LANDSCAPE · TANAP

The TANAP Landscape in 1975

Historical land-cover mapping
from KH-9 Hexagon imagery

Tatra National Park · Slovakia - Hrebienok

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TECHNICAL UNIVERSITY IN ZVOLEN

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OVERVIEW

From a historical image to a land-cover map in five steps

1

Data

Add the historical image and choose the working raster

2

Preparation

Derive coarser rasters that match the mapping scale

3

Segmentation

Split the image into homogeneous candidate polygons

4

Review

Assign classes, check and edit polygons

5

Results

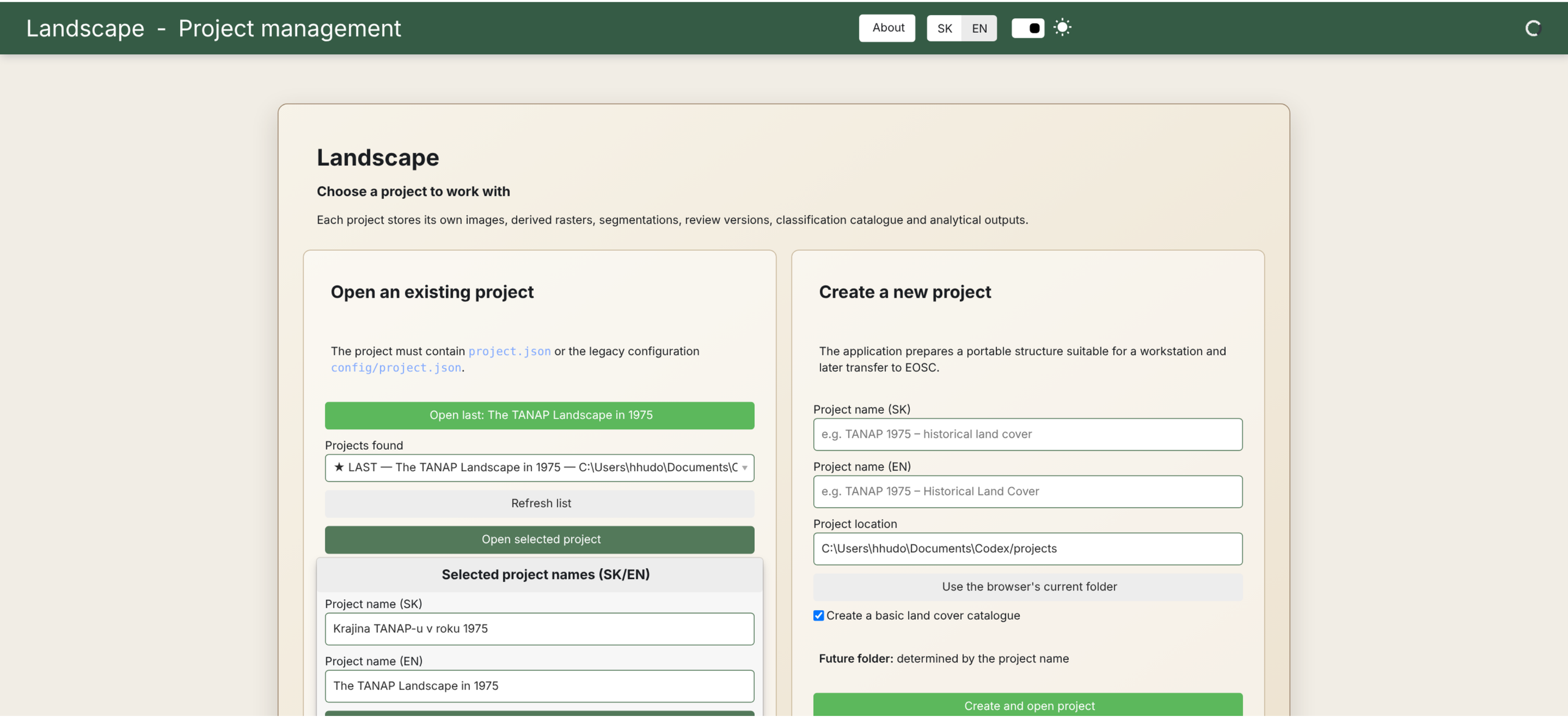
Statistics, version comparison, maps and export

Right-hand panels	Legend · Polygons · Statistics · Reclassify · Classes · Methods — viewing and analysis at any step
Project button	Project names and location, run diagnostics, program version

Input: KH-9 Hexagon image from 1975 · panchromatic, 0.5 m/pixel · no spectral bands, so the methods rely on brightness, texture and edges
Study area: Hrebienok, Tatra National Park · 2,500 ha · Output: land cover; land use only where the operator can identify it reliably

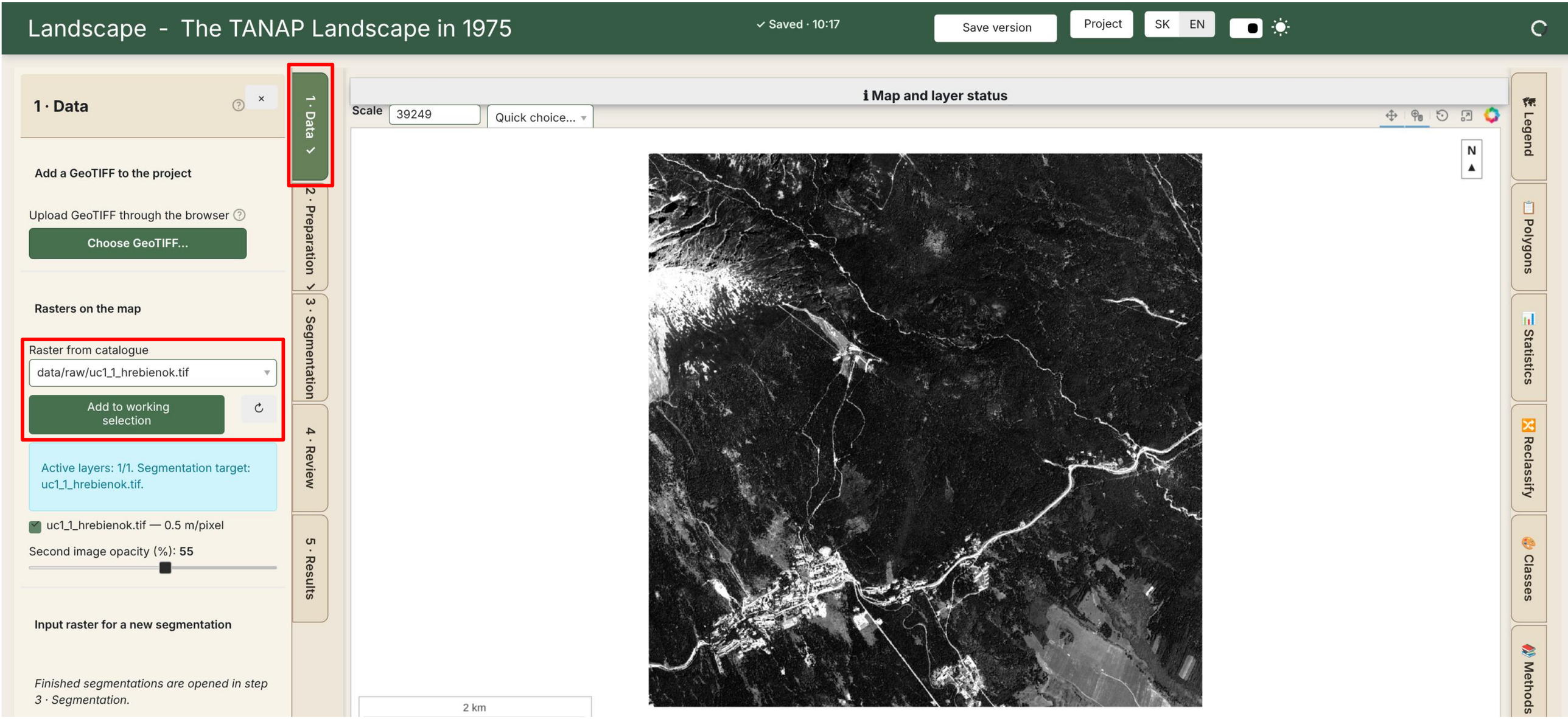
PROJECT

Creating or opening a project



STEP 1 · DATA

Main interface and input imagery



STEP 2 · PREPARATION

Deriving rasters at coarser resolutions

Landscape - The TANAP Landscape in 1975

✓ Saved · 10:17 | Save version | Project | SK EN

2 · Raster preparation

Creates derived rasters at lower spatial resolution. The original raster remains unchanged.

