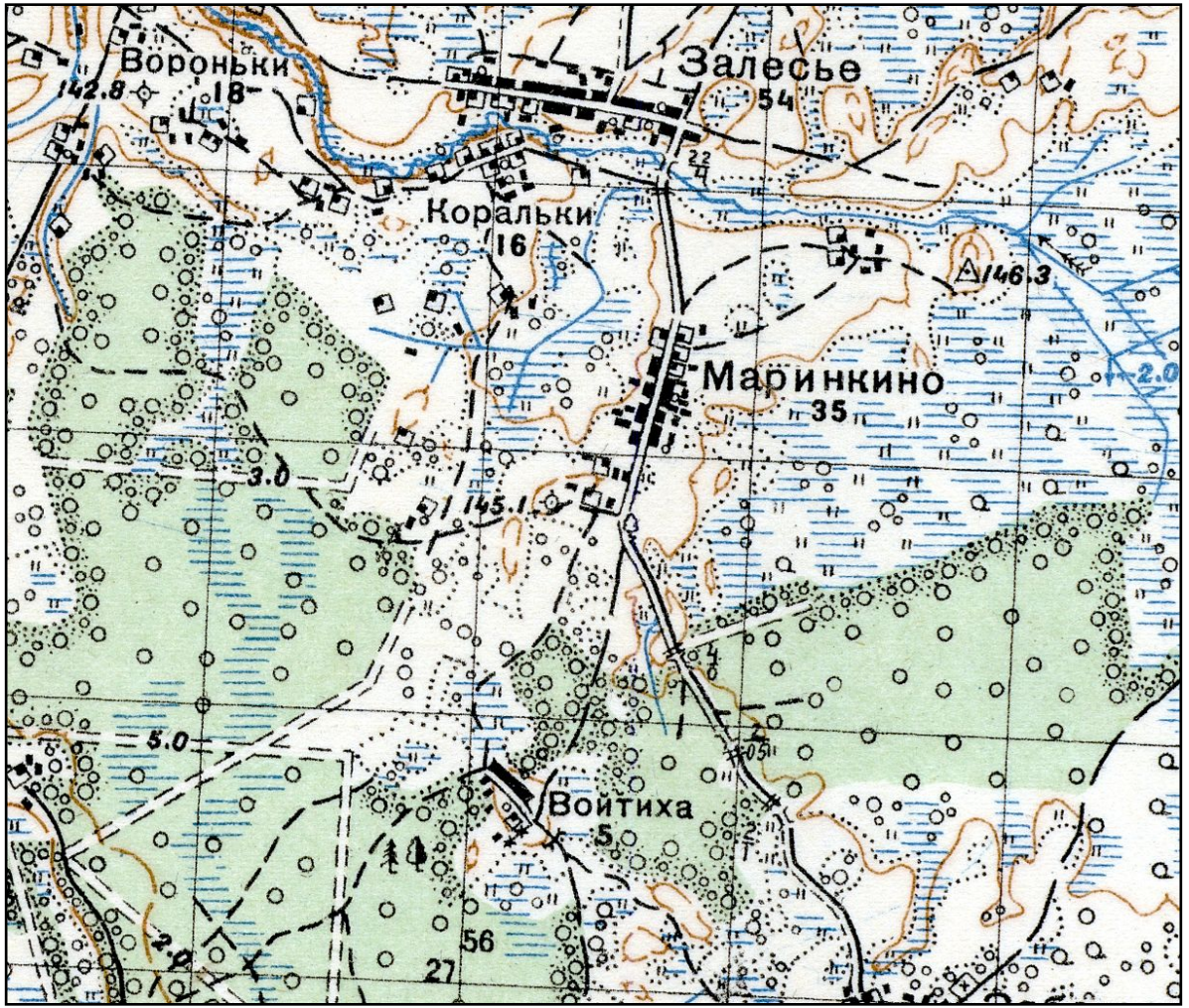
3 color bands:

- Red, Green, Blue

The 8 rasters for the bottom half of the AOI.

