GuidosToolbox Workshop

Part 2: Pattern (M)SPA

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The workshop will address the following topics:

GWS 1: Introduction/motivation for new ways of image analysis

GWS 2: Pattern Analysis (M)SPA

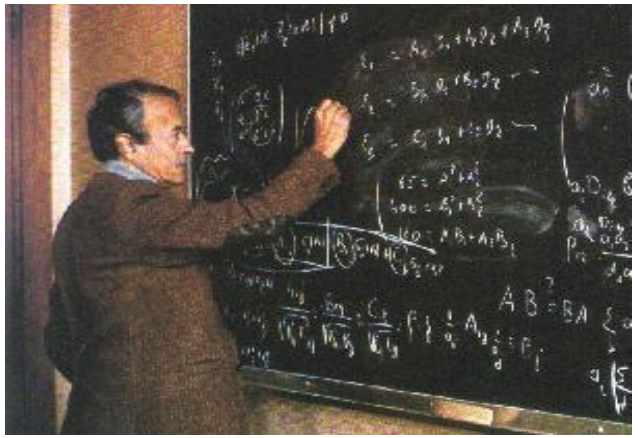
GWS 3: GuidosToolbox: program features and processing options

GWS 4: Hands-on examples using training data:

a) Data preparation, MSPA, Google Earth overlays, batch process

b) Distance, fragmentation, network, restoration, change, …

MSPA: Background

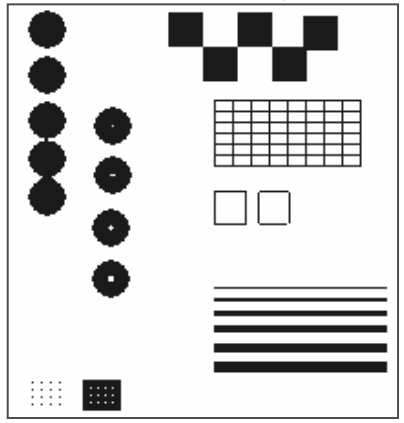


Georges Matheron (1930-2000):
Geostatistics (kriging),
Mathematical Morphology

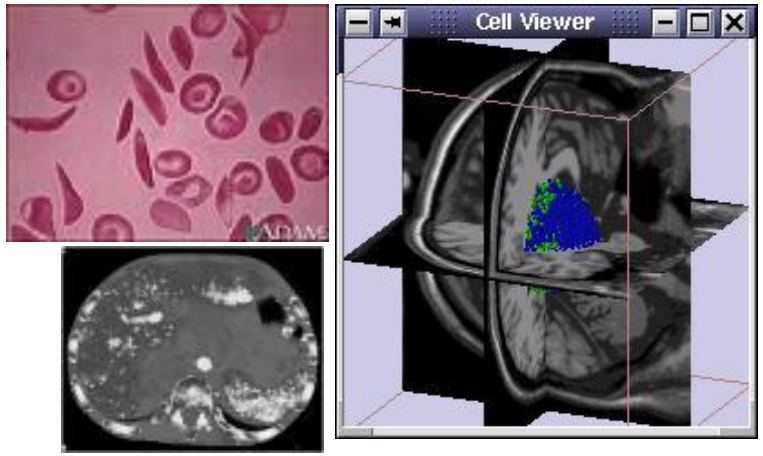
Pierre Soille (JRC)

Based on Set Theory: analyze-detect shape/structure/connectivity

Geometry



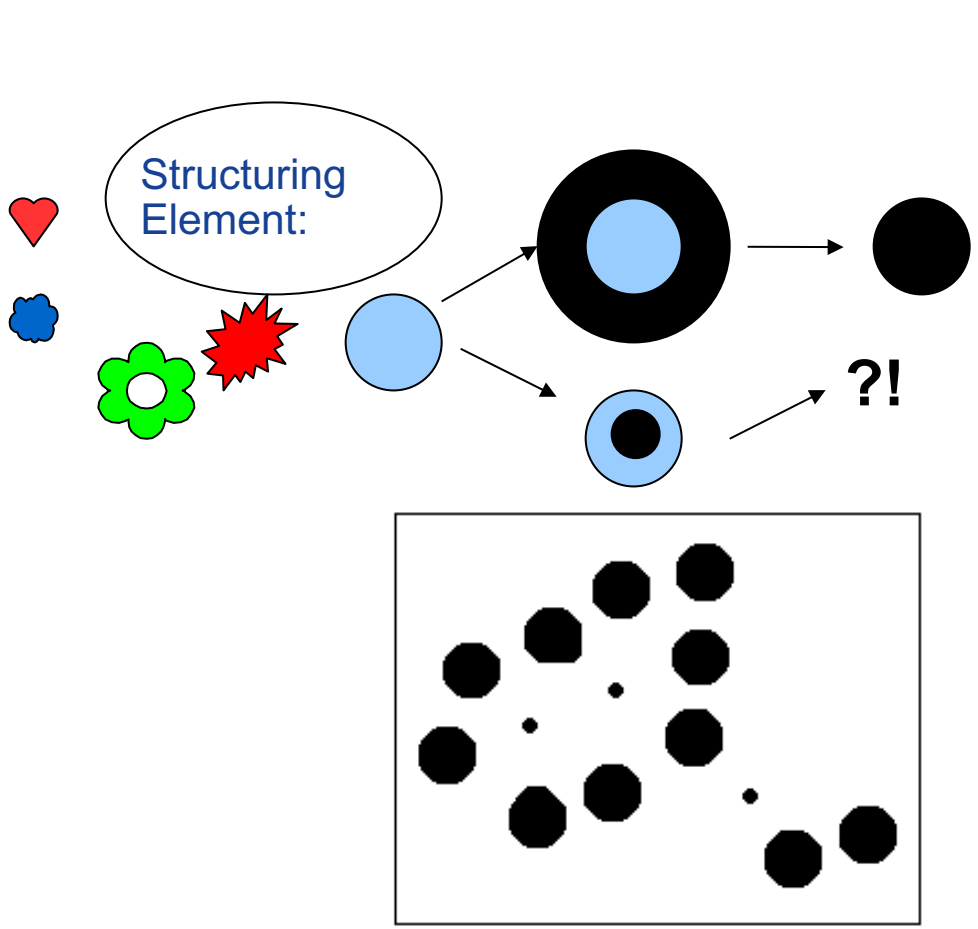
Medical Applications



Detect & analyze catchments; oil spills; vessels; mines; facial- fingerprint- character- recognition (security, fax); robotics; biology astronomy …

Now ecosystems!

Basic morphological filters

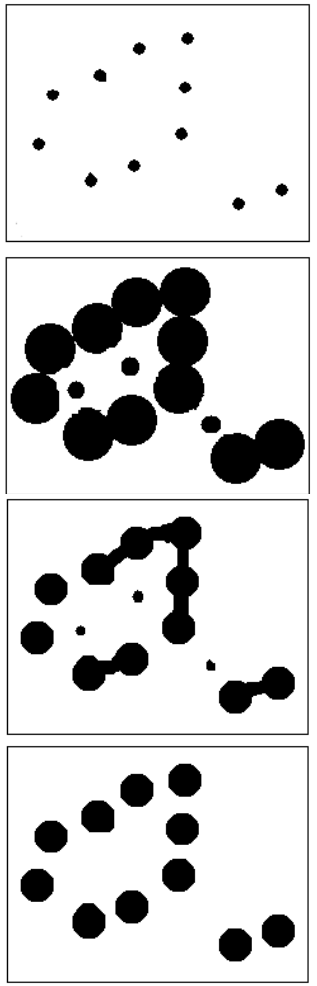


Erosion (shrink) →

Dilation (grow) →

Morph_close = Erosion(Dilation) →

Morph_open = Dilation(Erosion) →



Implementation principle (simple 4-class scheme)

1. CORE: erosion of forest mask

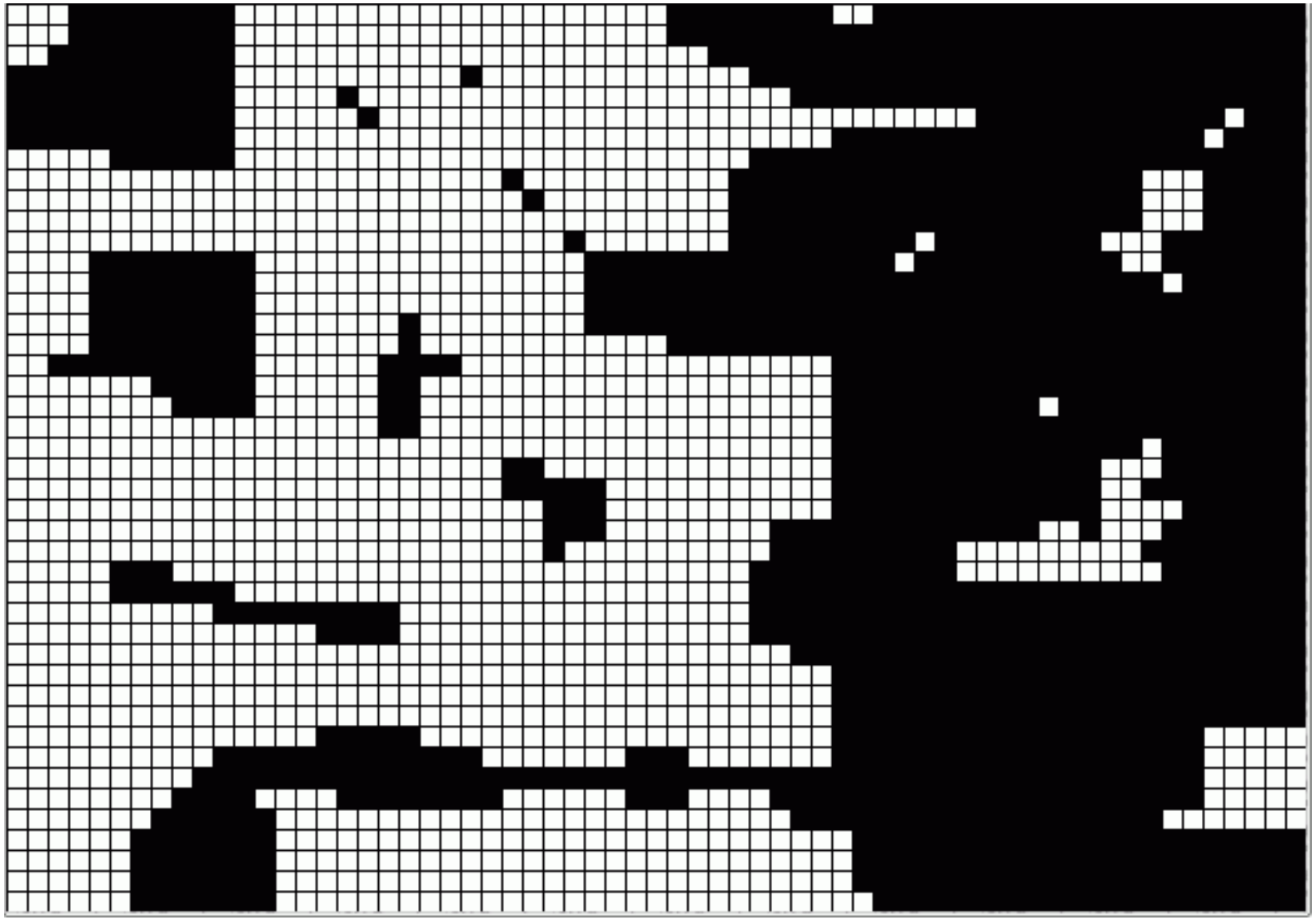
2. ISLET: morphological reconstruction of forest mask: opening; dilations, difference to original forest mask