Original image

uc1_1_hrebienok.tif

Already created resolutions

- **1 m/pixel** · 5,000 × 5,000 px · 18.7 MB
- **4 m/pixel** · 1,250 × 1,250 px · 1.2 MB

Target resolutions (m/pixel)

1, 2, 5, 10

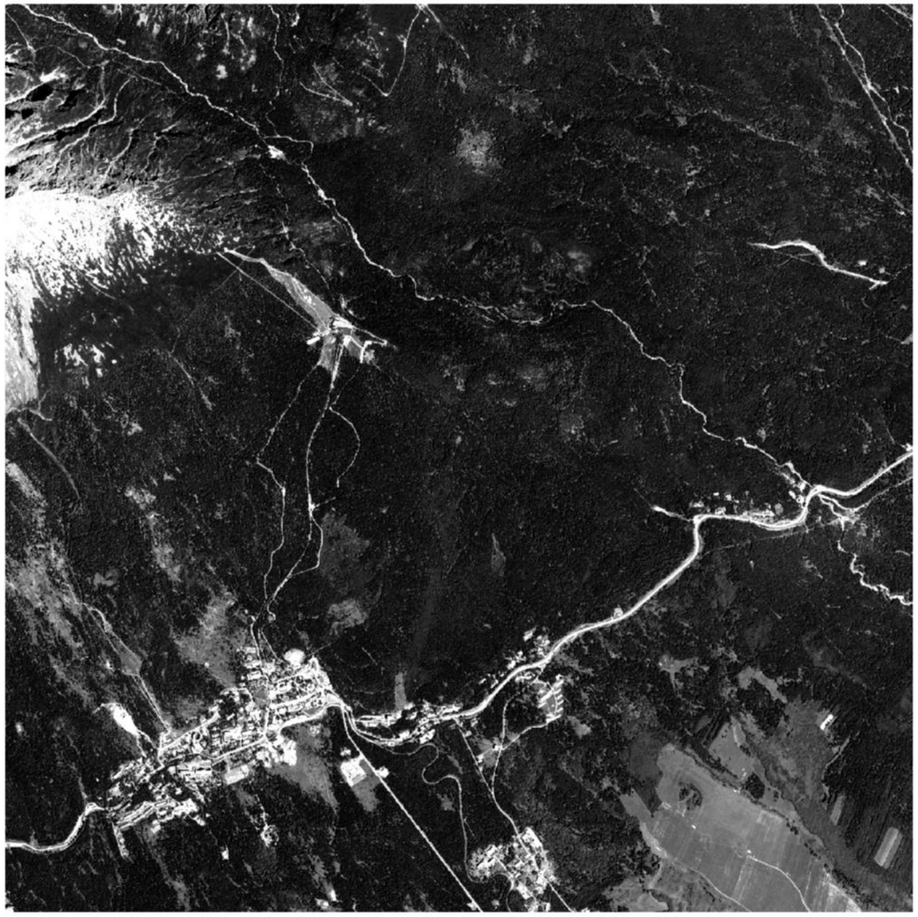
Create raster pyramid

Choose the original image and the required resolutions.

1 · Data > | 2 · Preparation > | 3 · Segmentation | 4 · Review | 5 · Results

ℹ Map and layer status

Scale 39249 | Quick choice...



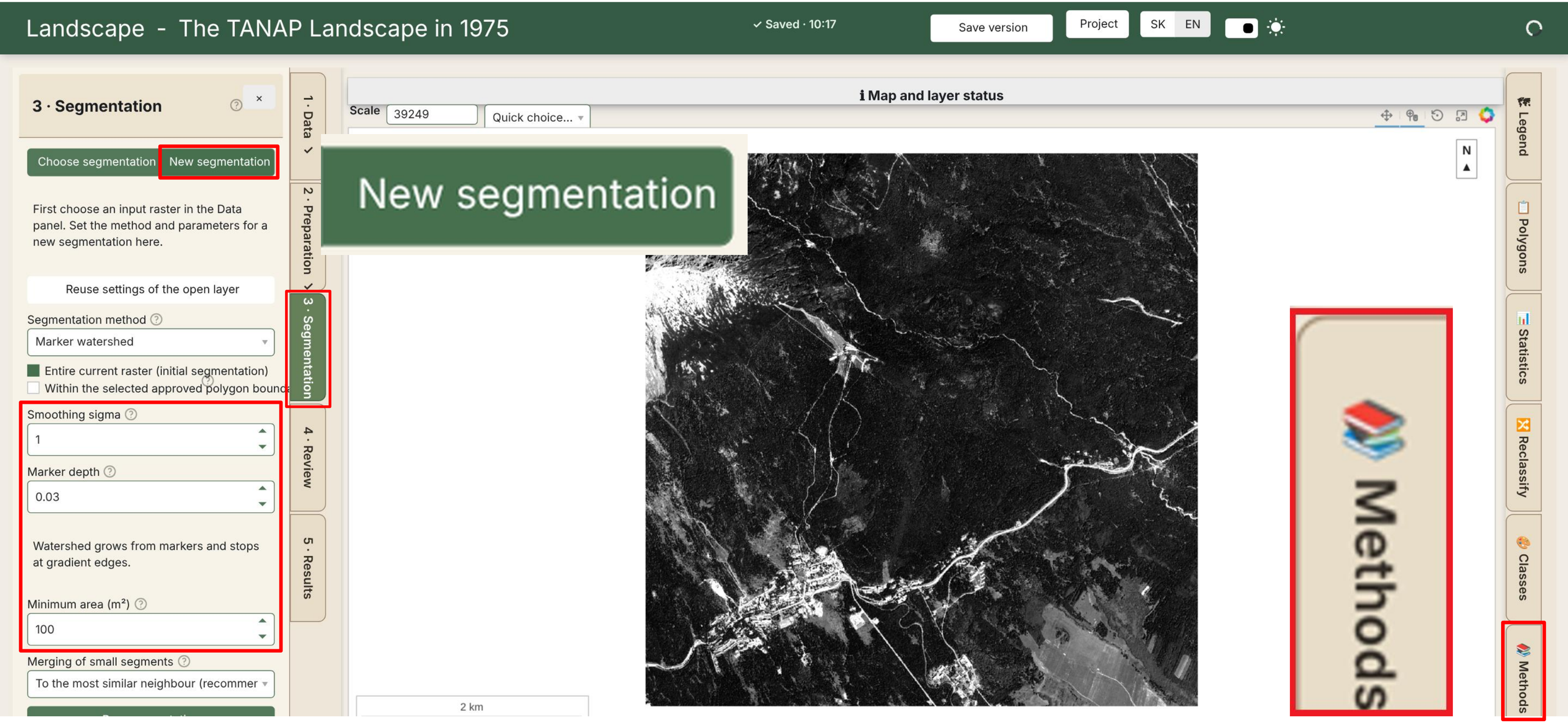
Legend | Polygons | Statistics | Reclassify | Classes | Methods