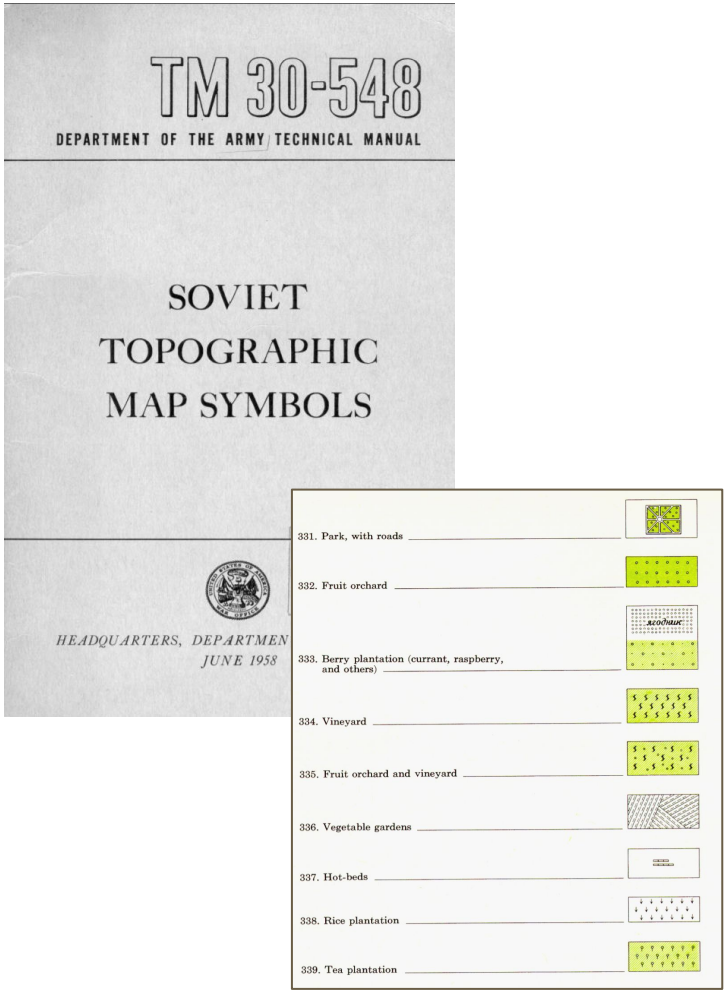
Area of Interest

Detail of the AOI: surroundings of Zales'ye, Belarus



Symbolization guide

- No legends on the map sheets
- The map users relied on a separate guide book
- Symbolization guide published by the U.S. Army in 1958 (Dept. of the Army Headquarters, 1958)
  - Found on the UC Berkeley Library's website
  - Seems to describe my maps perfectly



