RETROCHANGE · USE CASE

Analysis of forest fragmentation and forest edges from historical satellite imagery

RETROFRAG · forest fragmentation then and now

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eosc | GRAVITY
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THE QUESTION

How fragmented is this forest, and how much of it is core forest?

WHY EDGES MATTER

Size and isolation

Together they decide how much of a patch keeps interior conditions, and how well it connects to other forest.

Wind and drought stress

Edge trees are more exposed to wind, and the edge is warmer and drier.

An ecotone

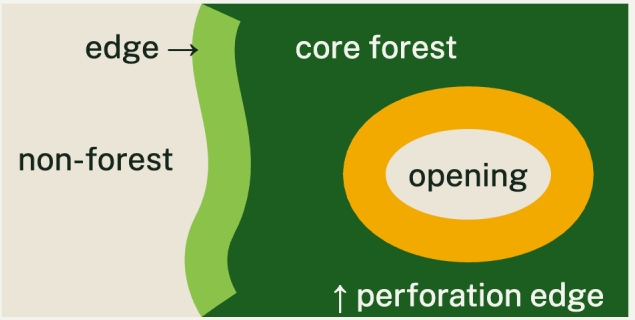
The forest–meadow transition is itself a habitat.

Where forest spreads

Forest advances from the edge into meadows no longer mown or grazed.

Edge = forest within a chosen depth of open land; **core forest** = everything farther in.

Measured with **landscape metrics** on a forest / non-forest map.



RETROFRAG

Two notebooks, one tool

Analysis notebook · set the parameters, Run All

```
In [1]: MODE = "single"            # "single" | "two_dates" | "two_areas"

        # ─── Input maps (forest / non-forest GeoTIFFs) ──────────────────────────────
        MASK_A  = "../outputs/nb3dvar_uc2_2_ruske_k14_0-1-2-3-4-5-6-8_roadveto.tif"      # KH-9 1975
        LABEL_A = "Ruské 1975"

        # Used only by "two_dates" and "two_areas".
        MASK_B  = "../outputs/nb3dvar_uc2_2_ruske_orto2017_pan_k14_0-1-2-3-4-5-6-7.tif"  # orthophoto 2017
        LABEL_B = "Ruské 2017"
        # Demos for "two_areas":
        # MASK_B  = "../outputs/nb6_uc2_4_3x3_havesova_forest_binary.tif"
        # LABEL_B = "Havešová 3×3 km 1975"
        # MASK_B  = "../outputs/nb3dvar_uc2_3_5x5_brzegi_k14_0-1-2-3-4-5-6-7-8-9-11_roadveto.tif"   # KH-9 1975
        # LABEL_B = "Brzegi 1975"

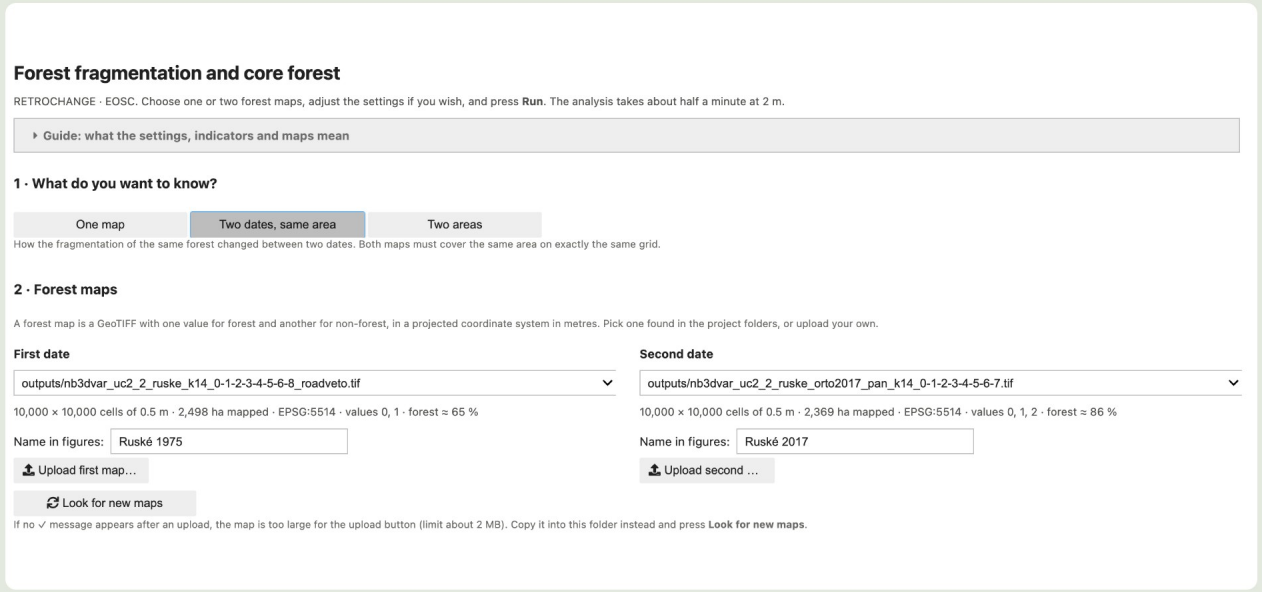
        FOREST_VALUE = 1
        NODATA_VALUE = 255          # used in addition to the no-data value declared in the file

        # ─── Grain ──────────────────────────────────────────────────────────────────
        TARGET_RES_M = 2.0          # cell size for every measurement; a whole multiple of the input pixel
        COVER_MIN    = 0.5          # a coarse cell is forest if >= this share of it is forest

        # ─── What counts as an opening or a patch of forest ─────────────────────────
        MIN_OPENING_HA = 0.1        # openings smaller than this are filled
        MIN_PATCH_HA   = 0.1        # forest patches smaller than this are dropped
        CONNECTIVITY   = 8          # 8 = diagonal neighbours join (FRAGSTATS default); 4 = edges only

        # ─── Core forest and forest area density ────────────────────────────────────
        EDGE_DEPTH_M   = 50         # depth of edge influence (headline)
        REPORT_DEPTH_M = 100        # reported alongside (edge width of the JRC European core-forest index)
        FAD_WINDOW_M   = 675        # side of the forest-area-density window
```