How pixel size changes the detail



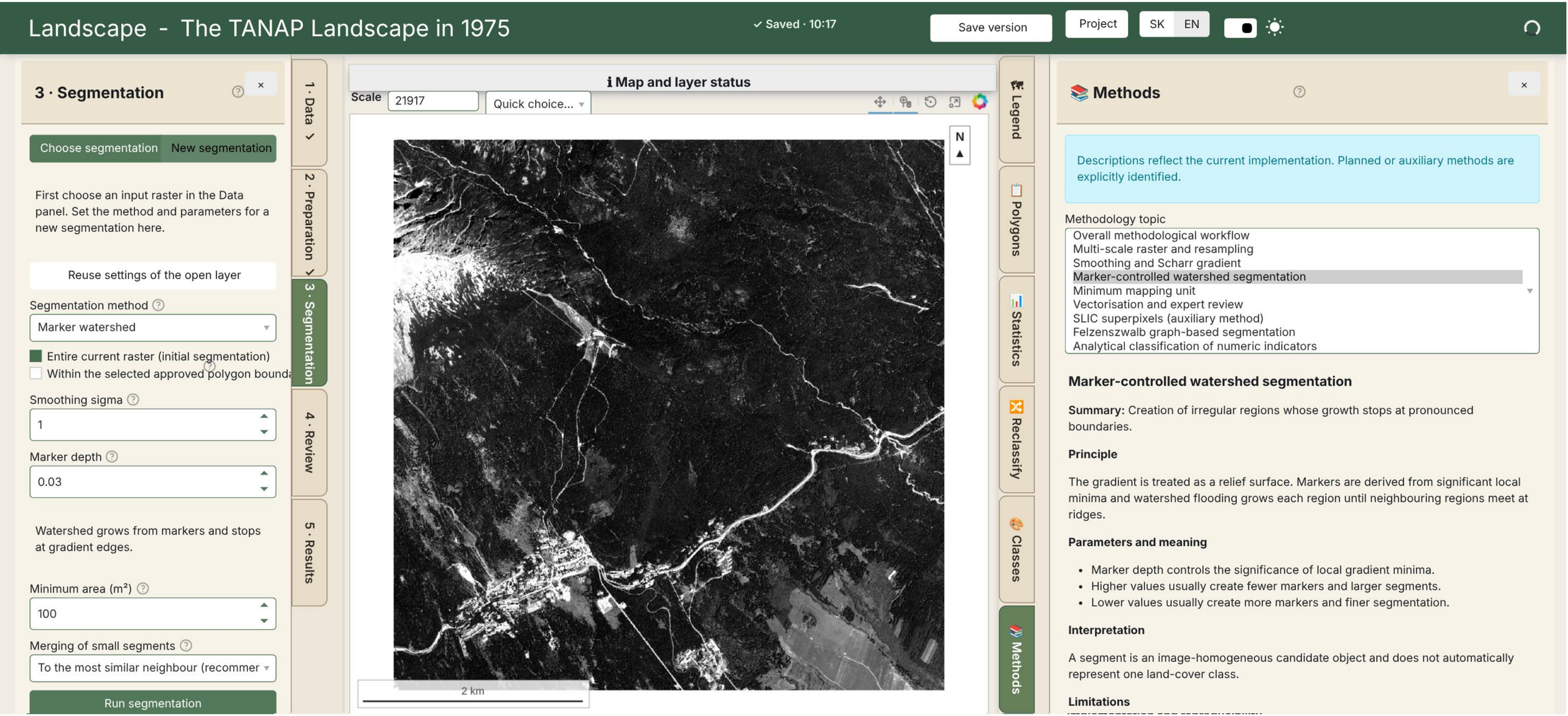
STEP 3 · SEGMENTATION

Setting up a new segmentation



METHODS

Method description inside the application



STEP 3 · SEGMENTATION

Segmentation result and run diagnostics

Segmentation analysis

Processing time and memory for completed segmentations. Filters compare only runs with the same source, method, extent and settings.

Method: Marker watershed

Extent: Full raster

Same settings: Source raster: uc1_1_hrebienok · Smoothing sigma: 1.0 · Marker depth: 0.03 · Minimum area (m²): 10(

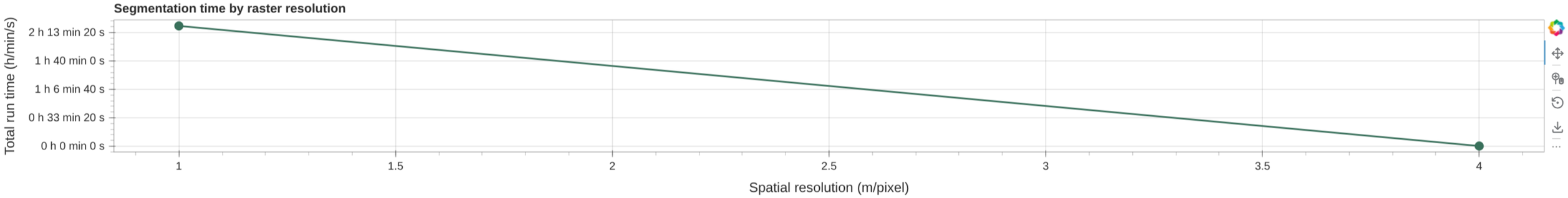
Refresh measurements

The chart shows the median of completed runs with the same method, scope and settings. Treat it as descriptive: polygon count and the processed mask also affect runtime.

Comparable runs: 2 · **Resolutions:** 2 · Only runs from the same source raster, method, scope and settings are grouped. s/Mpx normalises processing time; time until displayed includes the UI refresh.

Processing time by resolution

Chart height: **240**

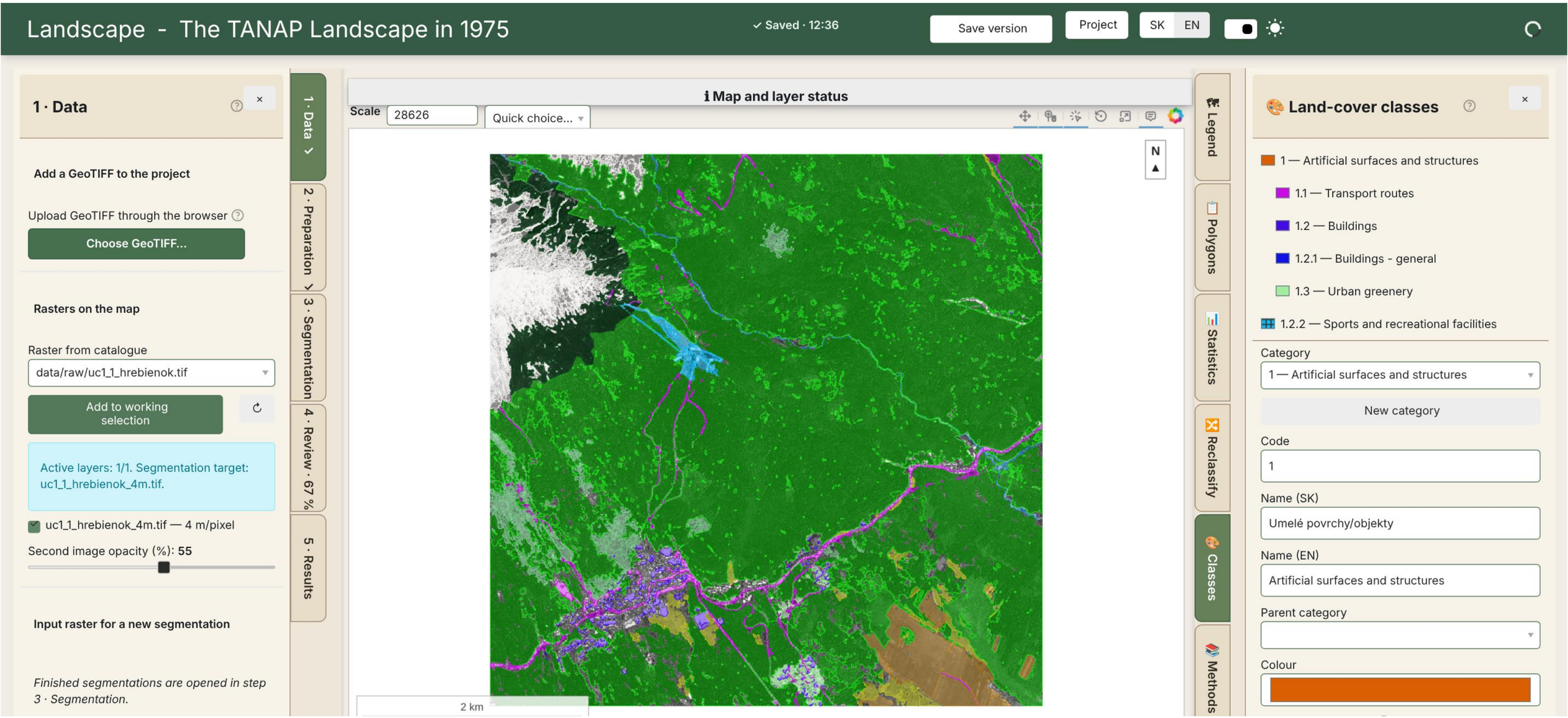


Comparable runs

Date	Raster	Resolution (m/pixel)	Processed pixels (Mpx)	Run time (h/min/s)	Time until displayed (h/min/s)	s/Mpx	Polygons	RAM after run (MB)
03.10.2026 23:54	uc1_1_hrebienok_1m.tif	1.0	25.0	2 h 20 min 58 s		338.309	41,632	451.7
03.10.2026 21:03	uc1_1_hrebienok_4m.tif	4.0	1.562	8.6 s		5.49	9,802	190.9