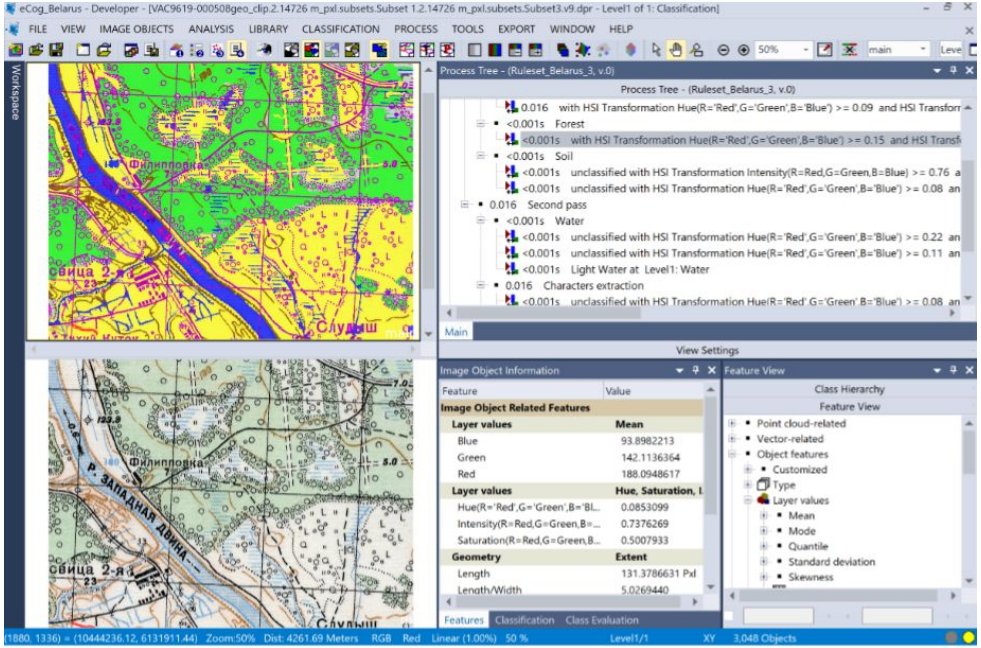
Project Methodology

2. Workflow

OBIA approach

- Overall approach selected: Object-Based Image Analysis (OBIA)

- Main software applications:
  - eCognition
  - ArcGIS Pro



eCognition interface

Workflow

AOI raster dataset (lower half)

1. **Acquire raster files**
2. Prepare AOI raster
   - Color calibration (?)
   - Create mosaic raster
   - Downsampling (?)
3. Define subsets
4. Develop rule set on subsets
   - Preprocessing steps
   - Segmentation
   - Classification
5. Run ruleset on entire AOI Raster
6. Generate shapefile output
7. Accuracy assessment
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Legend

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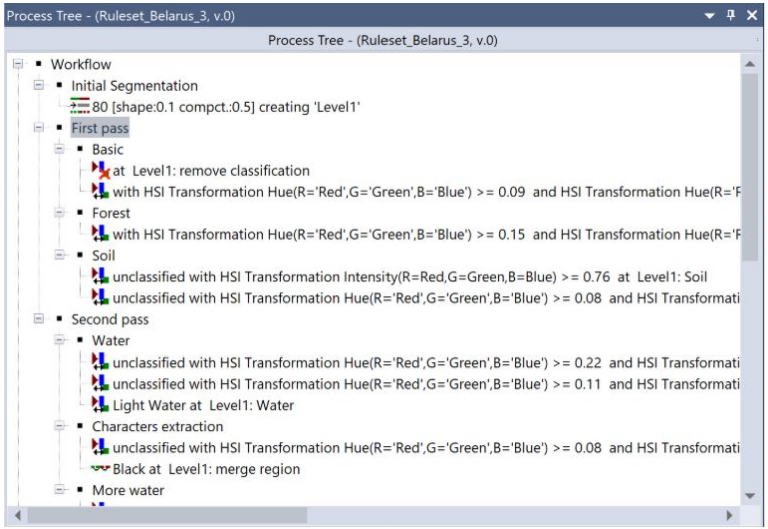

Rule set example

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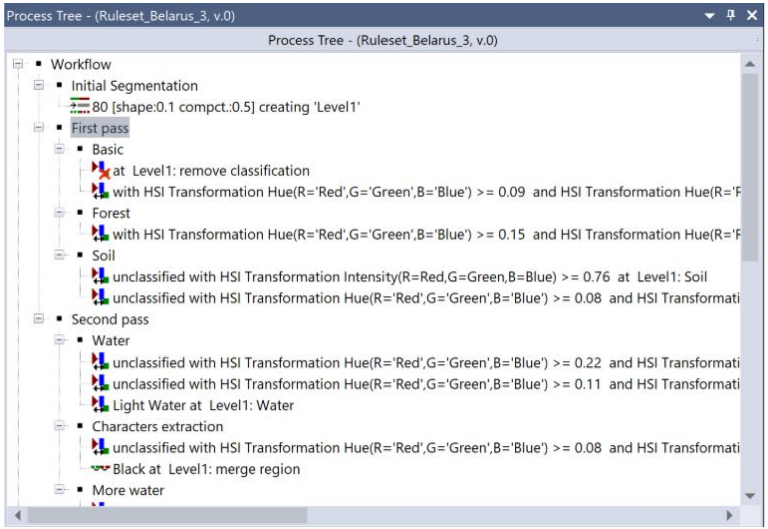