3. EDGE: forest mask - erosion = *buffer zone*, intersect with flood-fill from outside the image (wet background)

4. PERFORATED: dry background

Segmentation steps

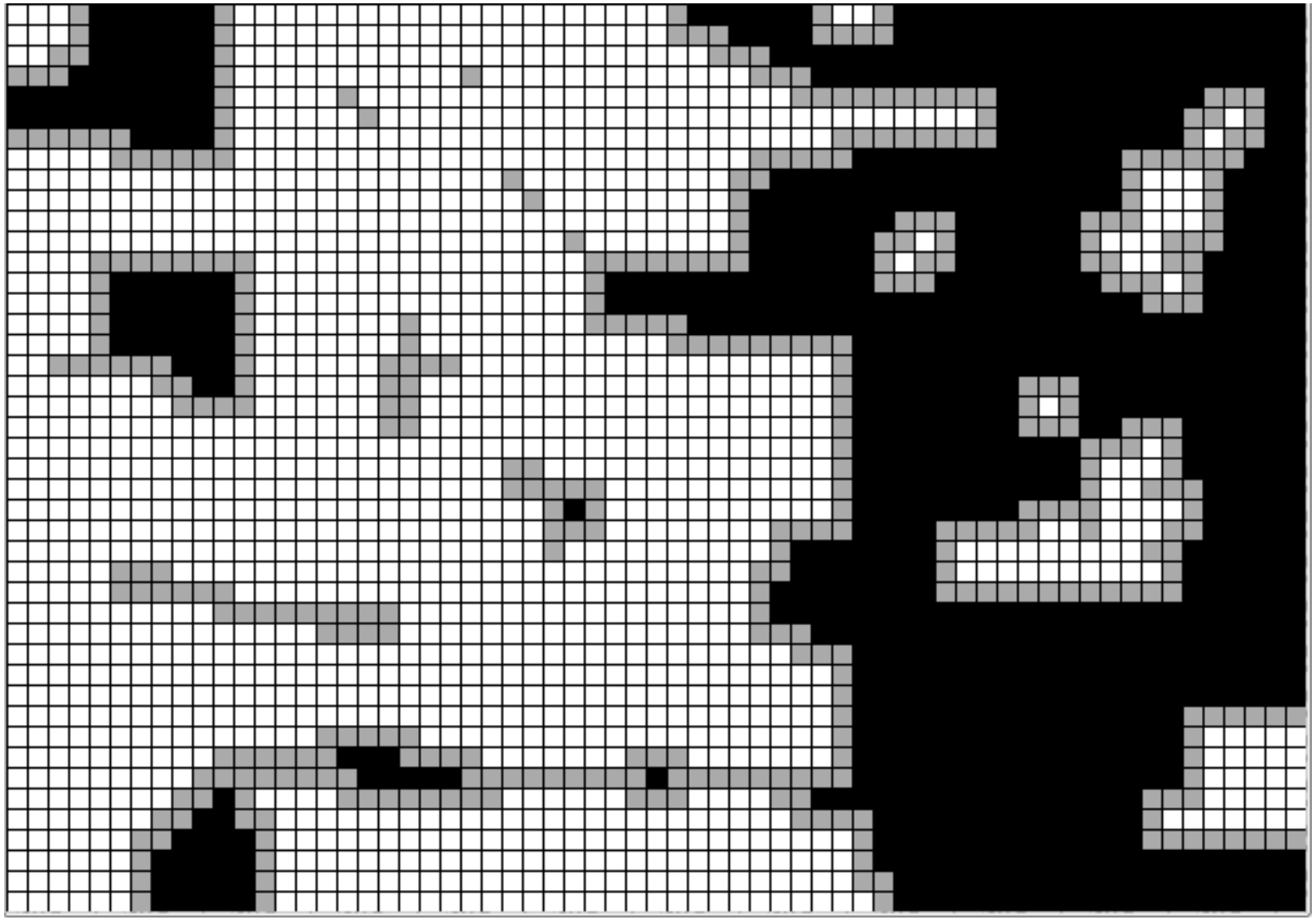
1. CORE: Step 0: starting with forest mask: forest – black; nonforest – white



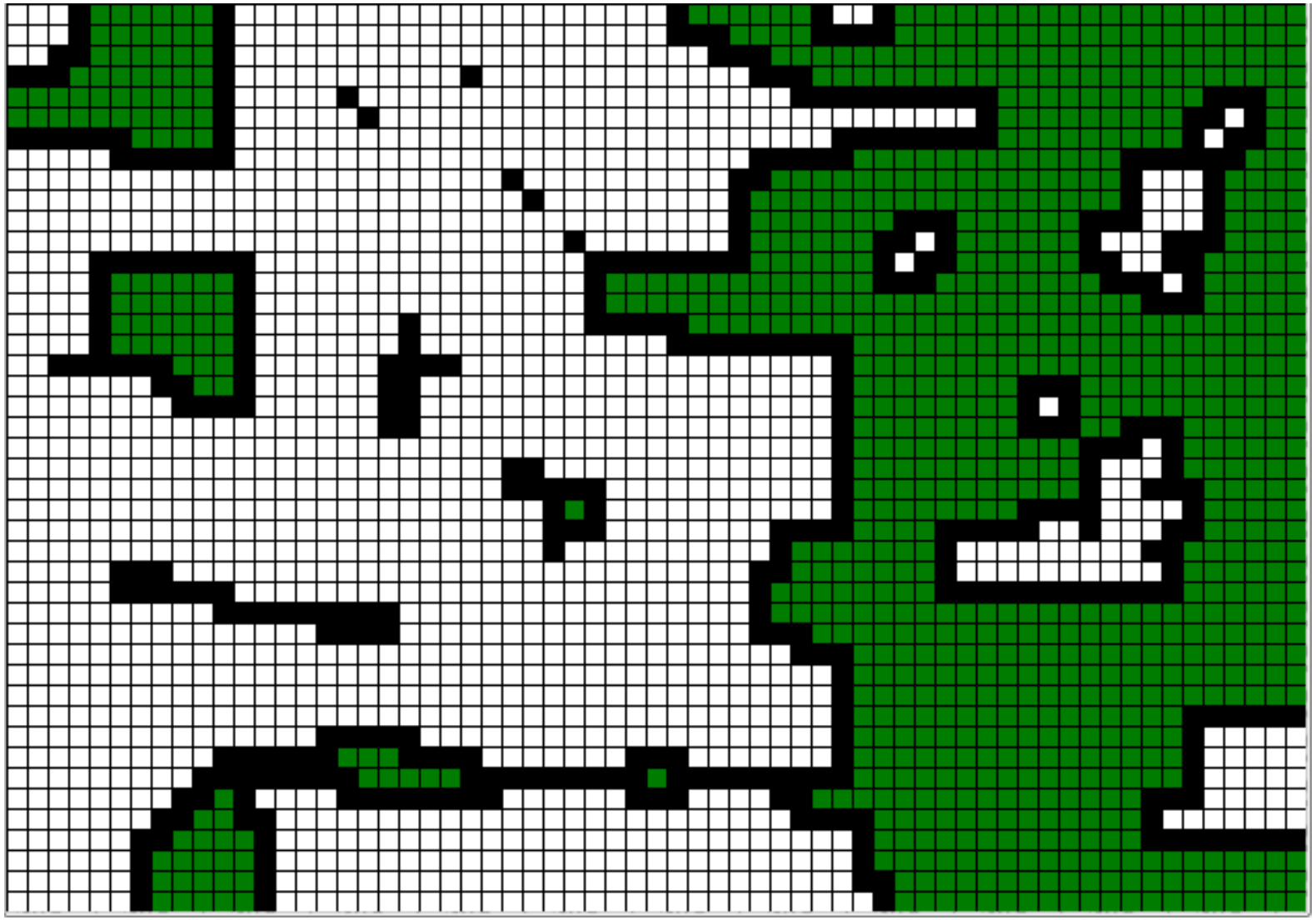
Segmentation steps

1. CORE: Step 1: erosion (forest mask)

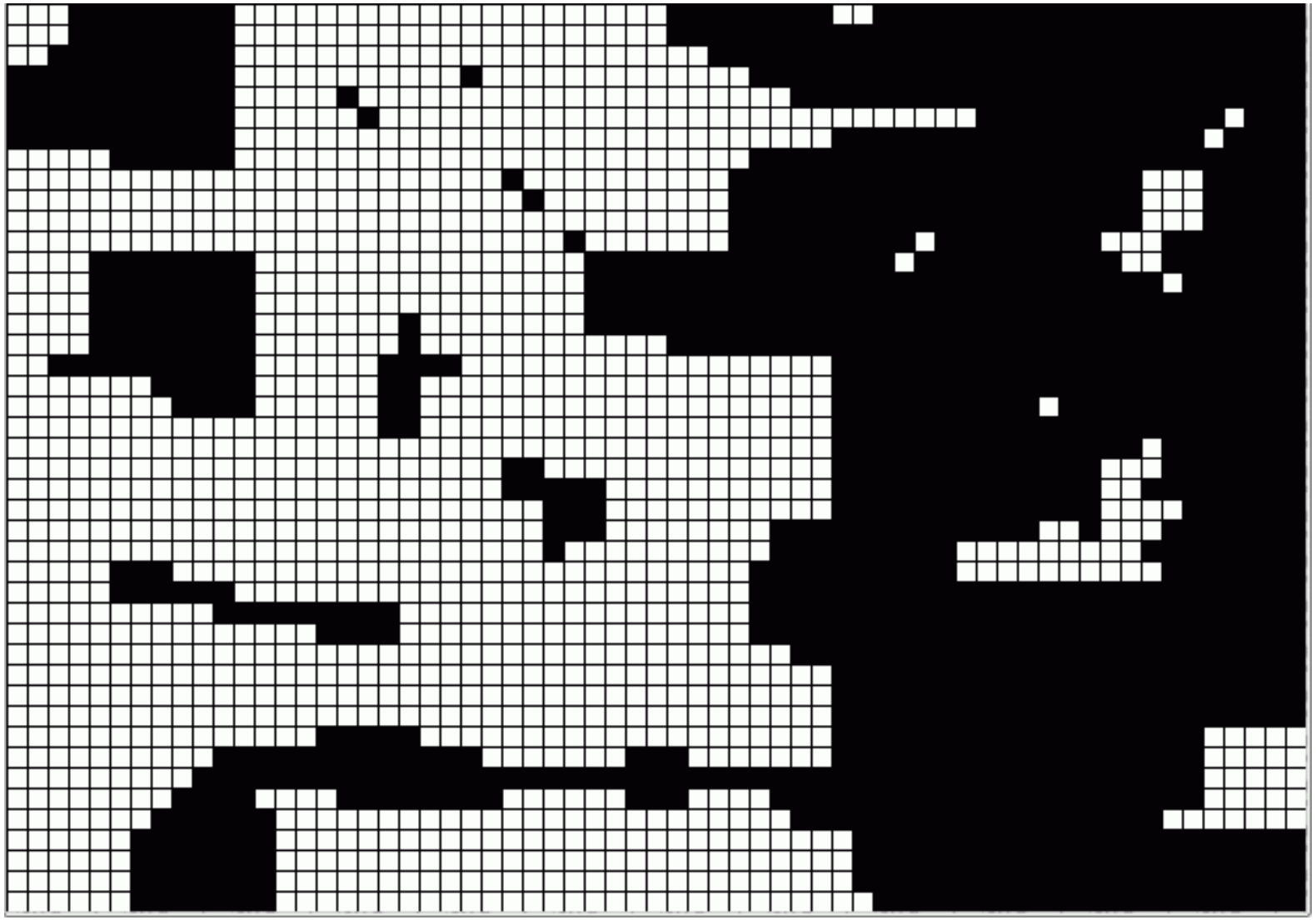
■ - removed forest pixels (buffer zone)



1. CORE: Result: forest mask – erosion (forest mask) showing CORE forest pixels



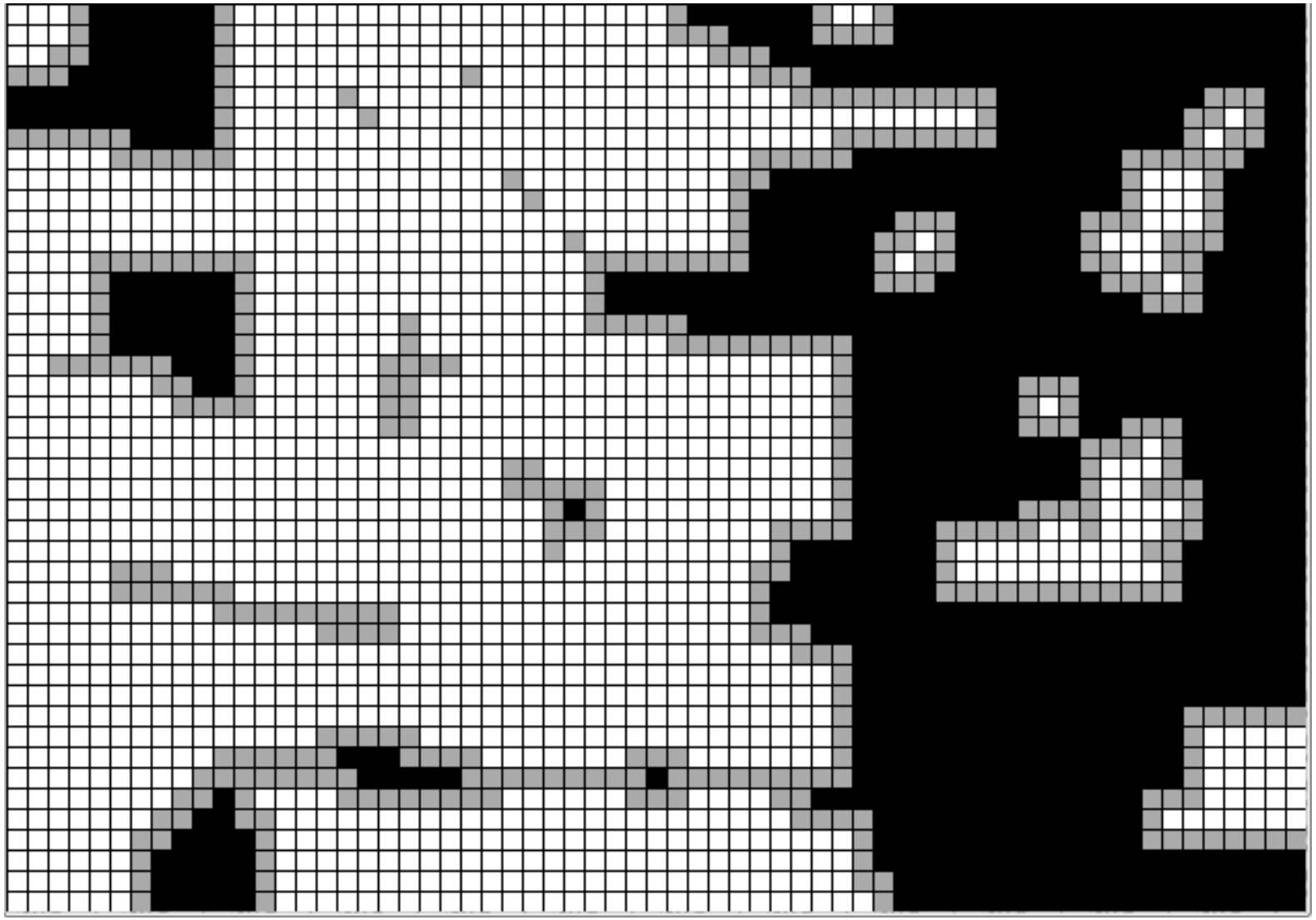
2. ISLET: Step 0: starting with forest mask: forest – black; nonforest - white