Interface notebook · runs the analysis notebook



Input: forest / non-forest GeoTIFF in metres

Where: EOSC JupyterHub or your own Python

Setup: notebooks and maps in one folder

Start: open the interface notebook, Run All

THE MODES

One tool, three questions

One map

How fragmented is this forest, and how much of it is core forest?

In: one forest map

Two dates, same area

How did its fragmentation change?

In: one area at two dates

Two areas

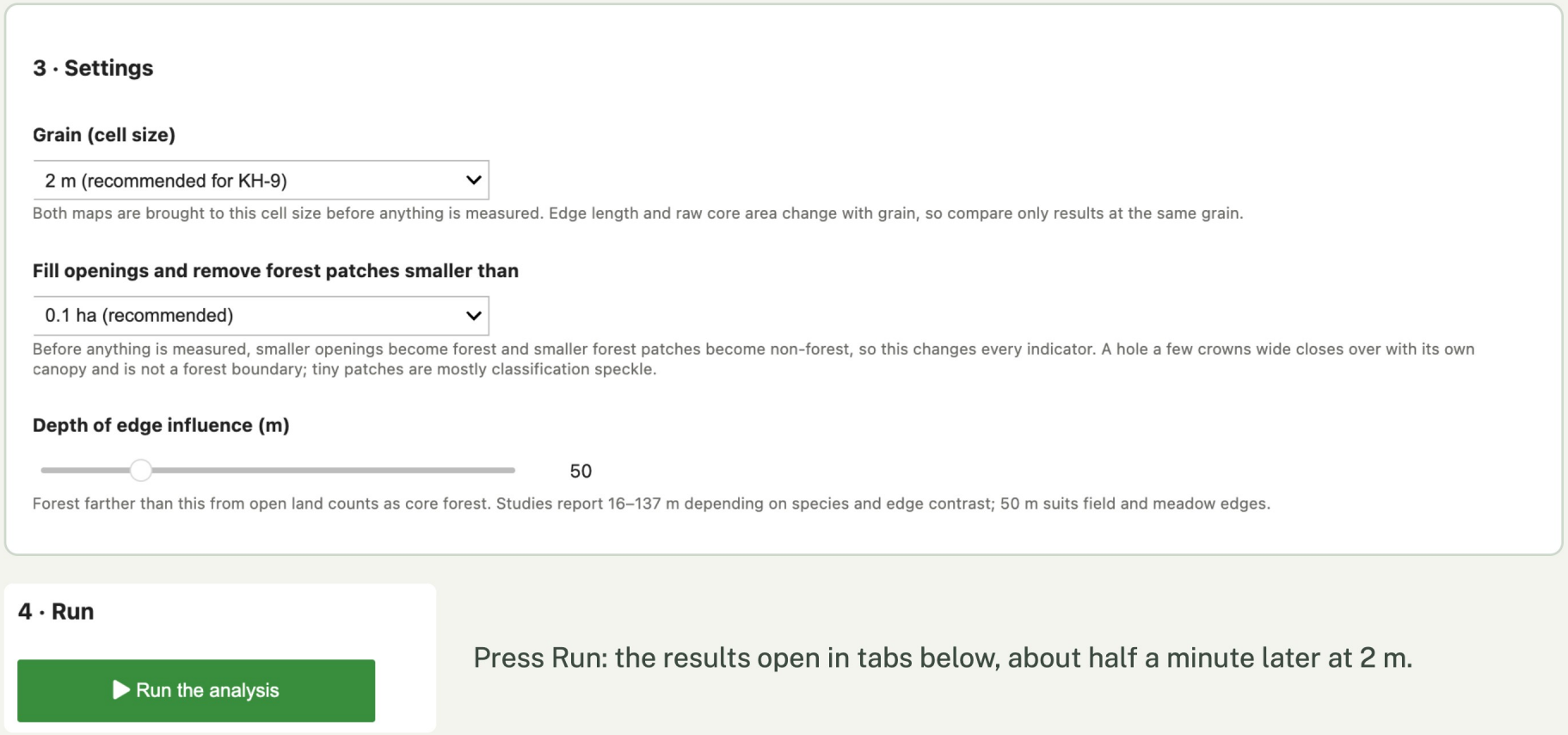
How do two forests differ in fragmentation?

In: two areas at one date

Same indicators in every mode.

THE SETTINGS

Three settings matter most



Press Run: the results open in tabs below, about half a minute later at 2 m.

WHAT IS MEASURED