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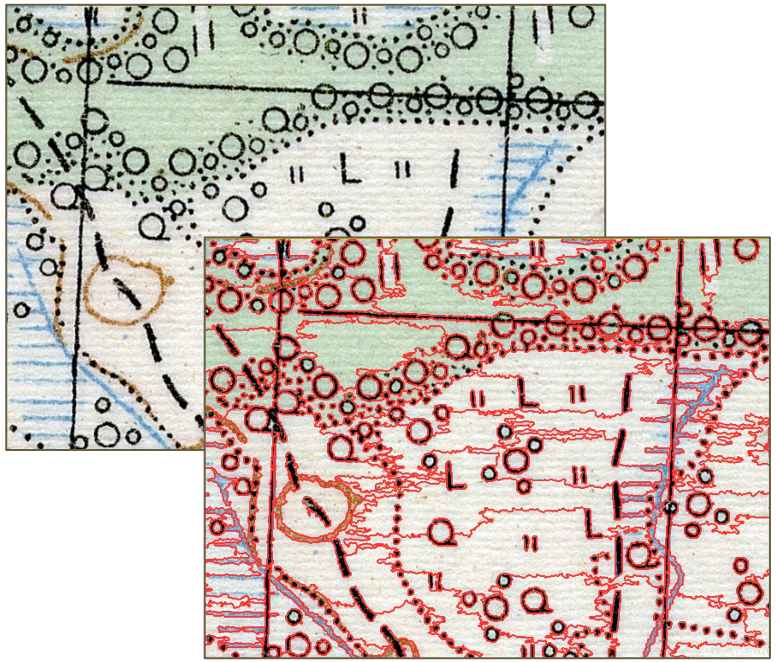

Segmentation example

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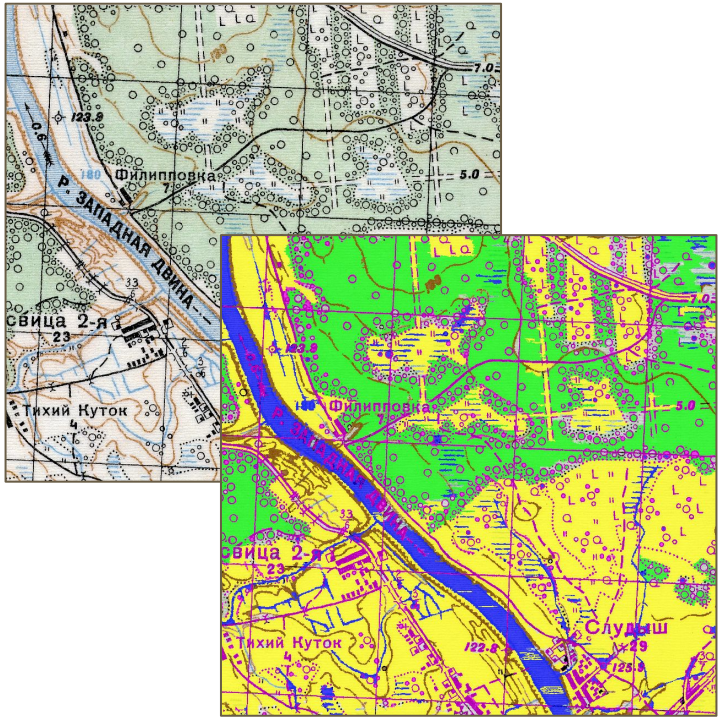