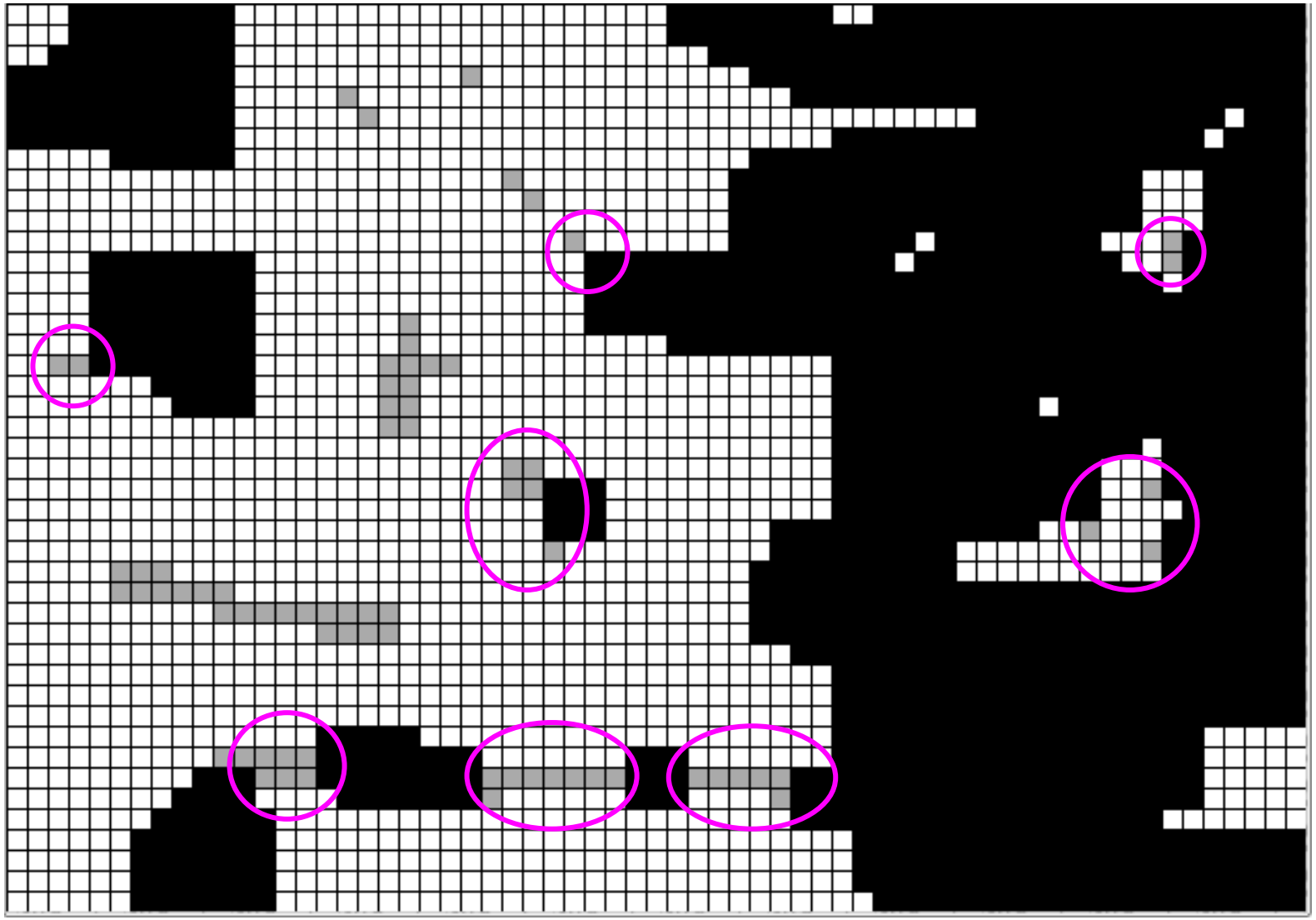
Segmentation steps

2. ISLET: Step 1: erosion (forest mask). Note:

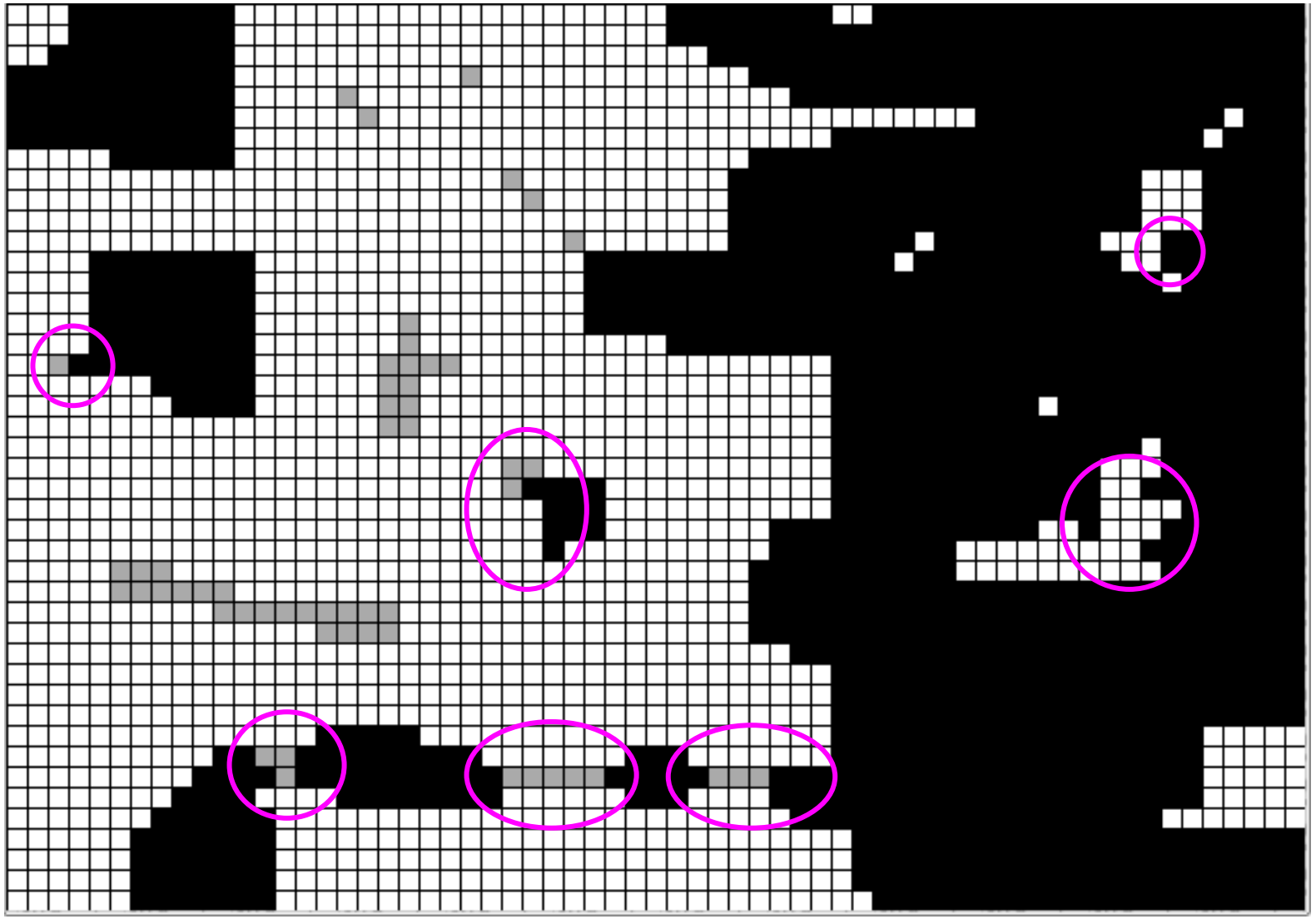
■ - removed forest pixels, including all ISLET pixels



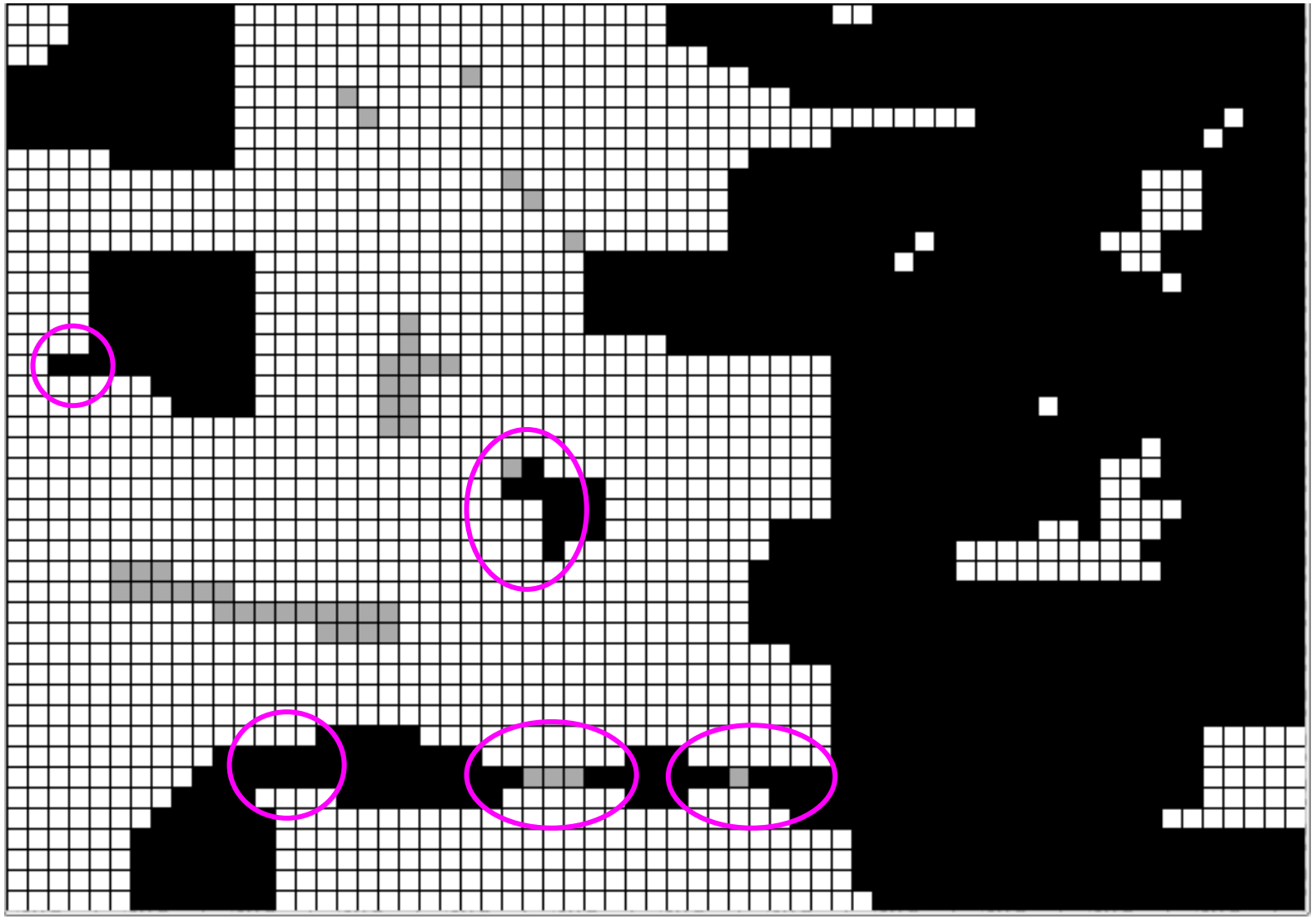
2. ISLET: Step 2: dilation (Step 1)
⇔ morph_open (forest mask)