The indicators and where they come from

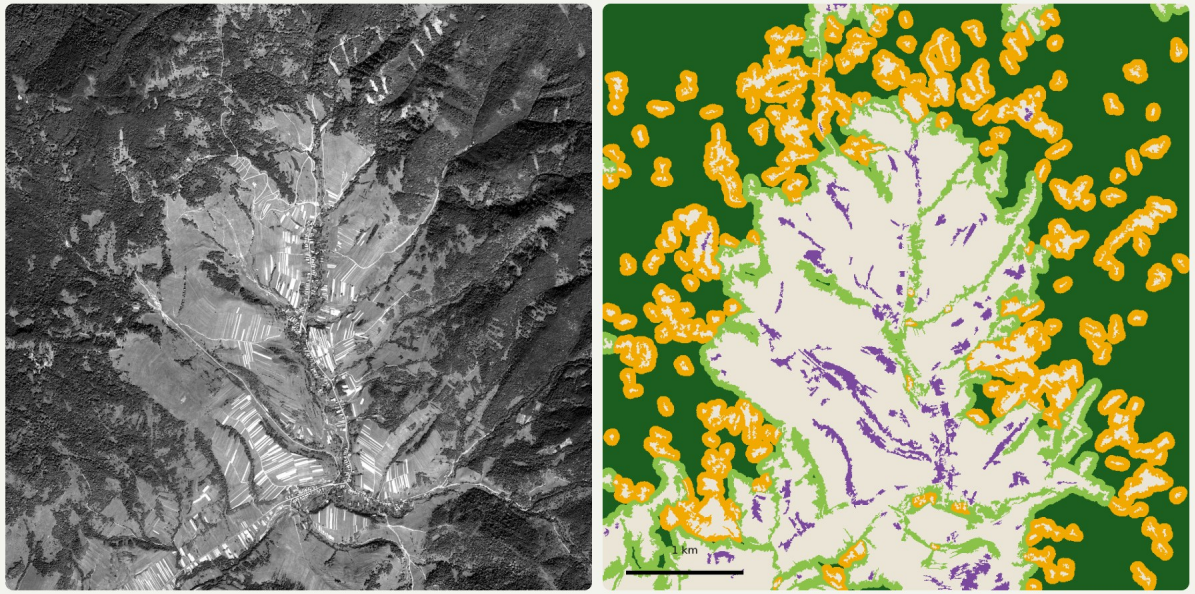
Group	Indicator	What it measures	Source
How much forest	Forest cover	Share of the area that is forest	FRAGSTATS (McGarigal et al. 2012)
How it is divided	Largest patch	Share of forest in its largest patch	FRAGSTATS (McGarigal et al. 2012)
	Mesh size, coherence	How finely the forest is divided	Jaeger 2000; Moser et al. 2007
Edges and core	Edge per forest ha	Forest–open boundary per ha of forest	FRAGSTATS (McGarigal et al. 2012)
	Core forest	Forest > 50 m from open land	Harper et al. 2005; Estreguil et al. 2012
	Morphology	Core, outer edge, perforation, islet	Simplified MSPA (Soille & Vogt 2009)
Surroundings	Forest area density	Forest share in a 675 m window	Riitters et al. 2002; Vogt 2026