Classification example

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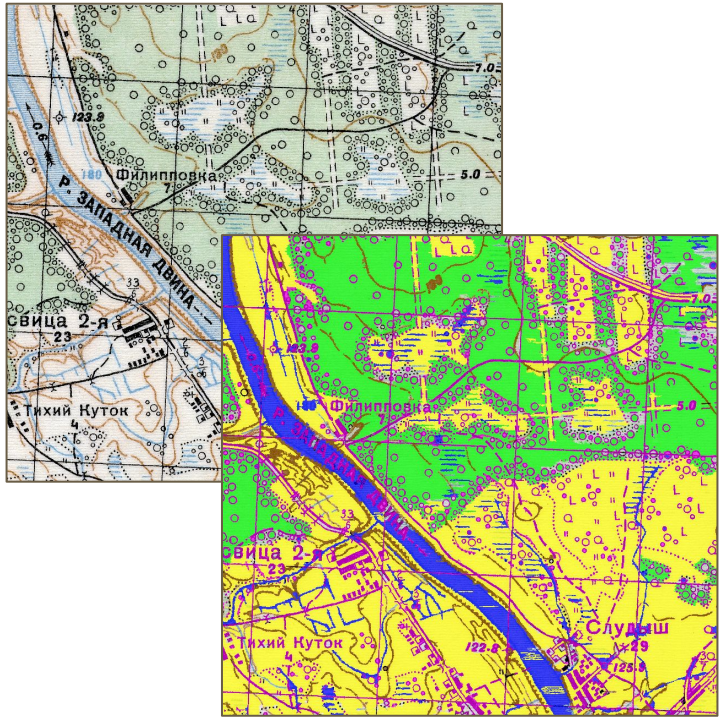

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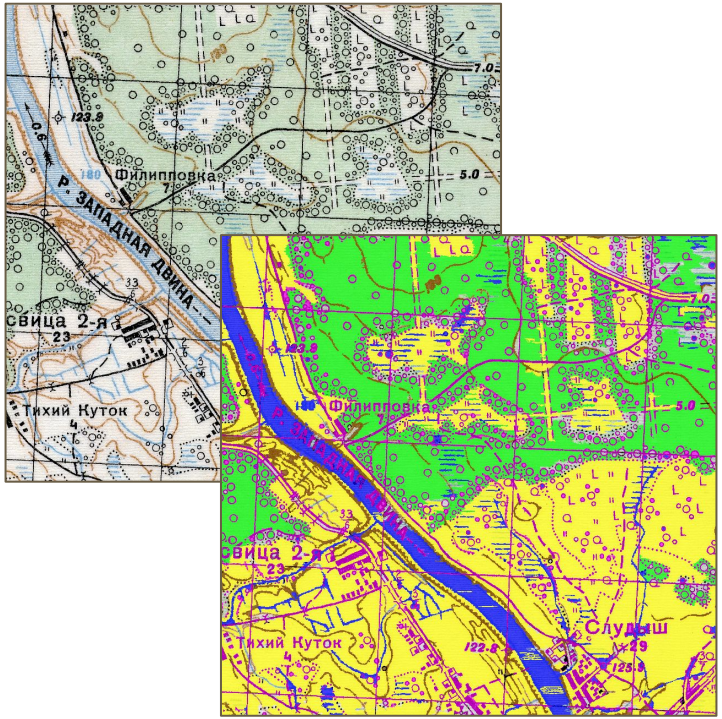