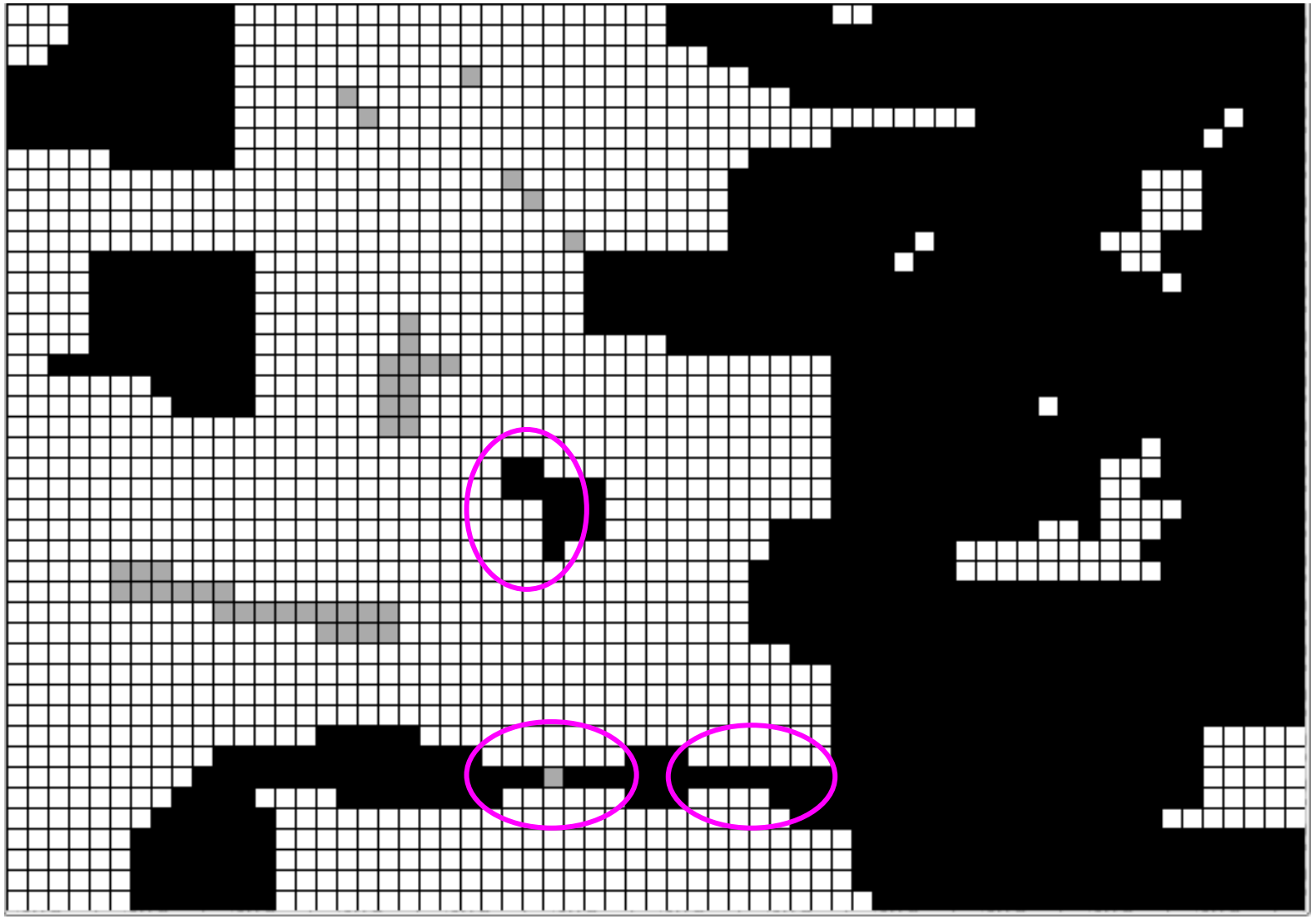
2. ISLET: Step 3: dilation (Step 2) * forest mask
⇔ morph_reconstruction (forest mask)



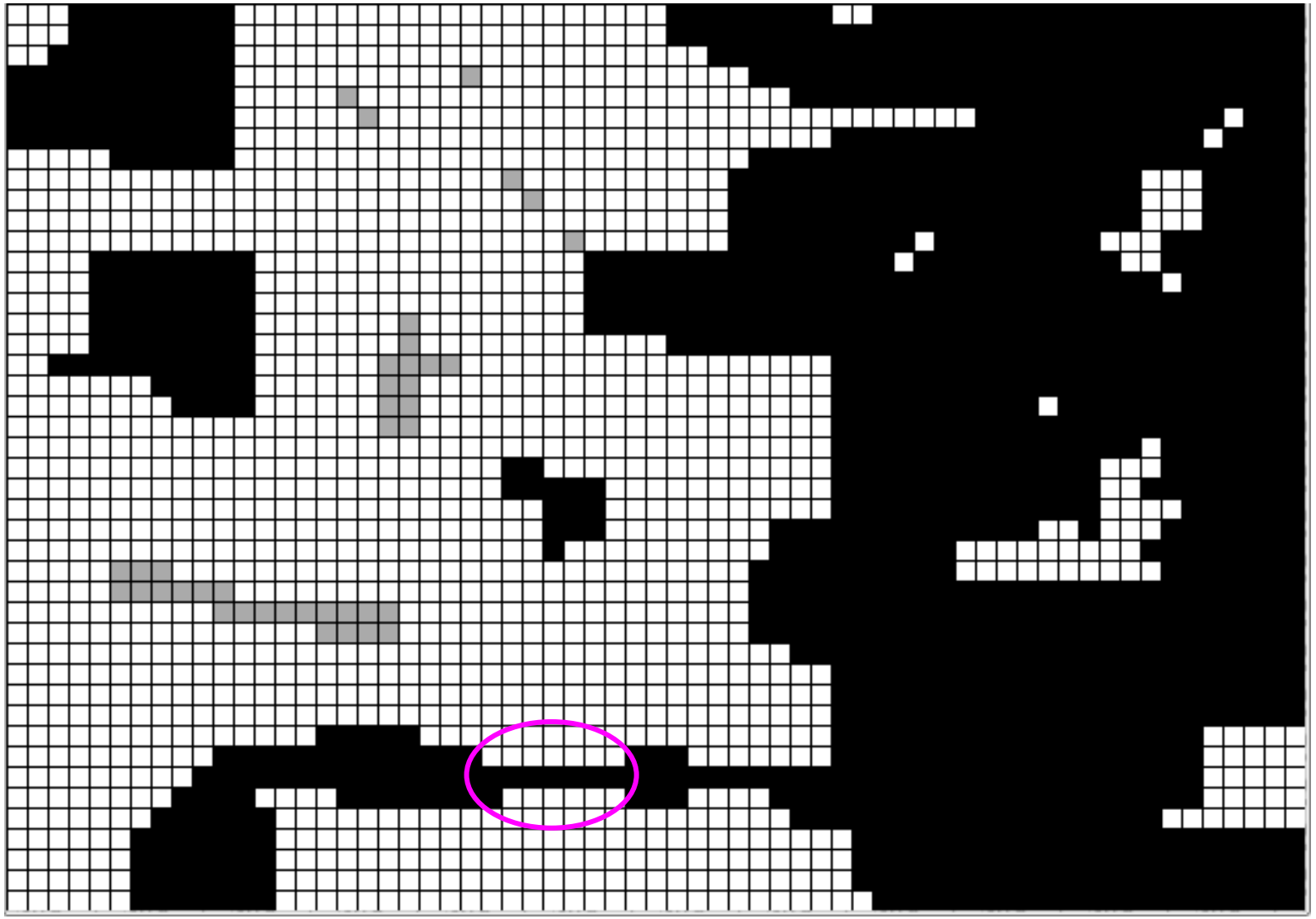
2. ISLET: Step 4: dilation (Step 3) * forest mask
⇔ morph_reconstruction (forest mask)



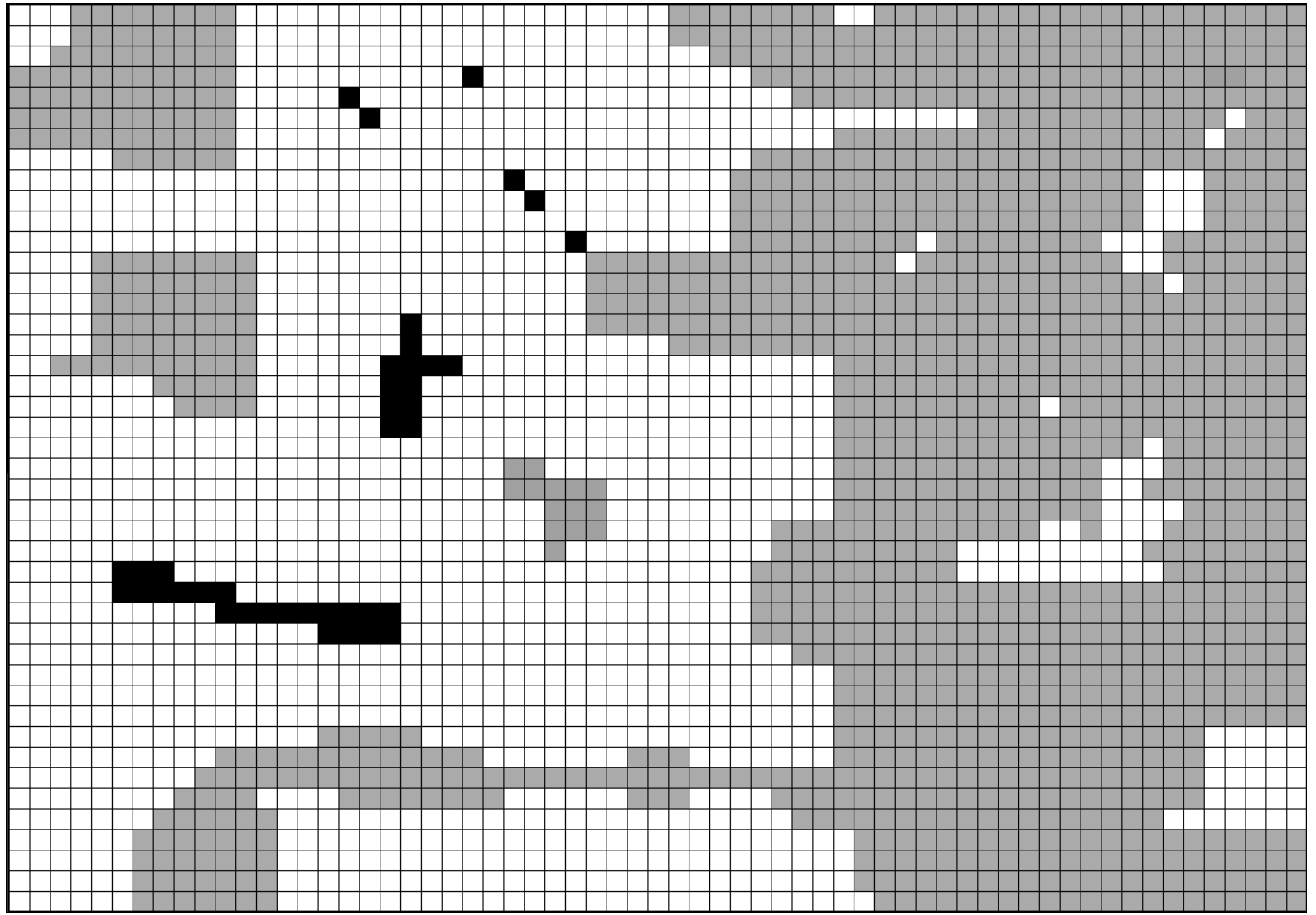
2. ISLET: Step 5: dilation (Step 4) * forest mask
⇔ morph_reconstruction (forest mask)



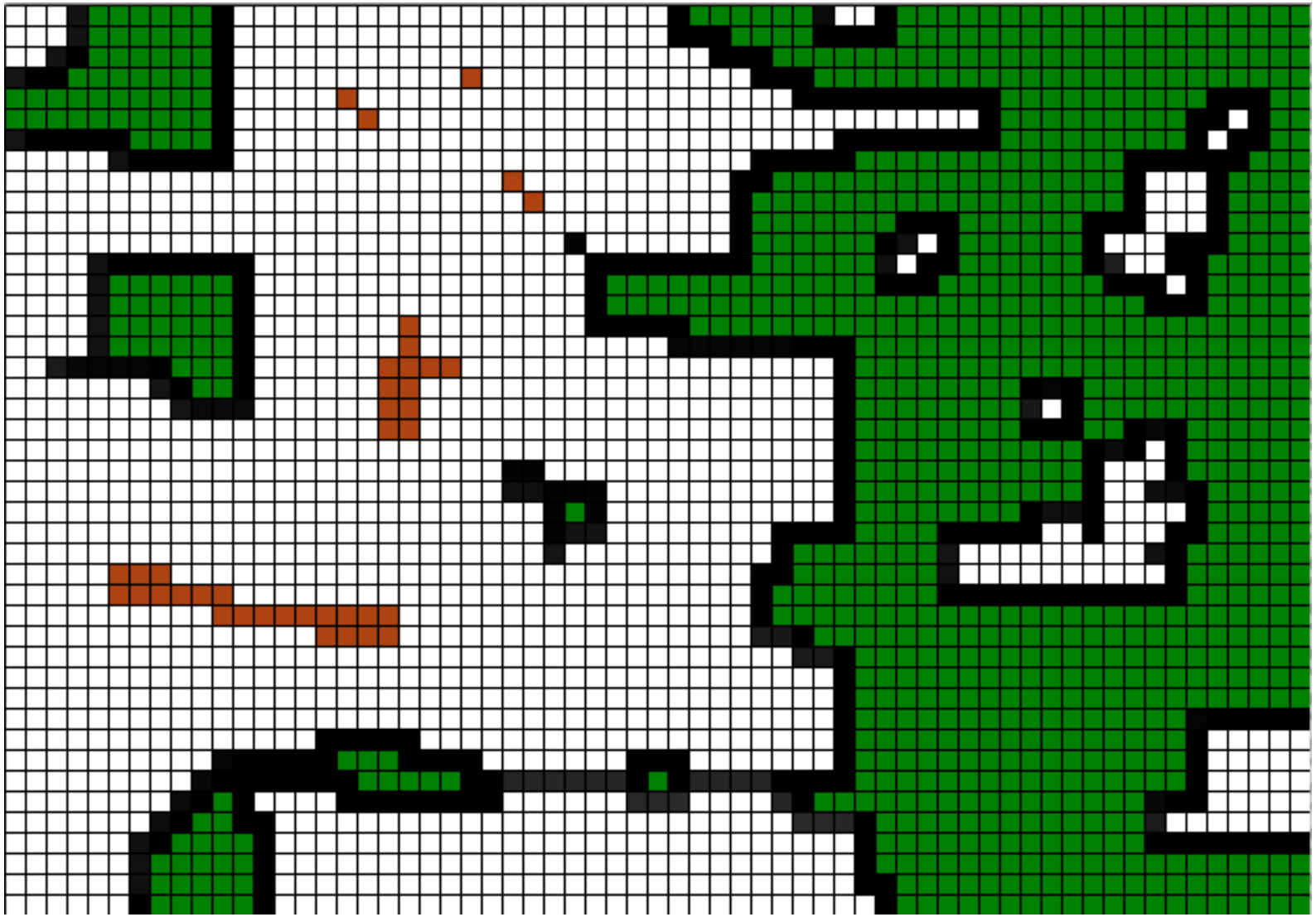
2. ISLET: Step 6: dilation (Step 5) * forest mask ⇔ idempotence ⇔ mask: forest – forest patch