Forest cover, largest patch, mesh size, edge density and patch counts match landscapemetrics (Hesselbarth et al. 2019) exactly.

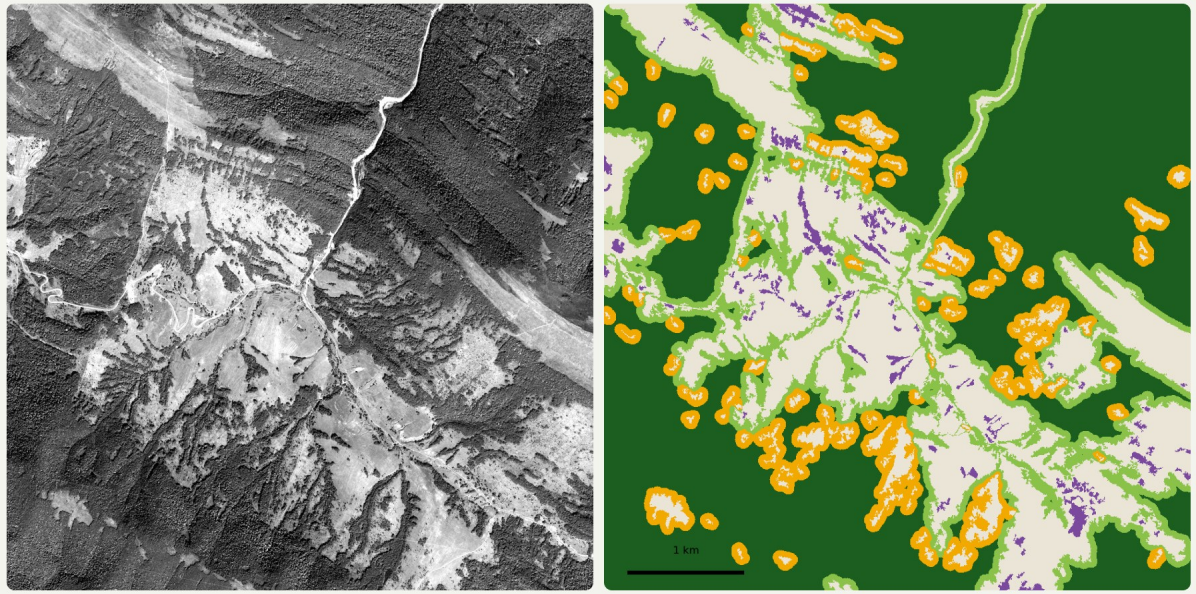
TWO AREAS · 1975 · SAME RULES

Two valleys, two histories

Ruské · a farmed village in 1975



Brzegi · emptied in 1946, then pasture