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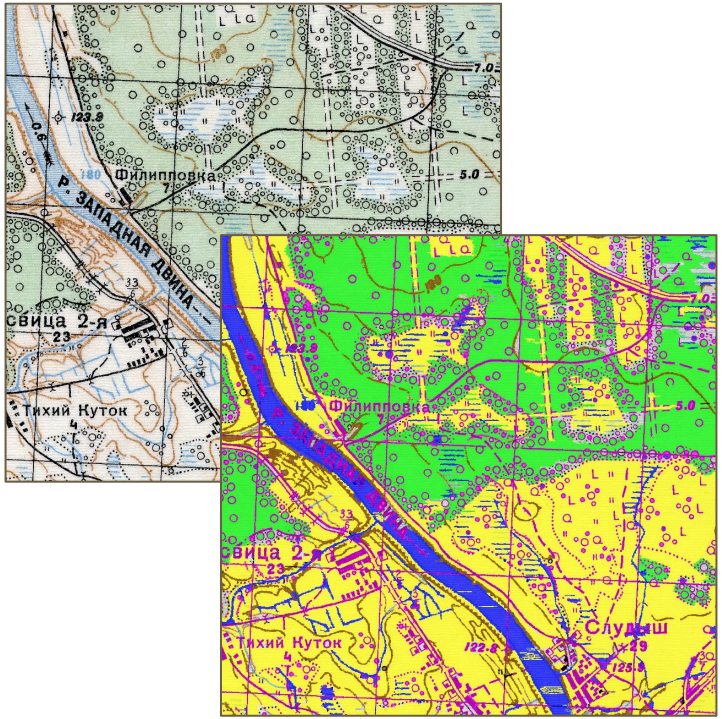

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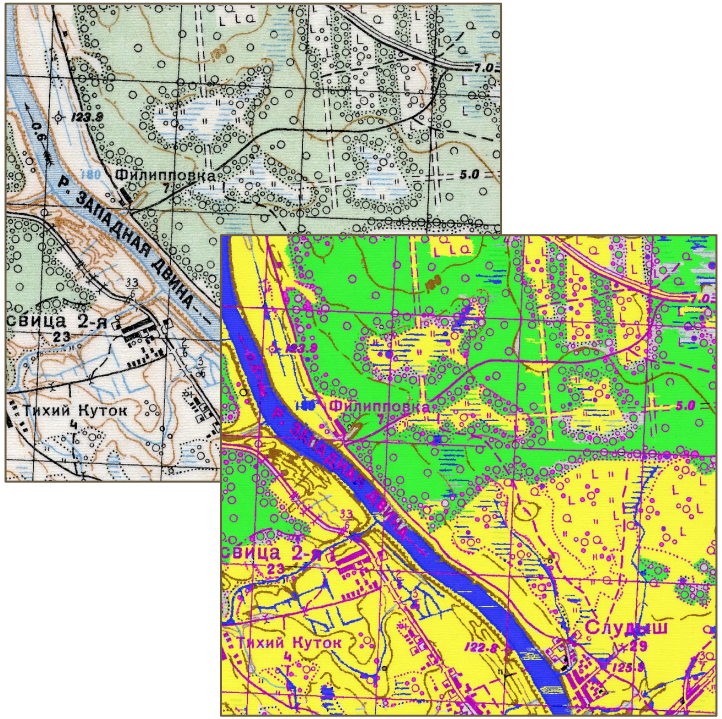

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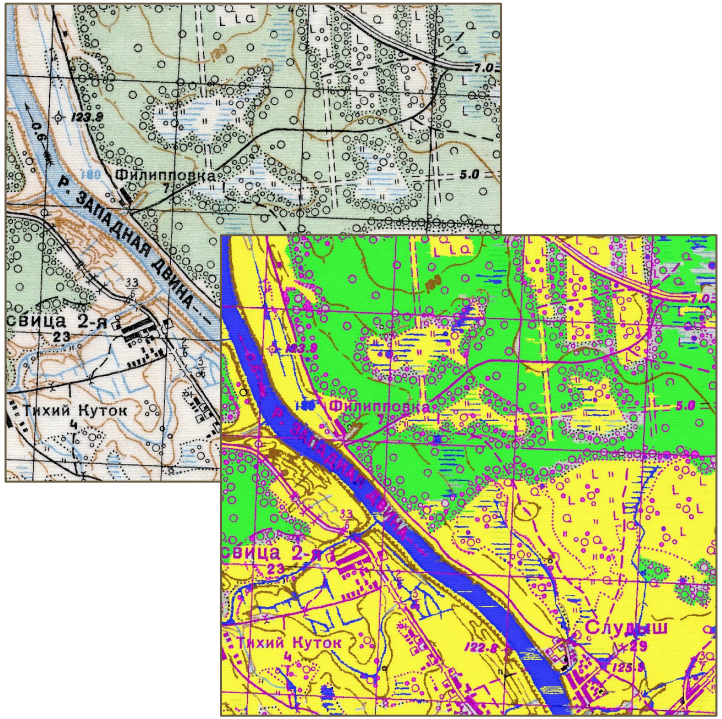