2. ISLET: Step 7: difference: forest mask – Step 6

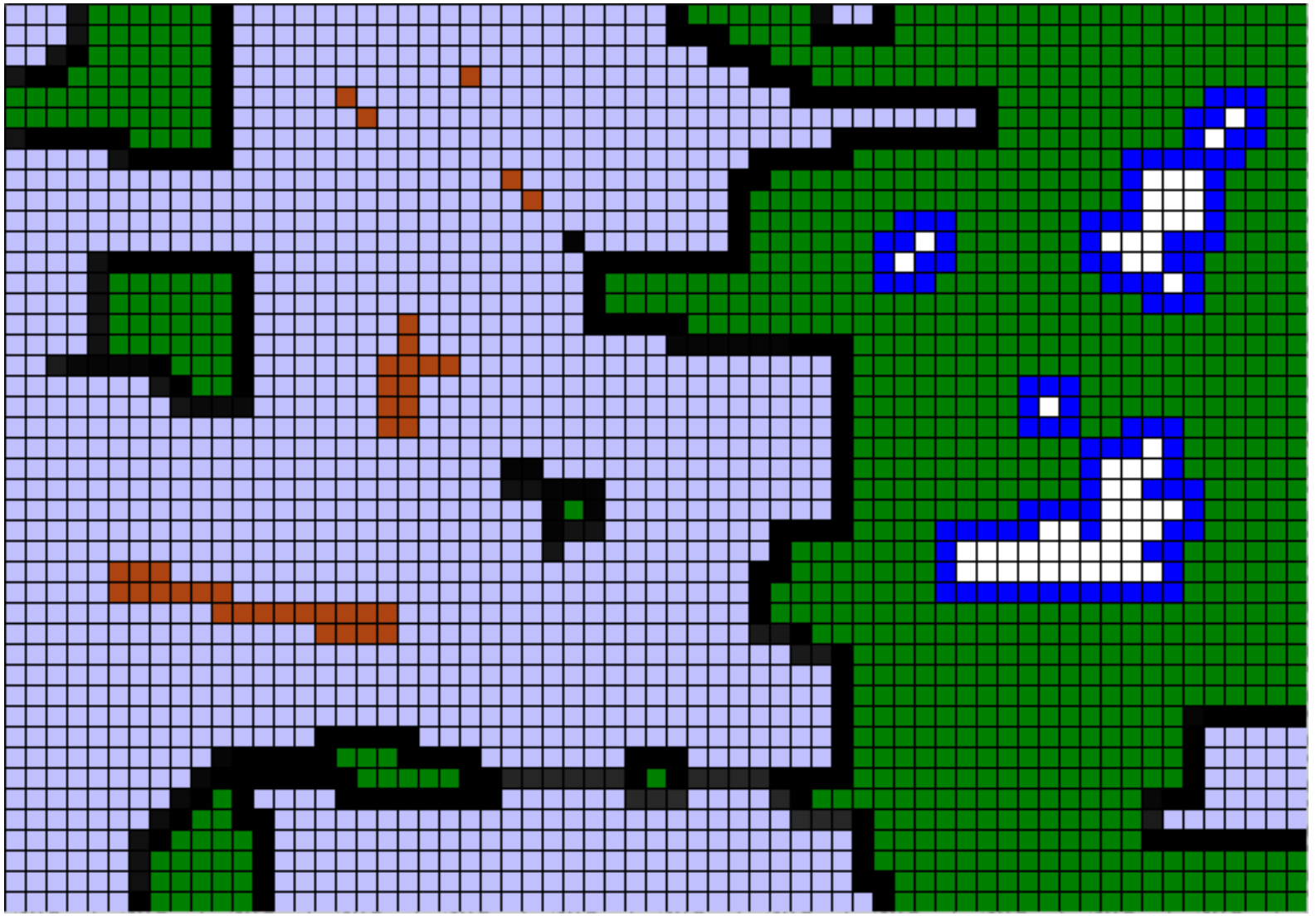


2. ISLET: Result: forest mask showing CORE + ISLET forest pixels



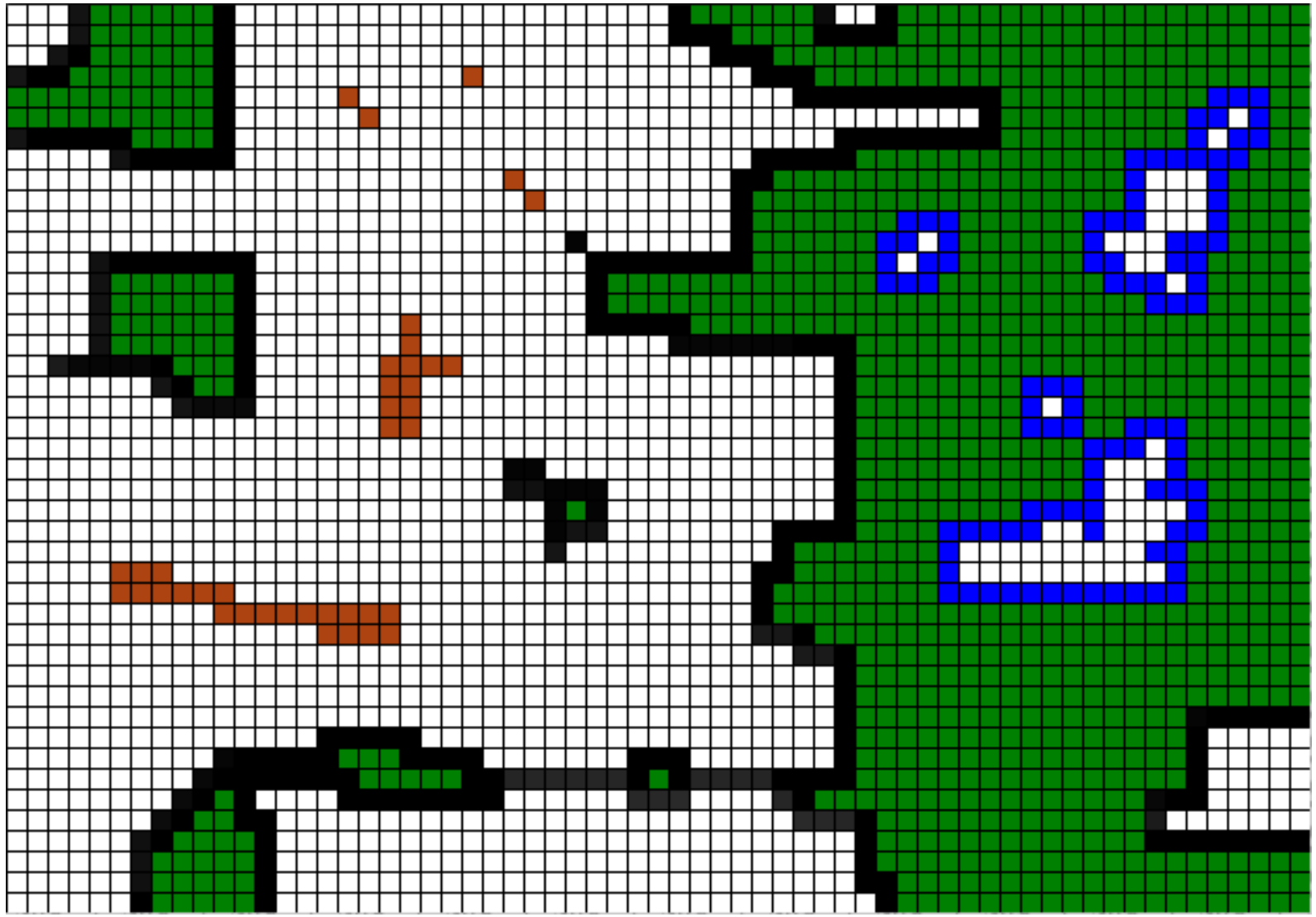
Segmentation steps

3. EDGE: flood-fill the background from outside image boundaries:
   EDGE: *wet background* PERFORATED: *dry background*

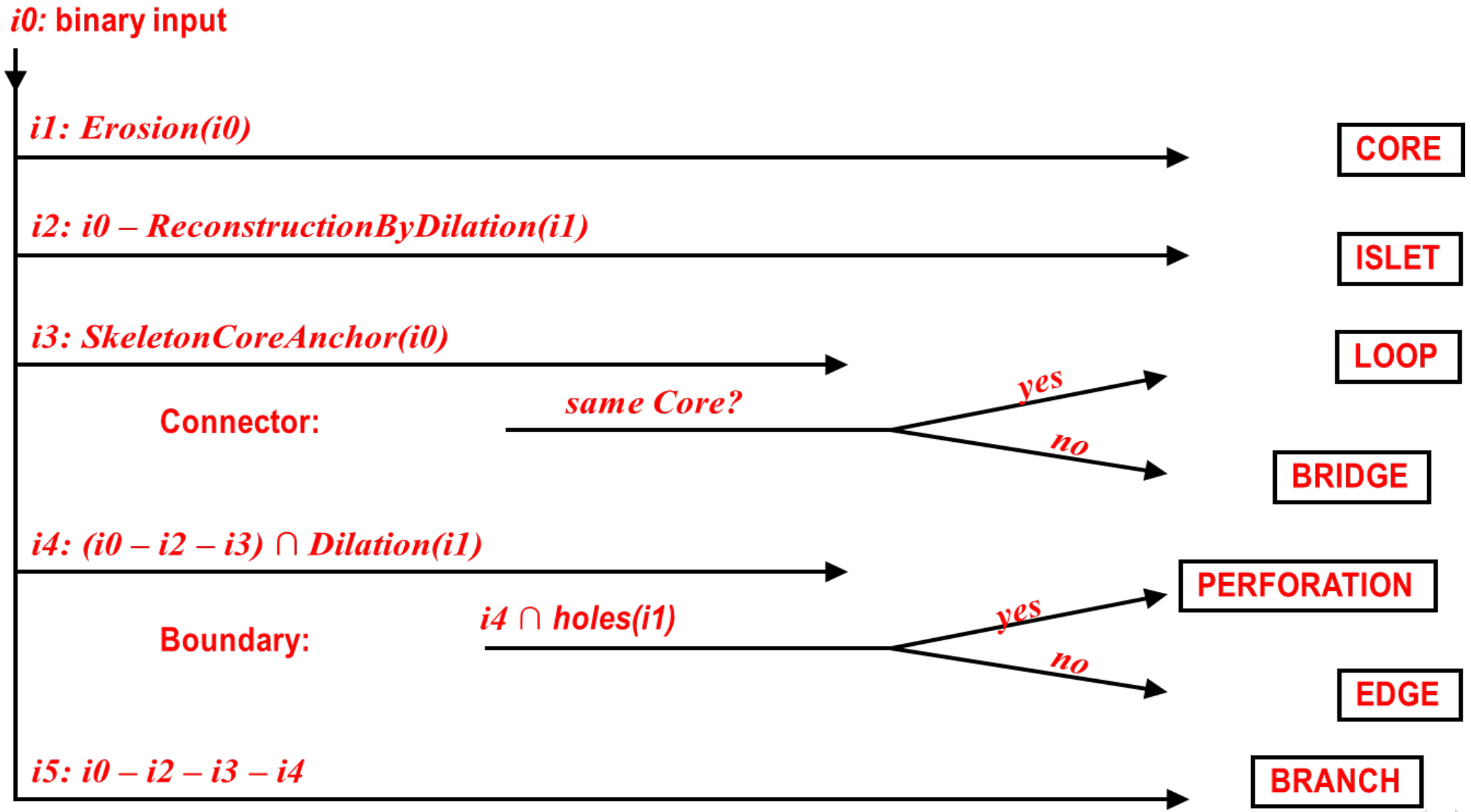


Segmentation steps

Result: CORE + ISLET + EDGE + PERFORATED forest pixels



Segmentation steps, MSPA



Homotopic shrinking:

Skeleton of an object maintaining the information of its shape (topology)