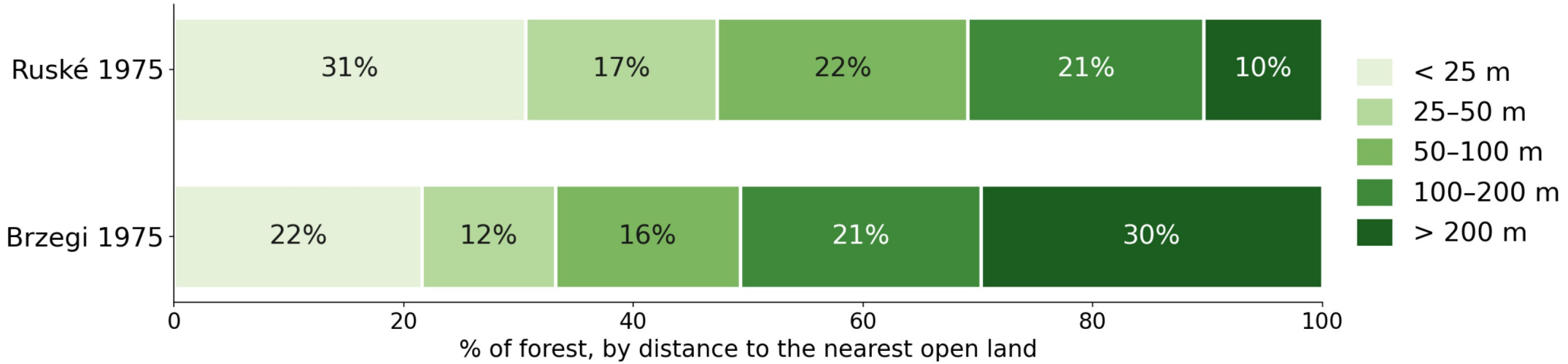
KH-9 Hexagon image | morphology: core forest · outer edge · perforation edge · islet · non-forest

TWO AREAS · 1975

Fragmentation is not one number

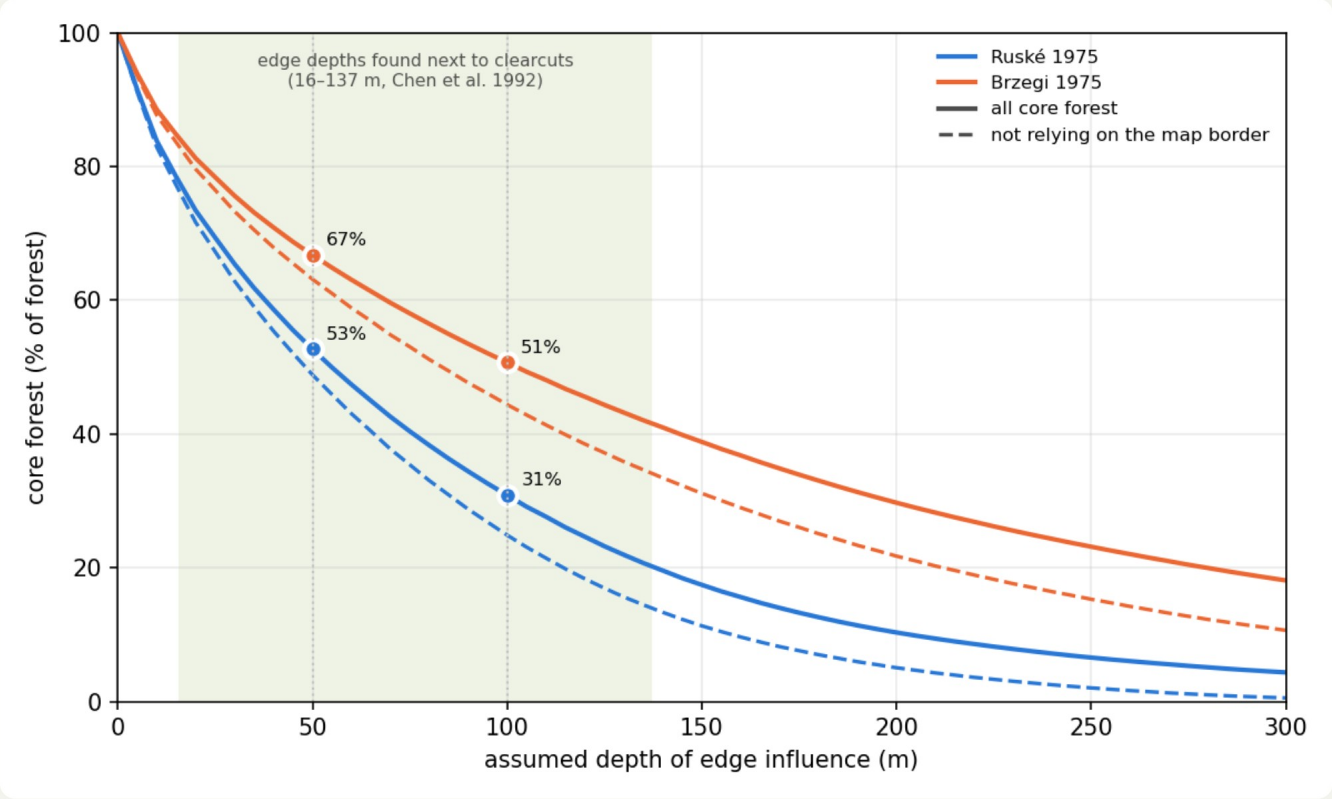
% of forest	Core forest at 50 m	Perforation edge	In the largest patch
Ruské | Brzegi	53 | 67	28 | 13	94 | 60