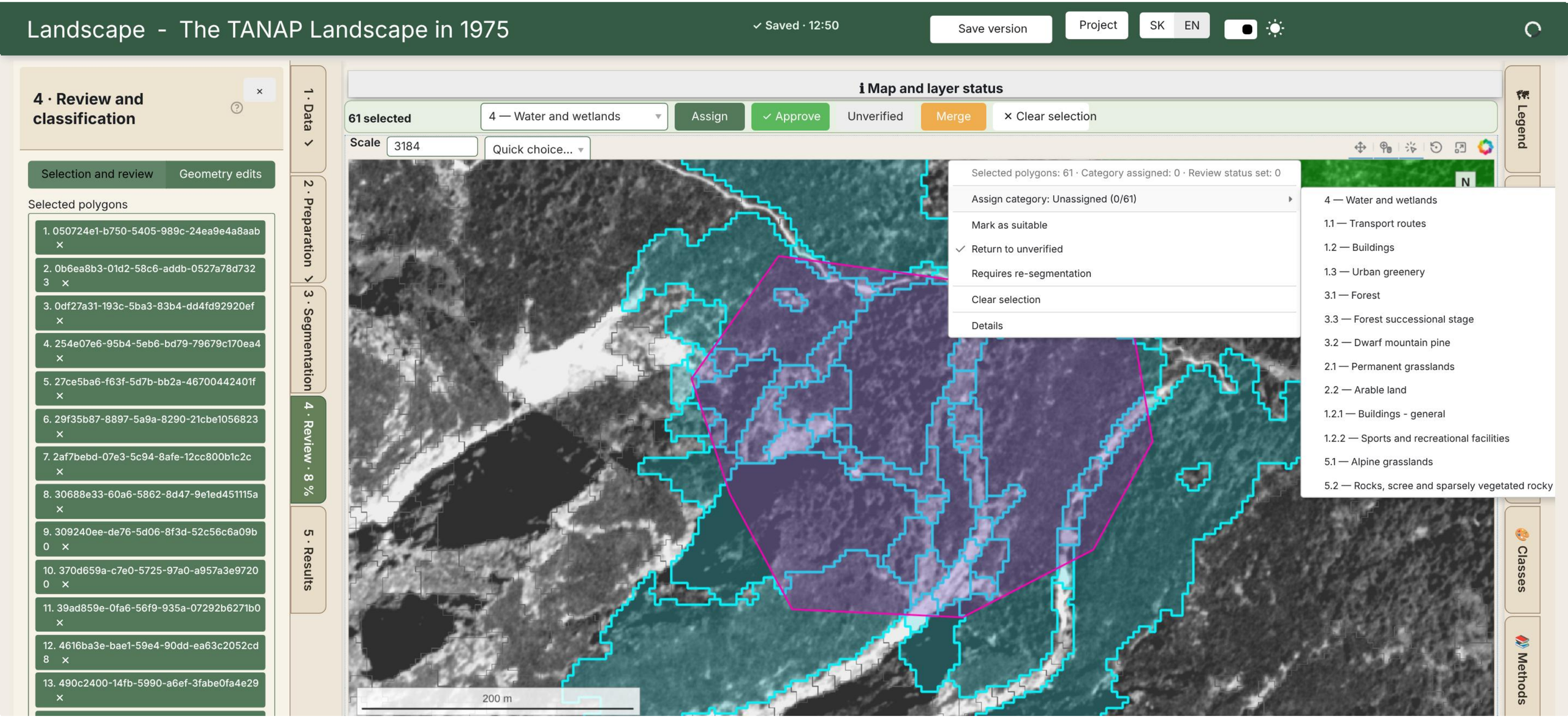
CLASSES

Building the classification catalogue



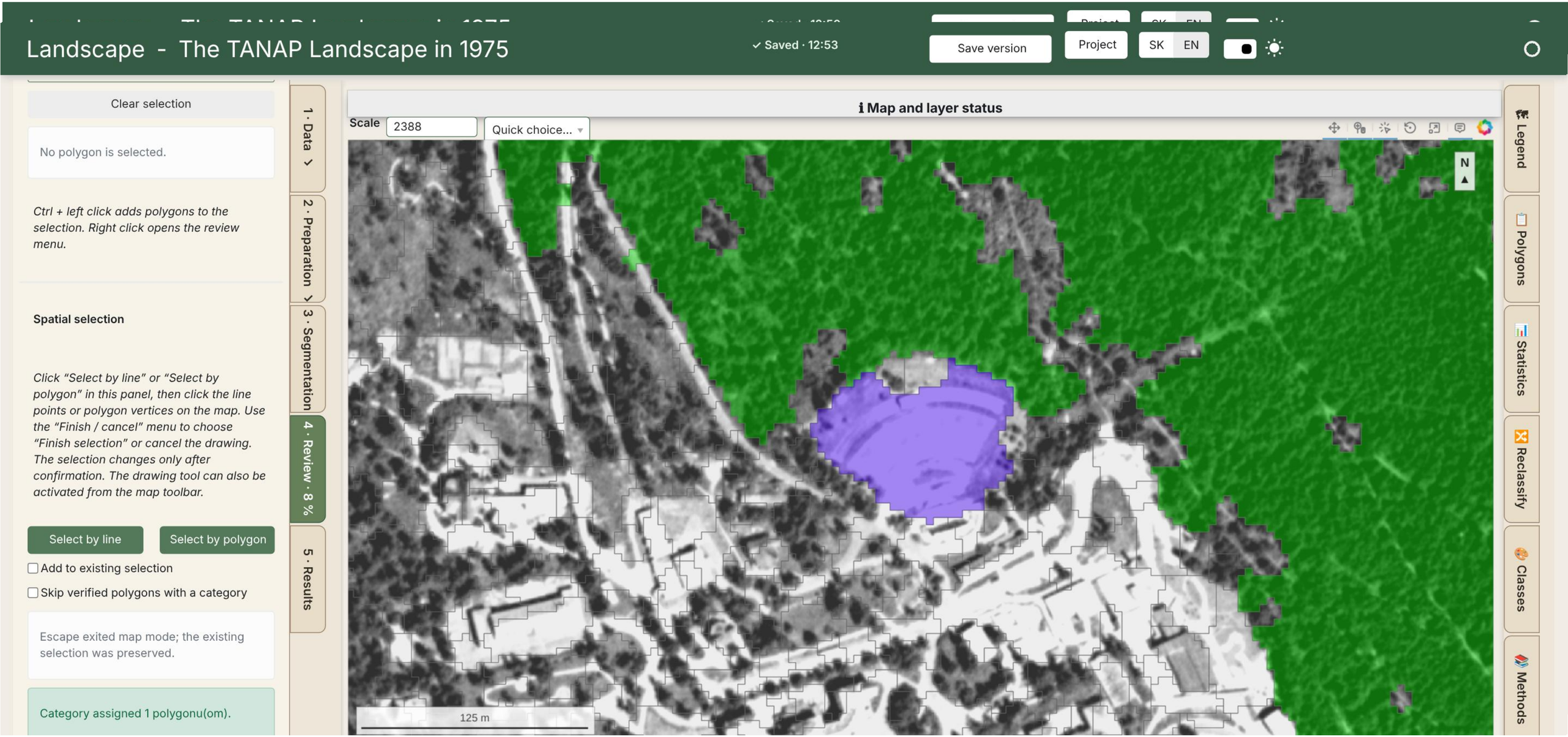
STEP 4 · REVIEW

Spatial selection of polygons



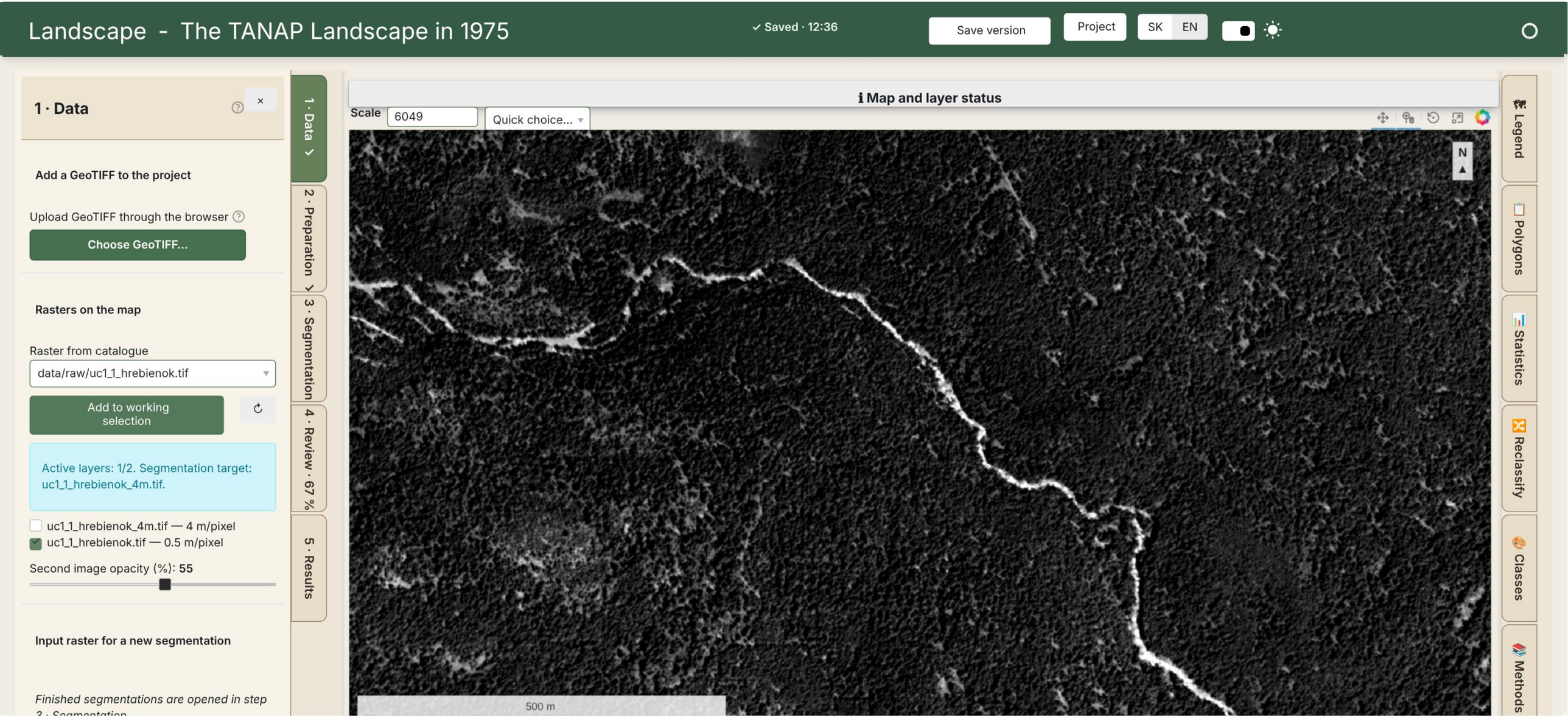
STEP 4 · REVIEW

Assigning a class and checking the result



OPERATOR EXPERTISE

Land use, texture and context: what the image alone cannot tell