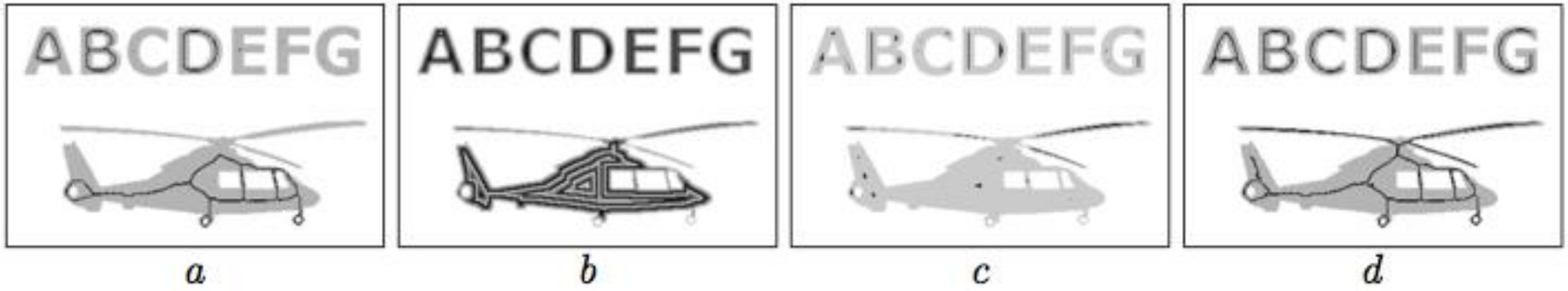
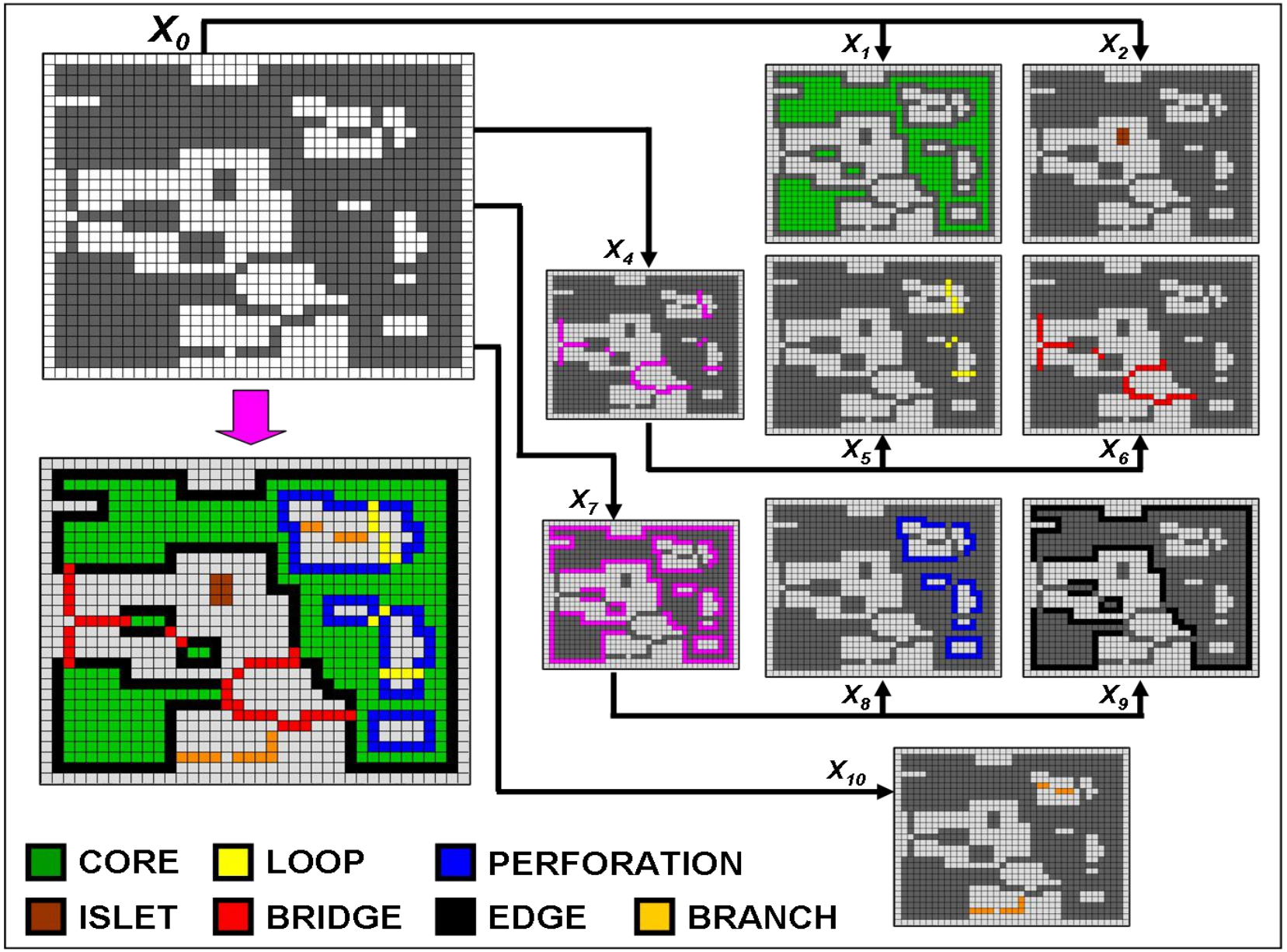


Fig. 4. Anchored order-independent skeletonisation for $\mathcal{G} = 8$: a - skeleton without anchors (homotopic marking), b - 8-connected distance function, c - regional maxima of the distance function, d - anchored skeleton.

Iwanowski & Soille, 2005: Computer Analysis of Images and Patterns, Lecture Notes in Computer Science, Volume 3691/2005, 538-545, DOI: 10.1007/11556121_66

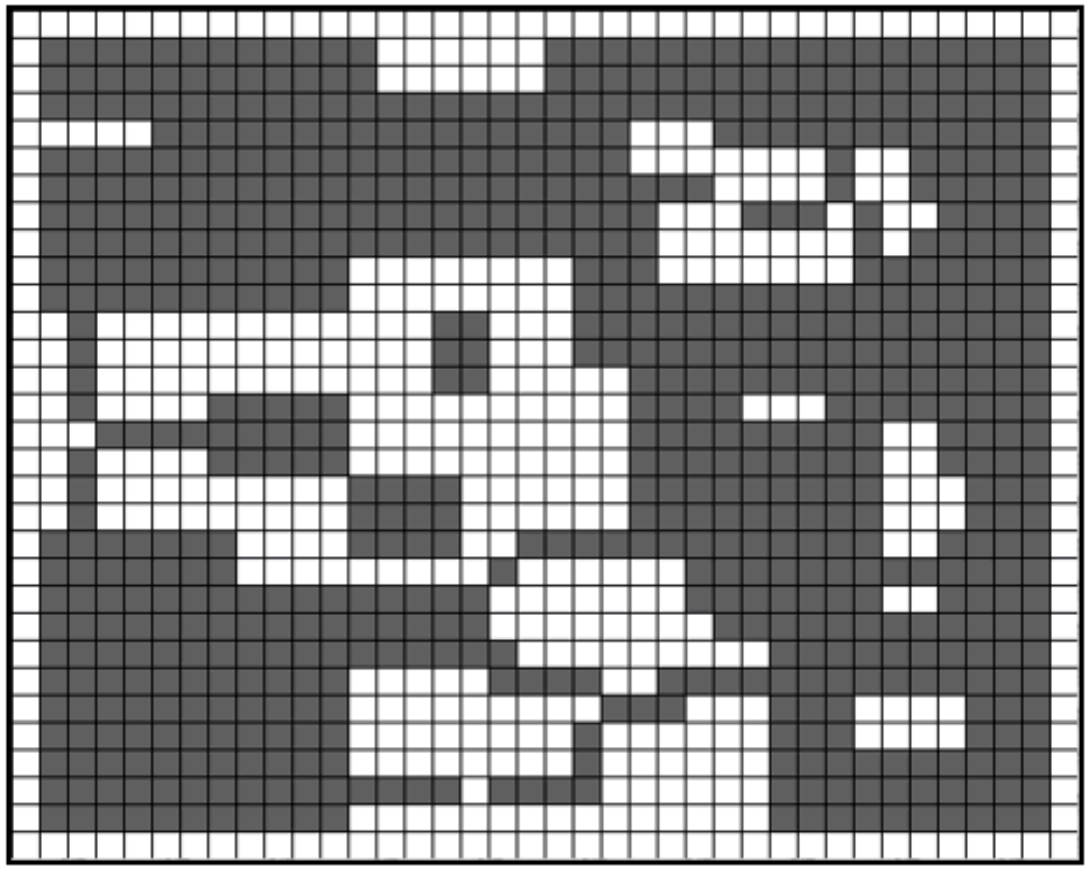
Segmentation steps



MSPA: FG/BG-Segmentation

INPUT: binary map

- Foreground: objects of interest
- Background: complementary area



MSPA foreground classes

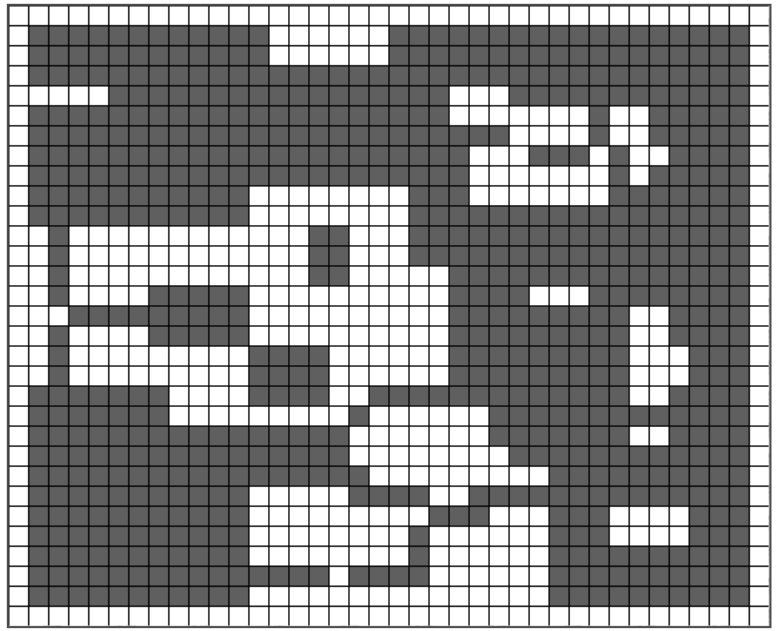
- Core: interior area excluding perimeter
- Islet: disjoint and too small to contain Core
- Loop: connected to the same Core area
- Bridge: connected to different Core areas
- Perforation: internal object perimeter
- Edge: external object perimeter
- Branch: connected at one end to Edge, Perforation, Bridge, or Loop.

MSPA background classes

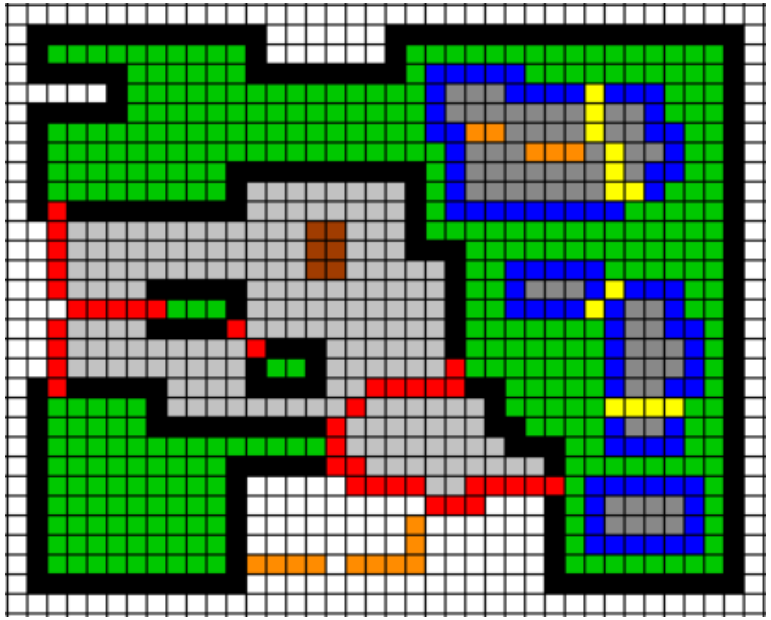
- Background
- Border-Opening: along Edge
- Core-Opening: within Perforation

Segmentation features

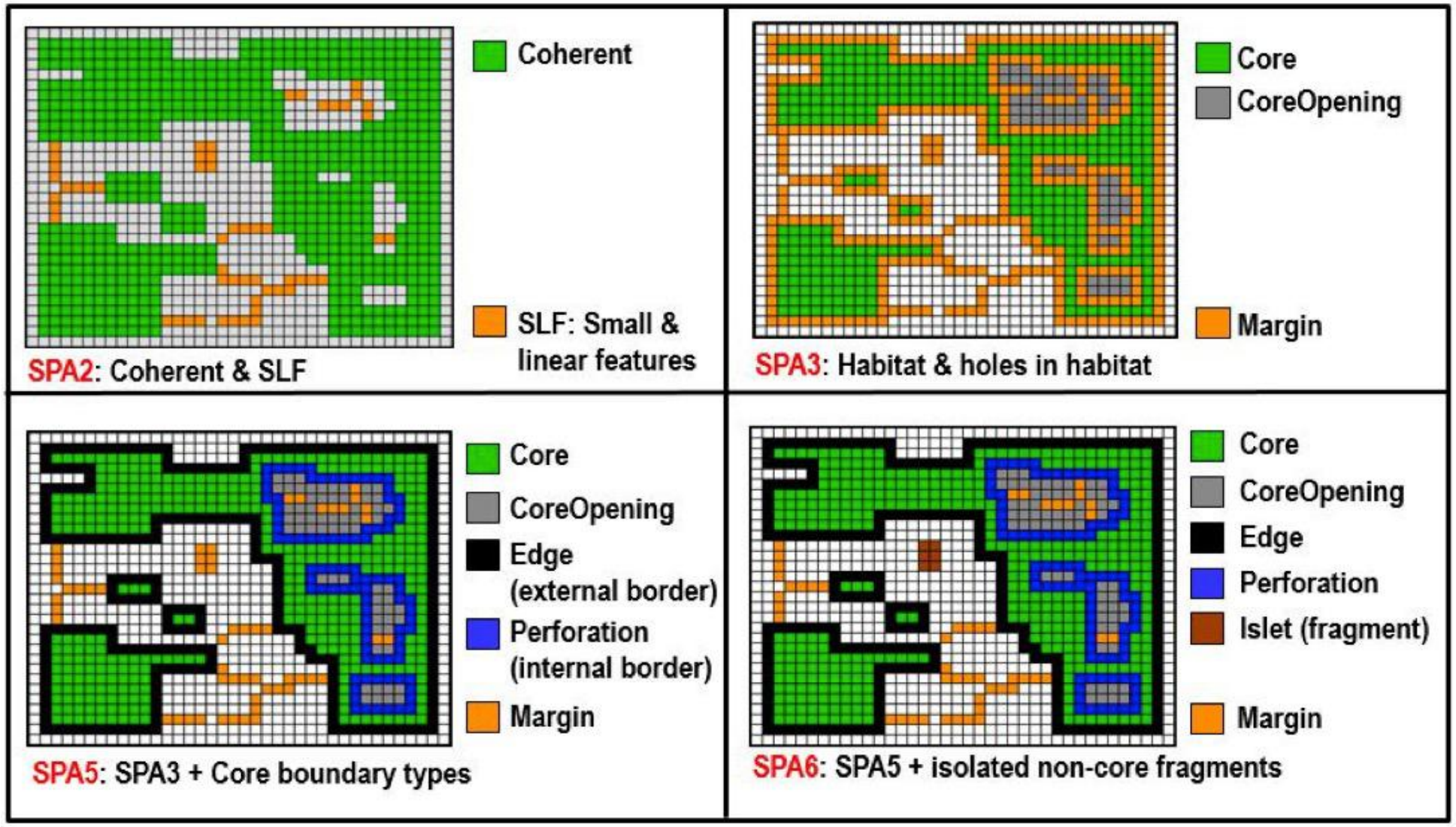
- Geometric (generic!) for any binary mask & any scale
- Automated description of pattern and connectivity
- The spatial detail of input and output are *identical*
- Each pixel is in *one* of the mutually exclusive classes
- Synthesis of object oriented and pixel based approach