How deep is the forest?



TWO AREAS · 1975

Core forest depends on the edge depth you assume



Edge depth	Ruské	Brzegi
50 m	53 %	67 %
100 m	31 %	51 %

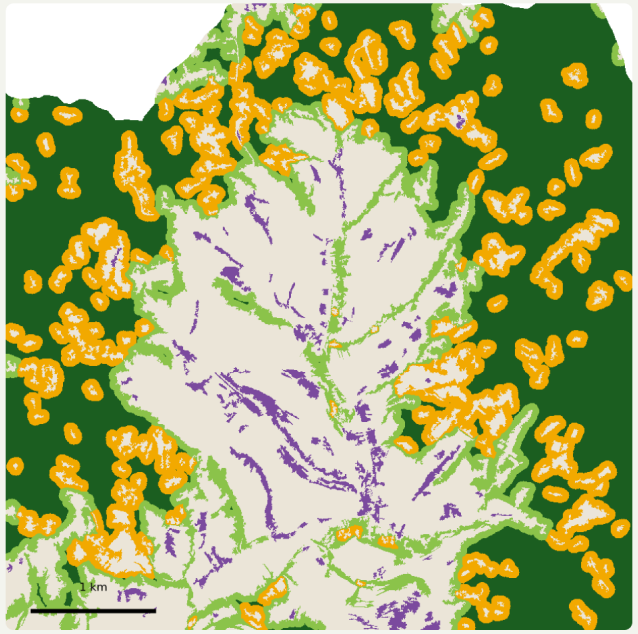
Edge effects on forest structure and air temperature reach different depths in different forests (Chen et al. 1992; Meeussen et al. 2020, 2021). The order of the two areas holds at every depth.

TWO DATES · RUSKÉ 1975 → 2017

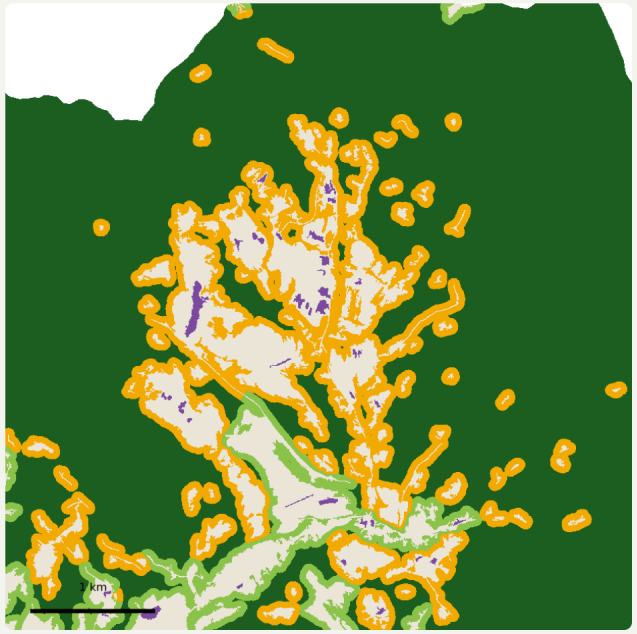
After resettlement: less fragmentation

1980–1986: seven villages were resettled for the Starina drinking-water reservoir. Ruské was the last.