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Project Methodology

3. Features targeted

Land cover features

- Focus on extracting land-cover styles features, such as forested areas, barren land, built-up areas, and wetlands

- Belarus has many wetlands/swamp areas, so it will be an important aspect of the project.

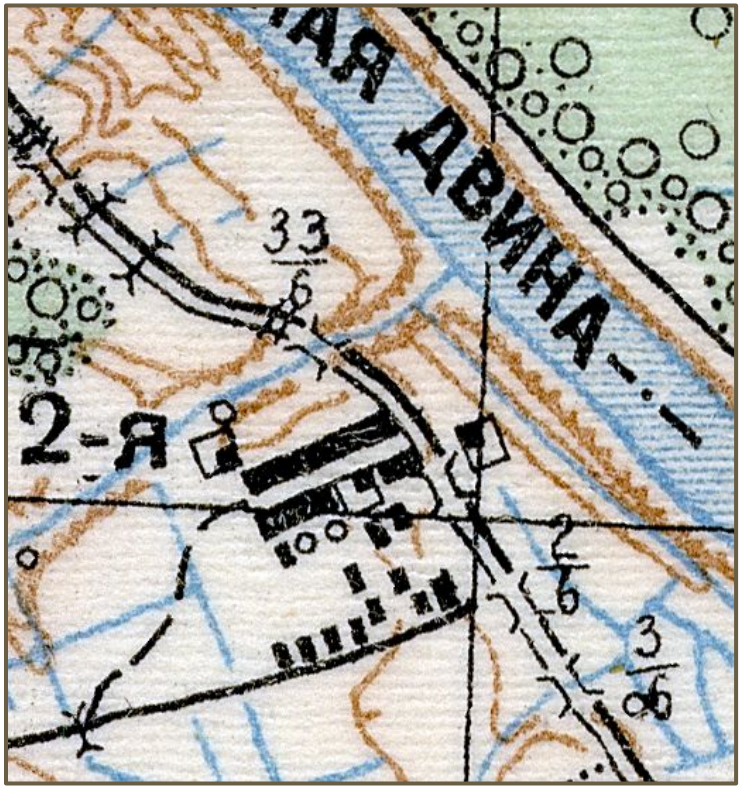
Forested wetland in Belarus (ramsar.org).

Challenging symbology

Built-up areas

- Same color as labels, roads, vegetation and tree symbols, etc.

- Variable shapes, which in many cases reproduce the actual shapes of the buildings



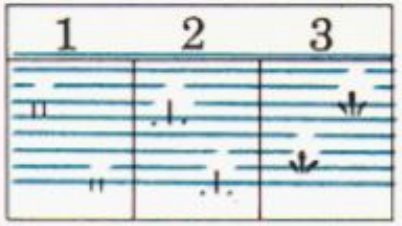
Example of built-up area.

Challenging symbology

Wetlands / swamps - multi-layered symbology:

- Stripes: wetlands / swamp areas
- Symbols: 1. grass, 2. moss, 3. reeds or cane
- White areas: A. impassable, B. hard to pass, C. passable (military concept of “going”)
- (Dept. of the Army Headquarters, 1958)

A.