MSPA



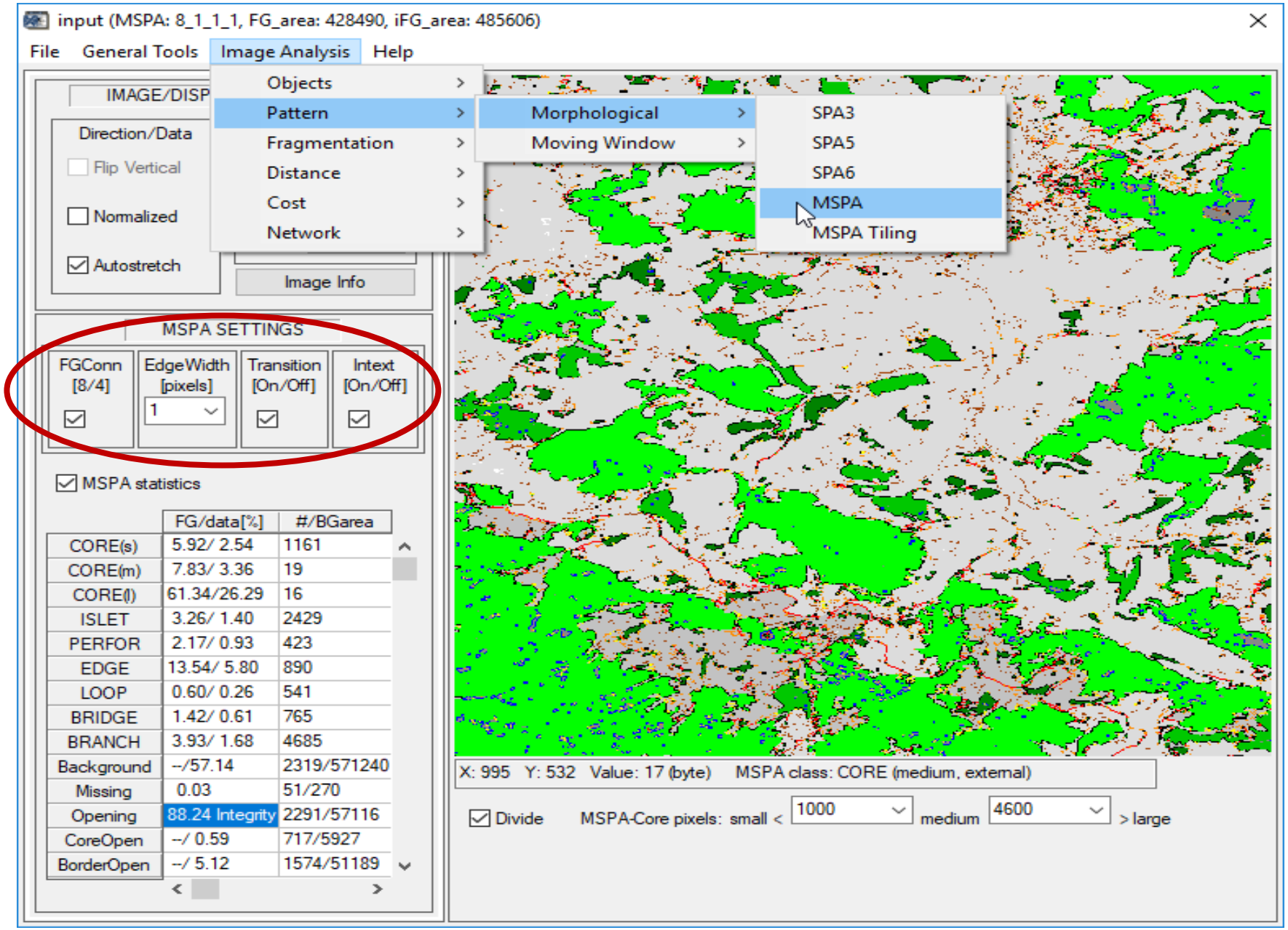
SPAx: simplified MSPA



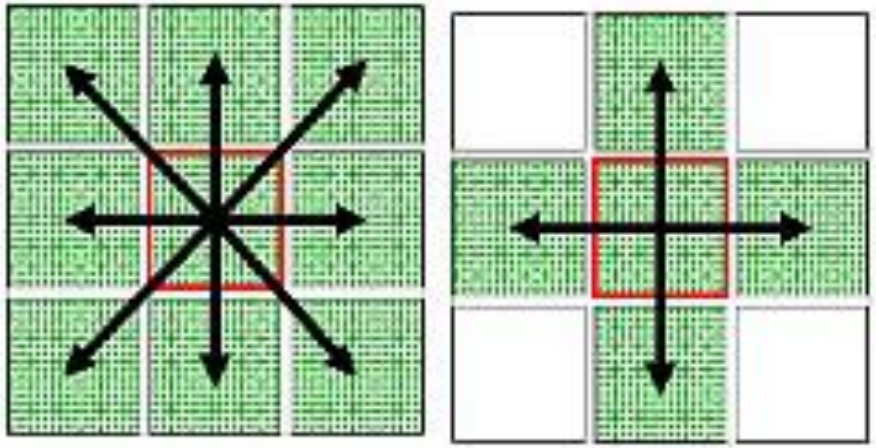
SPAx: fixed 8-connected FG & fixed EdgeWidth=1 pixel

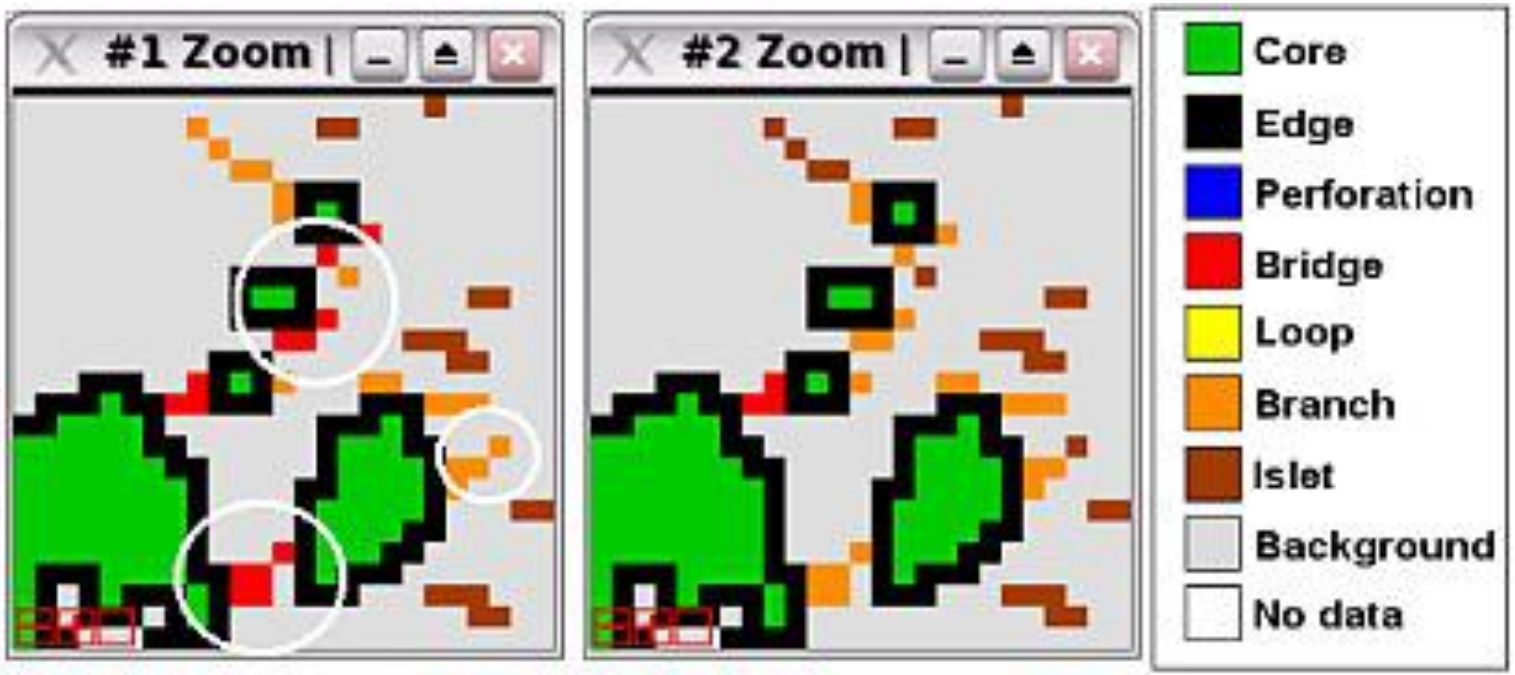
But *much* faster compared to MSPA …

MSPA-processing parameters



MSPA parameter 1: *FG connectivity* (8/4)



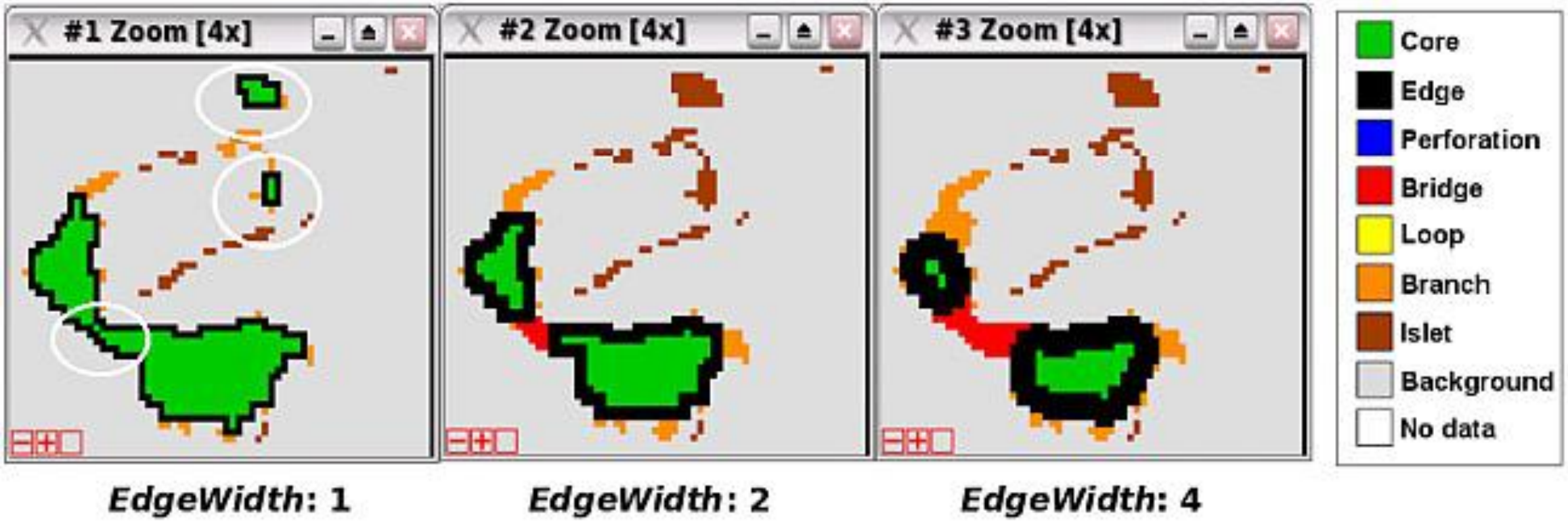


8-connectivity ↔ 4-connectivity **MSPA segmentation: 8100 ↔ 4100**

Parameter 1: *Foreground Connectivity* (<*Foreground Connectivity*>, 1, 0, 0).

White circles show the difference when using 8- (left image) or 4-connectivity (right image) for the MSPA-parameter 1: *Foreground Connectivity*.