CONTEXT — it may look like a path or bare rock, but its meandering course shows a watercourse → water

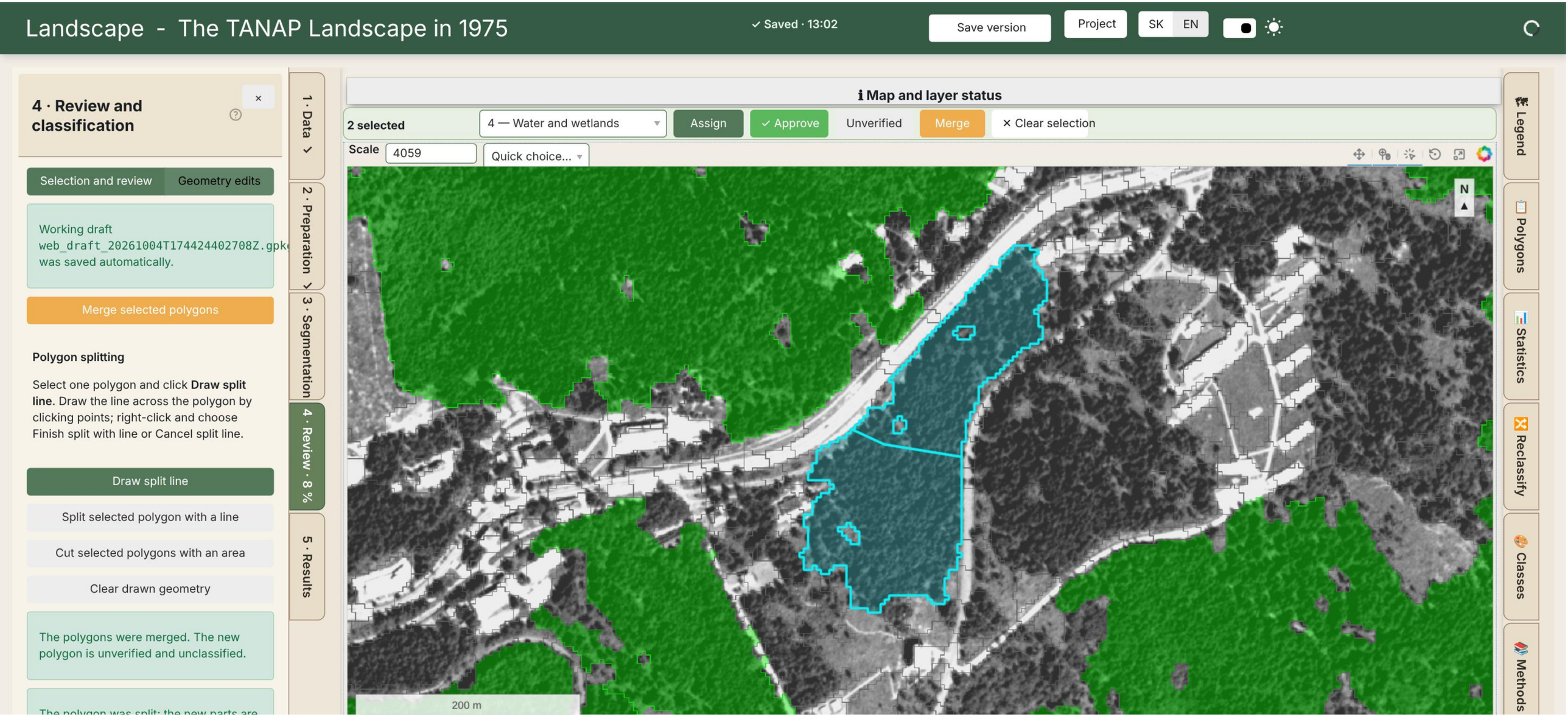
STEP 4 · REVIEW

Merging polygons



STEP 4 · REVIEW

Splitting a polygon with a line



STATISTICS

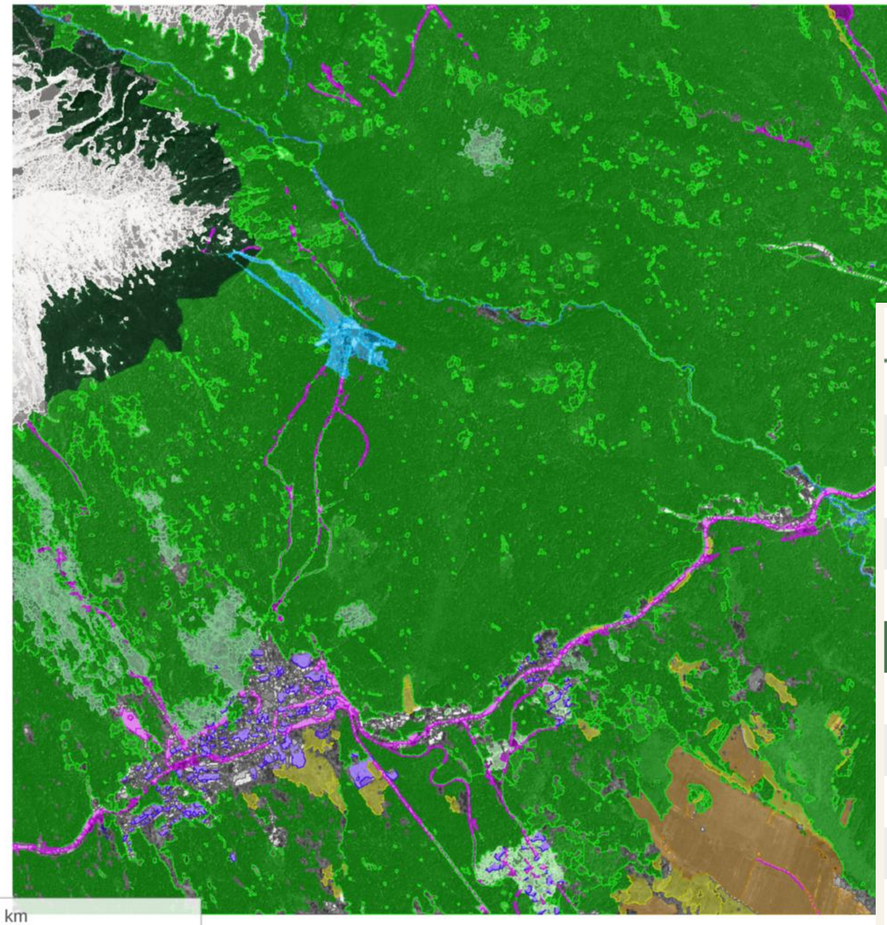
Land-cover statistics of the current layer