1975



2017



core forest · outer edge · perforation edge · islet · non-forest

64 → 87 %
forest cover

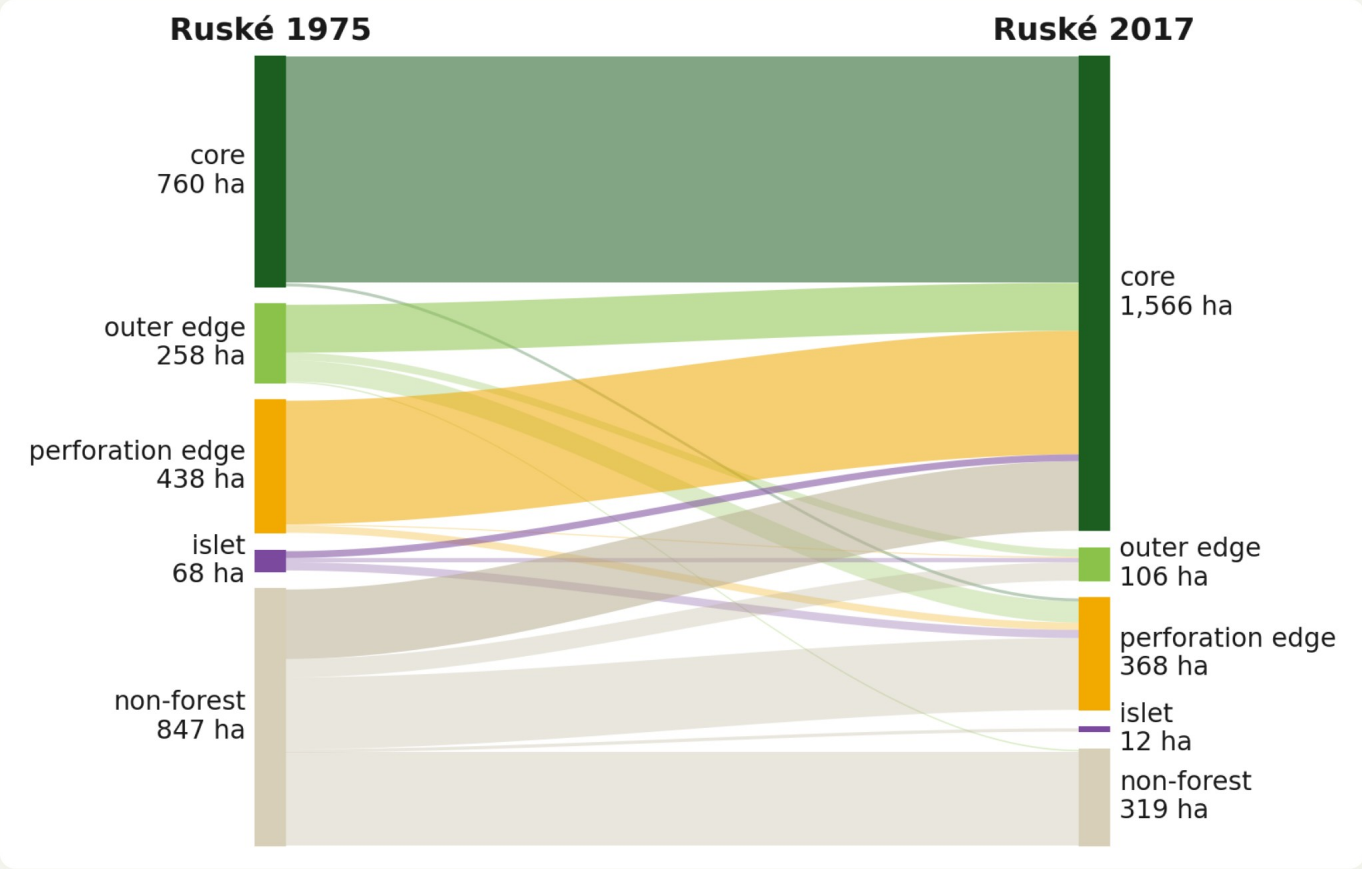
93 → 99 %
of forest in the largest patch

50 → 76 %
core forest at 50 m

290 → 103 m
edge per ha of forest

TWO DATES · RUSKÉ 1975 → 2017

98 % of the core stayed core for 42 years



98 % of the 1975 core is still core in 2017: 746 ha, 31 % of the area

13 ha of the 1975 core is now within 50 m of an edge

+820 ha new core around it, mostly where openings closed

KEEP IN MIND

Less fragmented is not always better.