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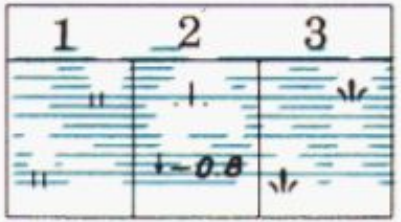

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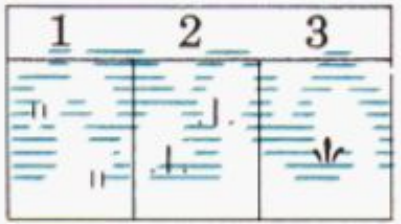
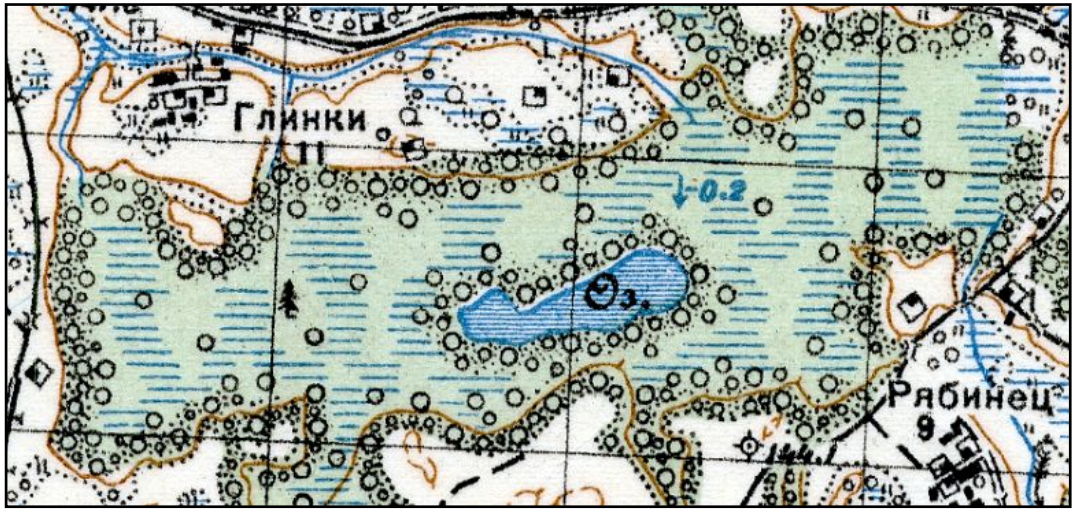


Challenging symbology

Swampy forest!



Forested wetland in Belarus.

Textual elements

- No attempt to parse the textual elements, such as labels
- However, identify text elements as a separate class of eCognition objects

Example of textual elements

Project Timeline

Project Timeline

- May 2019
  - Peer review presentation.
  - Finalize the map set and create single raster
  - Start developing eCognition rule set, working on several raster subsets.

- June-July 2019
  - Develop any pre-processing steps that might be needed.
  - Estimate processing time, and proceed to downsampling the two rasters if necessary
  - Fully develop the eCognition rule set, still working on several raster subsets

- August 2019
  - Apply the rule set to the full raster.
  - Perform accuracy assessment

- September 2019
  - Assessment of potential for a production workflow.
  - Create illustrative maps.
  - Write final report.
  - Prepare conference presentation.

- October 2019
  - Present at conference.
  - Finalize final report.

Anticipated Results / Outcome

Project deliverables

- The eCognition rule set that I produce
- Any pre-processing script I create
- The final output shapefiles
- Several illustrative maps
- A report describing the process and discussing the results
- Presentation at a conference

Conference presentation

- Primary conference targeted: North American Cartographic Information Society (NACIS) 2019 Conference in Tacoma, WA, October 16-19

- I already submitted a proposal

Further Developments

Further developments

- Try out the workflow in a production context
- Apply the workflow to larger geographic areas as more map sheets from the same series become available
- I will share my results with the Indiana University Library staff

Thank you!

To my advisor Dr Nathan Piekielek

To Michelle Dalmau and Theresa Quill, Indiana University Bloomington

References (1)

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