Landscape - The TANAP Landscape in 1975 ✓ Saved · 15:32 Save version Project SK EN

1 · Data
2 · Preparation
3 · Segmentation
4 · Review · 67 %
5 · Results

ℹ Map and layer status

Scale 27508 Quick choice...



Legend
Polygons

Land cover statistics

Hierarchy level
All classes – full catalogue

Full catalogue: 18 classes, 9766 polygons.

Total area: 2500.00 ha
Classified area: 2365.65 ha (94.6 %)
Review status: Suitable 6548 (2365.72 ha) · Requires re-segmentation 0 (0.00 ha) · Unverified 3218 (134.28 ha)

Category	Polygons	Area (m²)	Area (ha)	Share ('
3.1 – Forest	1,810	19,113,803.8	1,911.38	
Unclassified	3,221	1,343,536.2	134.354	
5.2 – Rocks, scree and sparsely vegetated rocky areas	1,727	1,144,182.3	114.418	
3.2 – Dwarf mountain pine	76	902,187.7	90.219	
2.2 – Arable land	21	632,354.0	63.235	
3.3 – Forest successional stage	785	550,160.0	55.016	
1.1 – Transport routes	1,062	452,320.0	45.232	
2.1 – Permanent grasslands	89	335,984.0	33.598	
1.2 – Buildings	234	189,424.0	18.942	
1.2.2 – Sports and recreational facilities	195	123,024.0	12.302	
1.3 – Urban greenery	200	108,480.0	10.848	

STEP 5 · RESULTS

Project results and site status

Project results

Site status | Lineage | Layer comparison | What changed? | Detailed statistics | Agreement with AI

Site statistics and current state

The latest classified layer, its statistics and full map.

Displayed saved layer: Working draft · web_draft_20261004T174424

Create / refresh map preview | Download PNG | Download print map (PDF)

Active result: · layer contains 9 766 polygons.

Main category area

← One level up

Forest and shrub vegetation

Category · area (ha)

Forest	1911.38
Dwarf mountain pine	90.22
Forest successional stage	55.02

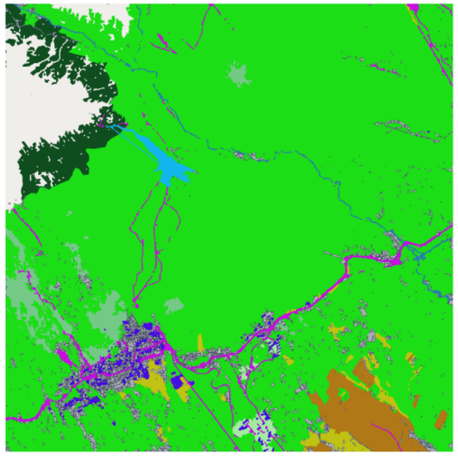
Subcategory summary

Category	Polygons	Area (ha)	Share (%)	Suitabl...	Verified ...
Forest	1,810	1,911.3804	92.94	1,911.3804	100.0
Dwarf mountai	76	90.2188	4.39	90.2188	100.0
Forest success	785	55.016	2.68	55.016	100.0

« ‹ 1 › »

Saved result preview: web_draft_20261004T174424402708Z. Unapproved areas are hatched; the working map extent does not affect it.

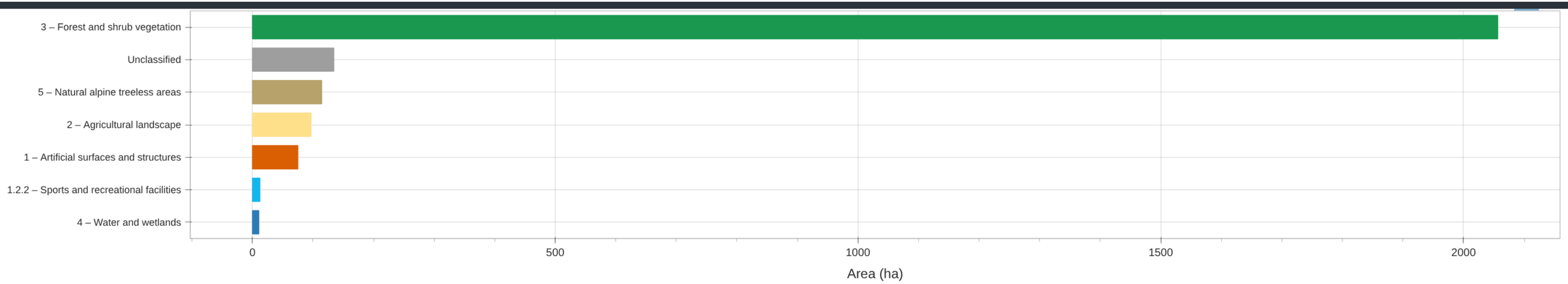
web_draft_20261004T174424402708Z
Period: 1975



- Unassigned or unknown category
- Rocks, scree and sparsely vegetated rocky areas
- Transport routes
- Water and wetlands
- Permanent grasslands
- Forest
- Dwarf mountain pine
- Forest successional stage
- Sports and recreational facilities
- Buildings
- Urban greenery
- Arable land
- Not yet approved

STEP 5 · RESULTS

Result lineage and detailed statistics



Land-cover share (%)

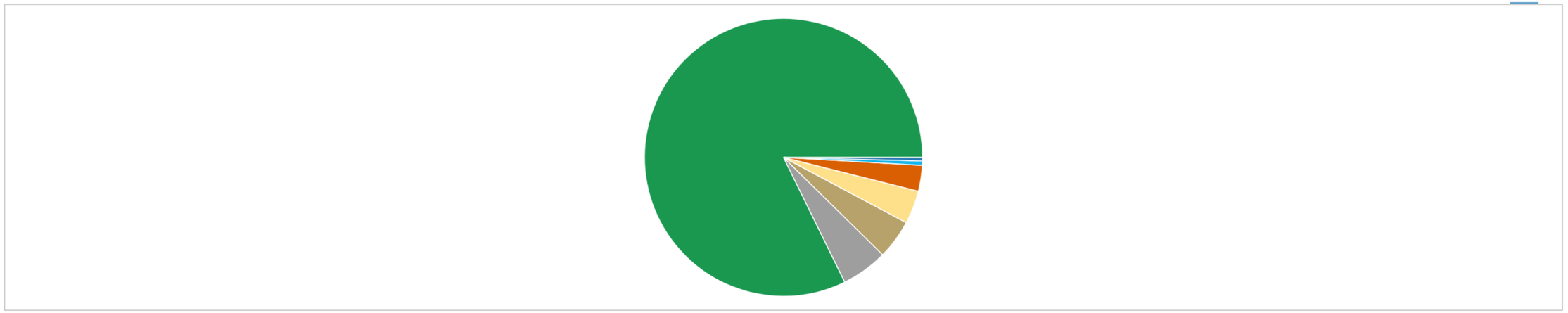


Table summary

Category	Polygons	Area (m²)	Area (ha)	Share (%)	Suitable (ha)	Verified (ha)	Requires re-segmentation (ha)	Unverified (ha)	Verified (%)
3 – Forest and shrub vegetation	2,671	20,566,151.5	2,056.615	82.26	2,056.615	2,056.615	0.0	0.0	100.0
Unclassified	3,221	1,343,536.2	134.354	5.37	0.075	0.0	0.0	134.278	0.0