Openings in a forest can themselves be valuable habitats, such as mountain hay meadows (Natura 2000, 6520). When mowing stops, forest closes them, and the indicators read that as less fragmentation.

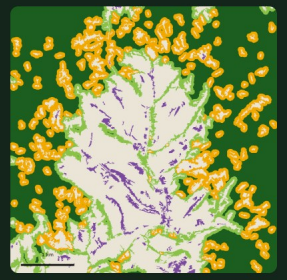
SYNTHESIS

Land-use history shows up in the indicators

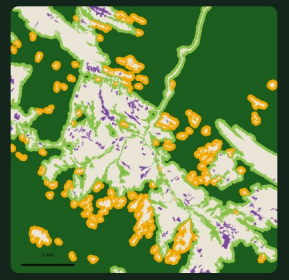
two areas

5 × 5 km each

1975: Ruské's forest was one patch with many openings;
Brzegi, emptied in 1946, had more core forest in larger blocks.



Ruské · core 53 %

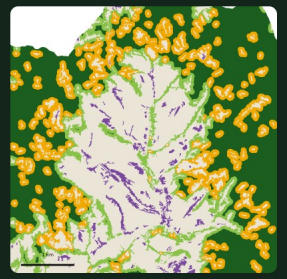


Brzegi · core 67 %

two dates

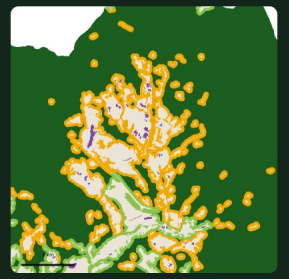
national-park part
2,371 ha

Ruské 1975 → 2017: less fragmentation after resettlement;
98 % of the 1975 core is still core.



1975 · core 50 %

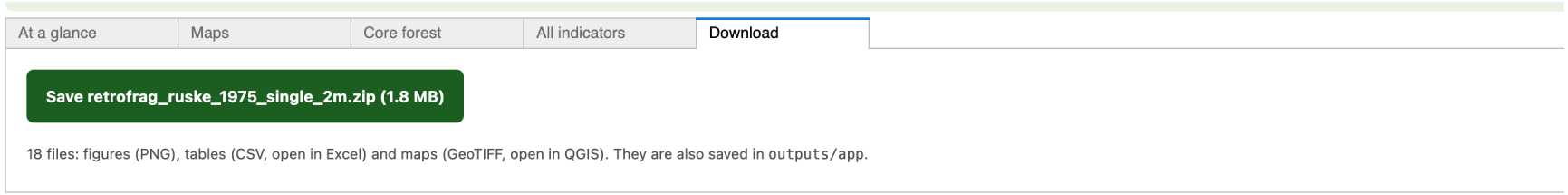
→



2017 · core 76 %

DELIVERY

What one run gives you



Maps

Forest, morphology and forest-density GeoTIFFs, with QGIS styles

Indicator table

Every value as CSV, with the rules it was measured under

Figures

At a glance, the fragmentation profile, the core-depth curve

Checks

Optional: how results move with grain and with the minimum opening size

README

Settings, inputs and software versions

User guide

What every setting, index and map means

RETROCHANGE · USE CASE

Thank you for your attention

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BACKUP

Sources

METHODS

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BACKUP

Sources (continued)

METHODS

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Riitters, K.H., Wickham, J.D., O'Neill, R.V., Jones, K.B., Smith, E.R., Coulston, J.W., Wade, T.G. & Smith, J.H. (2002). Fragmentation of continental United States forests. *Ecosystems* 5(8): 815–822.

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DATA

Orthophoto 2017: ZBGIS, Slovakia.