STEP 5 · RESULTS

Comparing classification versions

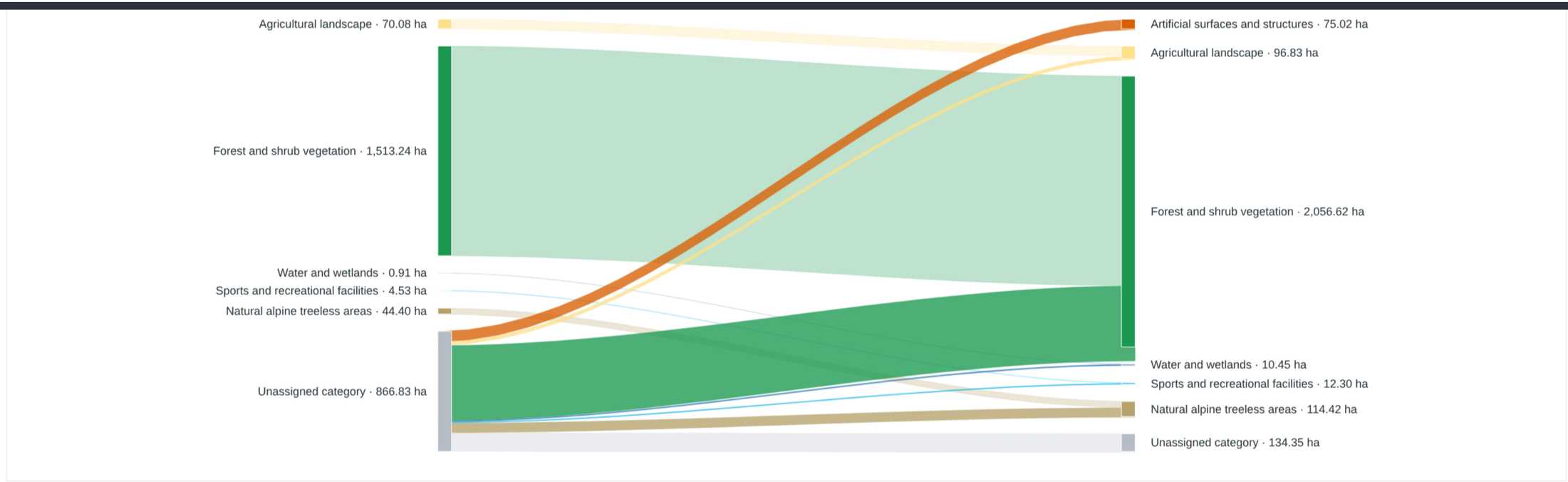


Table comparison

Category	A · web_draft_20261004T1744244027O8Z · 04.10.2026 23:27	B · web_draft_20261004T1744244027O8Z · 06.10.2026 11:39	Difference B − A
3 – Forest and shrub vegetation	1,513.245	2,056.615	543.371
Unassigned category	866.83	134.354	-732.477
5 – Natural alpine treeless areas	44.398	114.418	70.02
2 – Agricultural landscape	70.08	96.834	26.754
1 – Artificial surfaces and structures	0.0	75.022	75.022
1.2.2 – Sports and recreational facilities	4.533	12.302	7.77
4 – Water and wetlands	0.914	10.454	9.541

STEP 5 · RESULTS

Where the classification changed

Project results

Site status | Lineage | Layer comparison | What changed? | Detailed statistics | Agreement with AI

A · baseline layer

Working draft · web_draft_20261004T174424402708Z · 04.10.2026 23:27 · 9763 polygons · 803 approved · 606 classified

B · comparison layer

Working draft · web_draft_20261004T174424402708Z · 06.10.2026 11:39 · 9766 polygons · 6548 approved · 6545 classified

Main category to track

Forest and shrub vegetation

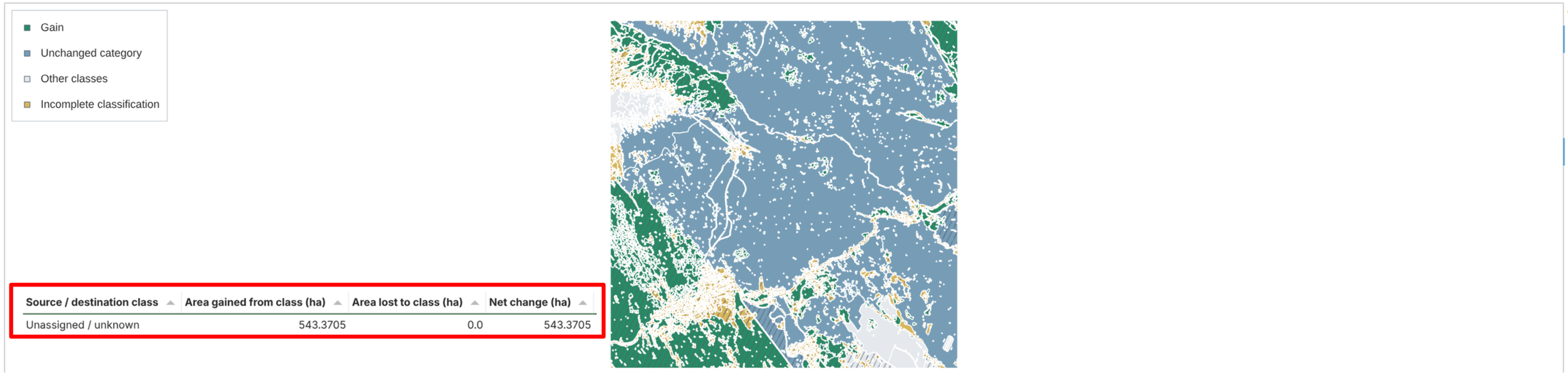
Show spatial transitions

Spatial differences in classification A → B. For the same period, this represents differences between interpretations or versions. Temporal change should only be inferred from comparable periods and verified data. The result includes unapproved areas.

A: 1513.245 ha → **B:** 2056.615 ha · **Gain:** 543.371 ha · **Loss:** 0.000 ha · **Net:** +543.371 ha

Shared coverage: 2500.000 ha. Unclassified → selected class counts as gain, and the reverse as loss. Other uncertain areas: 323.460 ha; outside shared coverage: 0.000 ha.

Forest and shrub vegetation · transitions A → B · hatching: unapproved area



Source / destination class	Area gained from class (ha)	Area lost to class (ha)	Net change (ha)
Unassigned / unknown	543.3705	0.0	543.3705

RECLASSIFY

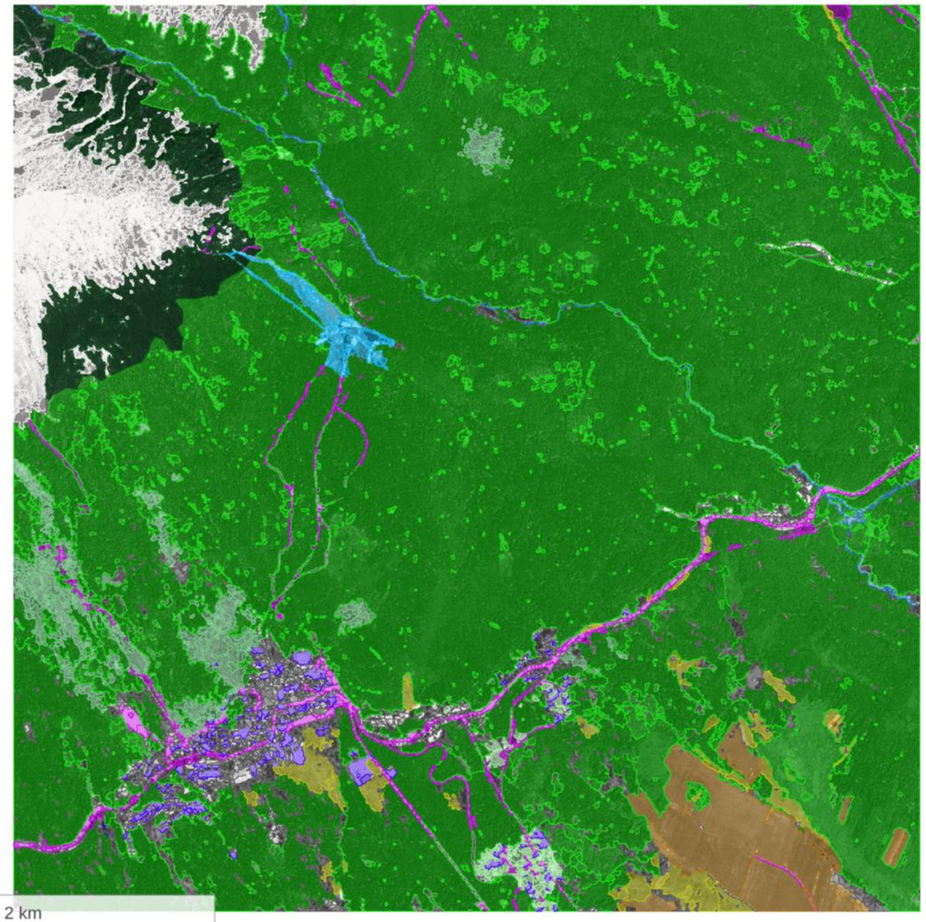
Derived layers: forest / non-forest

Landscape - The TANAP Landscape in 1975 ✓ Saved · 15:32 Save version Project SK EN

1 · Data
2 · Preparation
3 · Segmentation
4 · Review · 67 %
5 · Results

ℹ Map and layer status

Scale 26949 Quick choice...



Legend
Polygons
Statistics
Reclassify
Classes
Methods

Reclassification and export

Reclassification creates a new derived vector and never overwrites the original detailed layer.

1. Class mapping

Class visibility on the map is switched in the Legend. In the table below, the Use column controls inclusion and the target code and name can be edited.

Reclassification preset

Forest / Non-forest

- [ ] 1.1 — Transport routes
- [ ] 1.2 — Buildings
- [ ] 1.2.2 — Sports and recreational facilities
- [ ] 1.3 — Urban greenery
- [ ] 2.1 — Permanent grasslands
- [ ] 2.2 — Arable land
- [x] 3.1 — Forest
- [ ] 3.2 — Dwarf mountain pine
- [ ] 3.3 — Forest successional stage
- [ ] 4 — Water and wetlands
- [ ] 5.2 — Rocks, scree and sparsely vegetated rocky areas

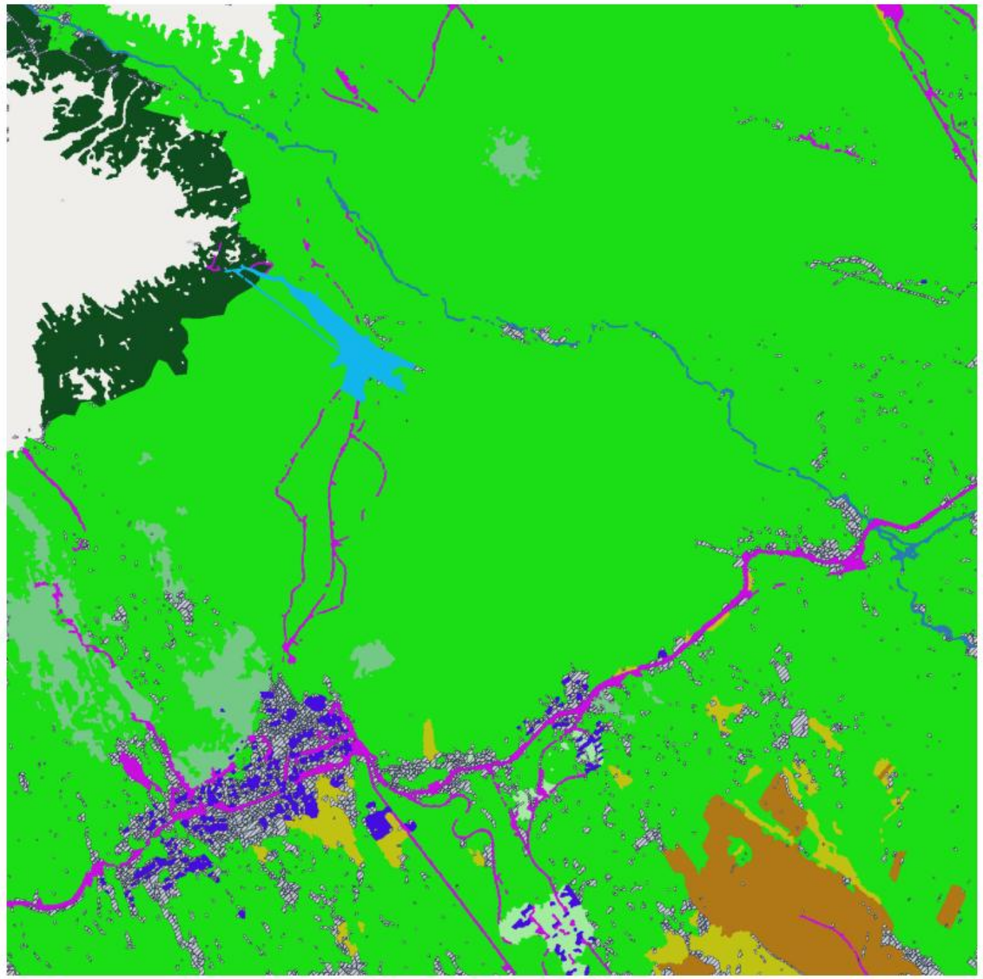
For the Forest/Non-forest preset, explicitly decide whether mountain pine, for example, counts as forest. The decision is saved in the metadata.

Apply	Source code	Source category	Target code	Target ...

STEP 5 · RESULTS

Map output for print and presentation

web_draft_20261004T174424402708Z
Period: 1975



- Unassigned or unknown category
- Rocks, scree and sparsely vegetated rocky areas
- Transport routes
- Water and wetlands
- Permanent grasslands
- Forest
- Dwarf mountain pine
- Forest successional stage
- Sports and recreational facilities
- Buildings
- Urban greenery
- Arable land
- Not yet approved

9766 polygons · 2500.000 ha · approved area 94.6 %
Classification preview; hatching indicates verification status.

CONCLUSIONS

What the Landscape workflow offers

1

Historical imagery becomes a land-cover map

Segmentation proposes candidate polygons; the operator classifies, checks and edits them in five guided steps.

2

Land cover first, land use where justified

The image shows the physical surface. Land use is added only where operator knowledge of the area makes it reliable.

3

Every result is traceable

Lineage, run diagnostics and metadata record sources, parameters and program version; outputs can be passed on to follow-up applications.

4

Next step: change over time

The same comparison tools work for layers from different periods — the basis for interpreting how the landscape changes.

REFERENCES

Methods and sources cited in the application

ACHANTA, R. et al. SLIC Superpixels Compared to State-of-the-Art Superpixel Methods. IEEE TPAMI. 2012, 34(11), 2274–2282. DOI: 10.1109/TPAMI.2012.120

BLASCHKE, T. Object based image analysis for remote sensing. ISPRS J. Photogramm. Remote Sens. 2010, 65(1), 2–16. DOI: 10.1016/j.isprsjprs.2009.06.004

FELZENSZWALB, P. F.; HUTTENLOCHER, D. P. Efficient Graph-Based Image Segmentation. IJCV. 2004, 59(2), 167–181. DOI: 10.1023/B:VISI.0000022288.19776.77

FISHER, W. D. On Grouping for Maximum Homogeneity. JASA. 1958, 53(284), 789–798. DOI: 10.1080/01621459.1958.10501479

KNIGHT, J. F.; LUNETTA, R. S. An Experimental Assessment of Minimum Mapping Unit Size. IEEE TGRS. 2003, 41(9), 2132–2134. DOI: 10.1109/TGRS.2003.816587

SCHARR, H. Optimale Operatoren in der Digitalen Bildverarbeitung. PhD thesis, Heidelberg University, 2000

SOILLE, P. Morphological Image Analysis: Principles and Applications. 2nd ed. Berlin: Springer, 2003

VINCENT, L.; SOILLE, P. Watersheds in Digital Spaces: An Efficient Algorithm Based on Immersion Simulations. IEEE TPAMI. 1991, 13(6), 583–598. DOI: 10.1109/34.87344

Software documentation: Rasterio (resampling); scikit-image (filters, h_minima, watershed); scikit-learn (KBinsDiscretizer) — cited 2026-10-05

Thank you for your attention

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