MSPA parameter 2: *EdgeWidth* (1-100)

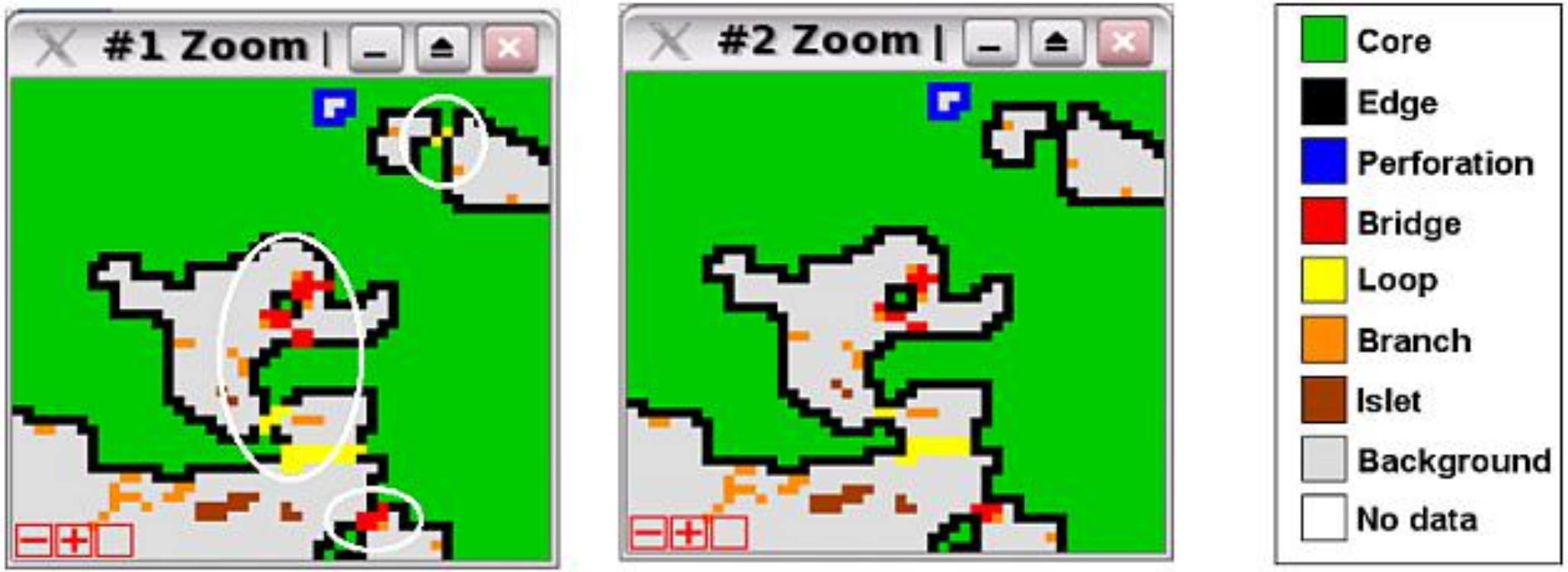


Parameter 2: *EdgeWidth* (8, <EdgeWidth>, 0, 0).

EdgeWidth increase reduces core-area and may change the non-core pattern classes (white circles).

EdgeWidth changes do not affect foreground coverage.

MSPA parameter 3: *Transition* (1/0 – on/off)



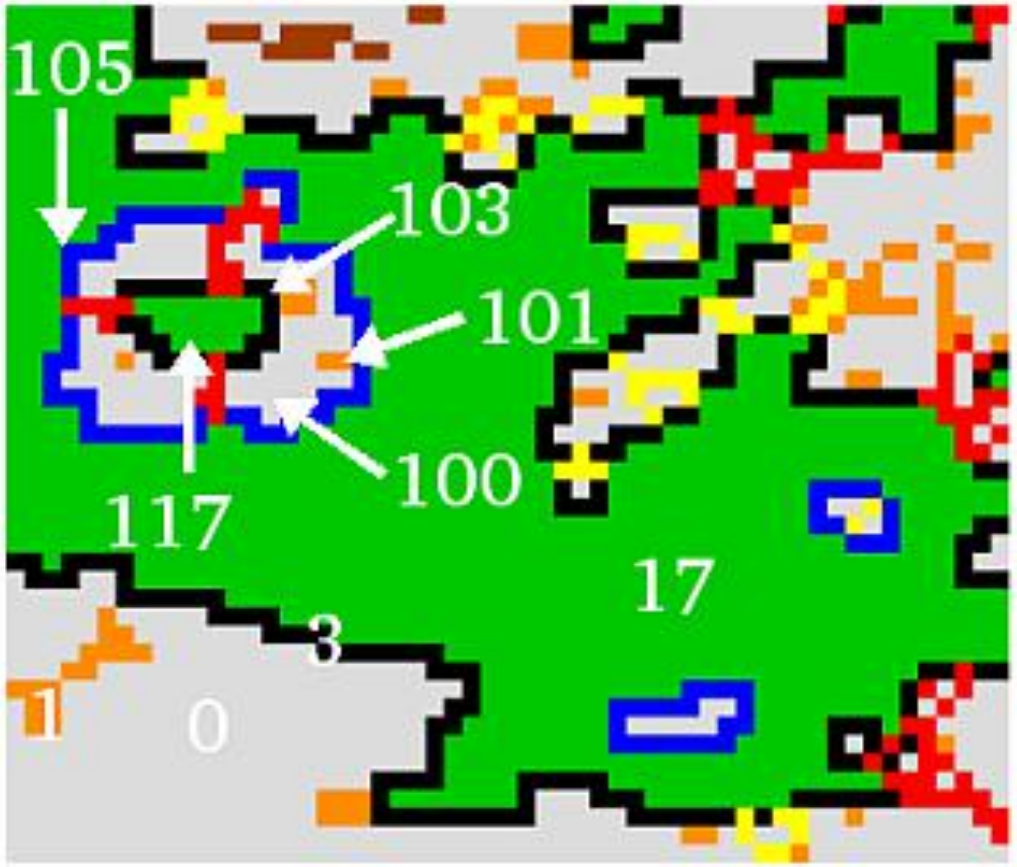
Parameter 3: *Transition* (8, 1, <*Transition*>, 0).
Left: *Transition* on (8110). Right: *Transition* off (8100).

Transition: set to *show* connecting transition pixels to Core area (white circles) or hide these pixels to maintain closed perimeters for the classes Perforation and Edge.

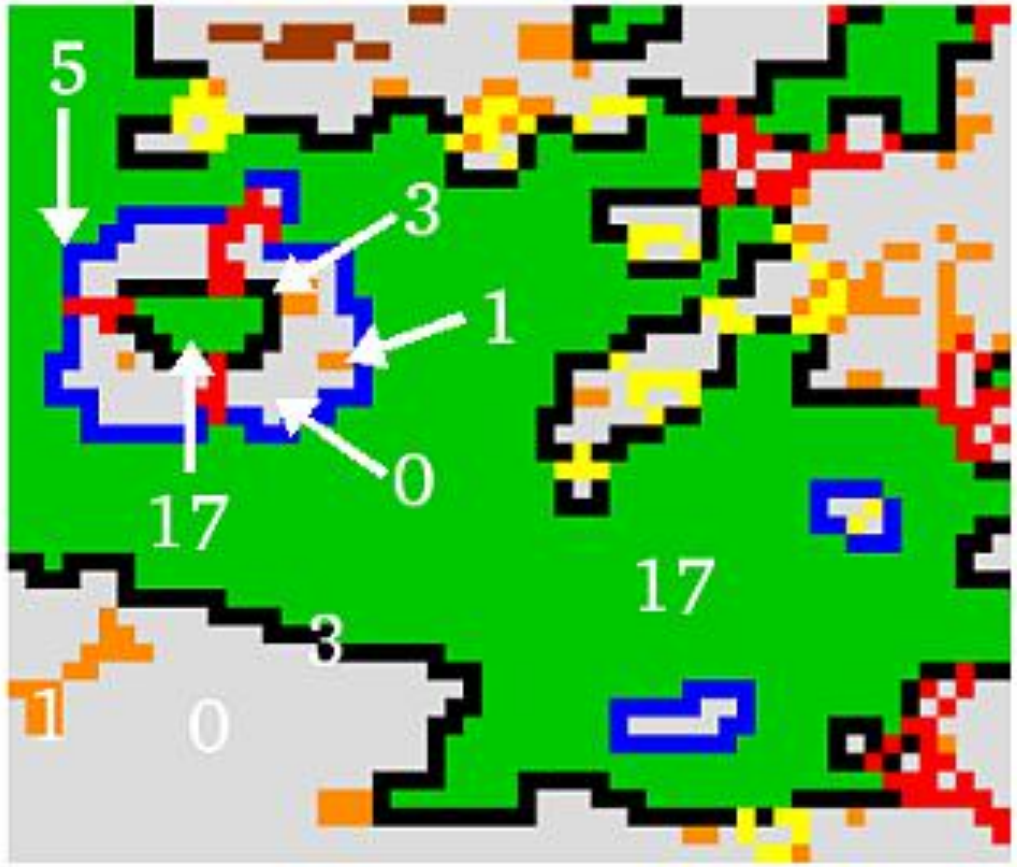
Transition: Visual switch, data remains unchanged!

MSPA parameter 4: *Intext* (1/0 – on/off)

Intext=1



Intext=0

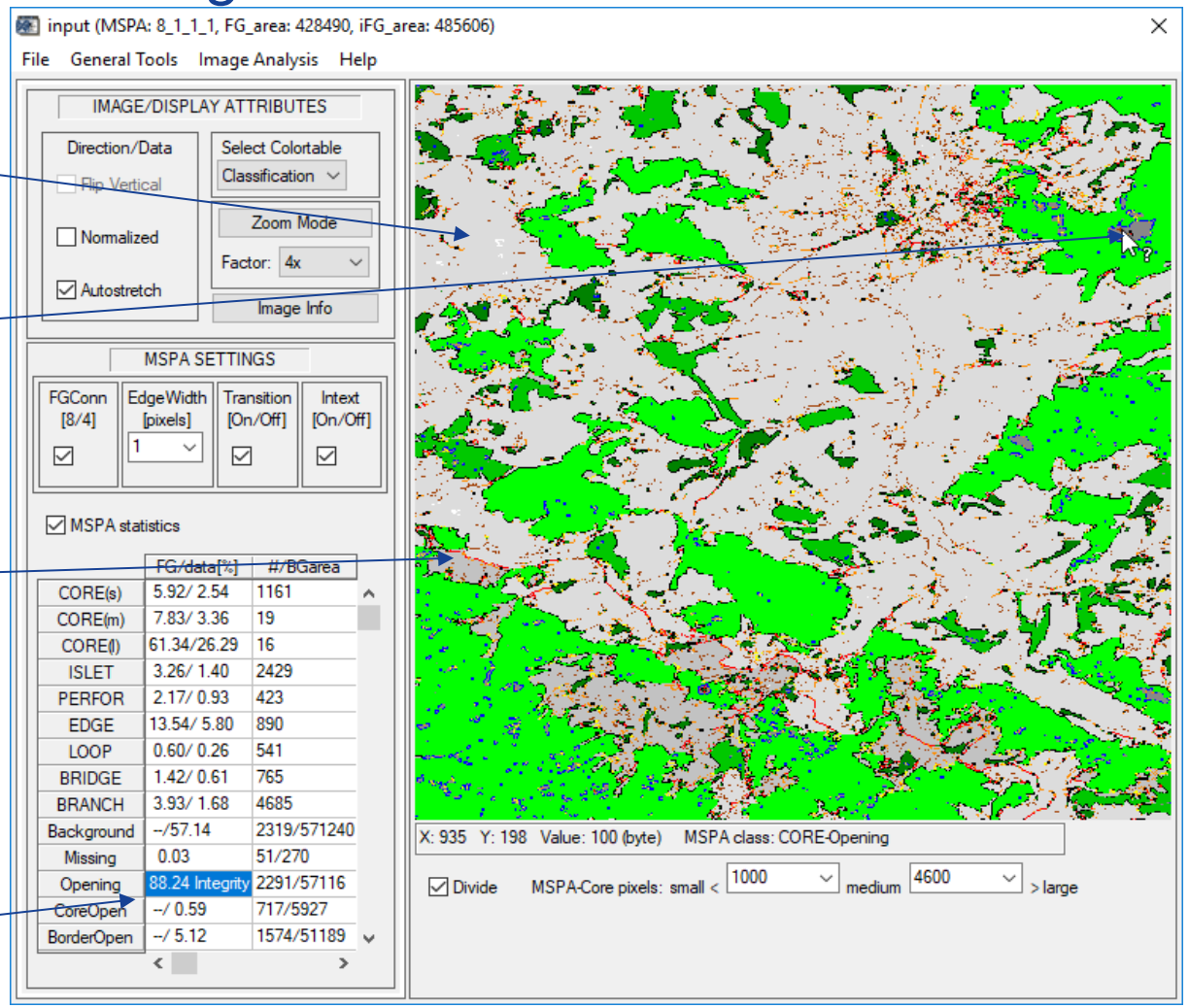


Intext can be used to add a second layer of the 7 basic classes inside perforations. When *Intext* is on (1), a pixel offset of 100 is added to the feature classes inside of the internal areas of foreground objects.

MSPA parameter 4: *Intext* = 1 ↔ BG-Openings

MSPA locates & quantifies 3 types of Background:

1. Background - 0 byte:
   outside foreground
2. Core-Opening – 100 byte:
   enclosed by Perforation
3. Border-Opening - 220 byte:
   along FG boundaries



Integral FG = FG + Openings

(ex.: 88.24% of iFG is forest → 11.76% of iFG are forest openings)

(M)SPA input data

GTB: Help → GTB Documentation → MSPA Guide

- Single channel, (Pseudo-) binary raster data having maximum 3 values:

  0 byte – Missing (optional)

  1 byte – Background (mandatory)

  2 byte – Foreground (mandatory)

- Format: 8bit Tiff (GeoTiff), generic image formats additional files (.hdr, .tfw, etc) are not needed; Compression: none or LZW

(M)SPA input data

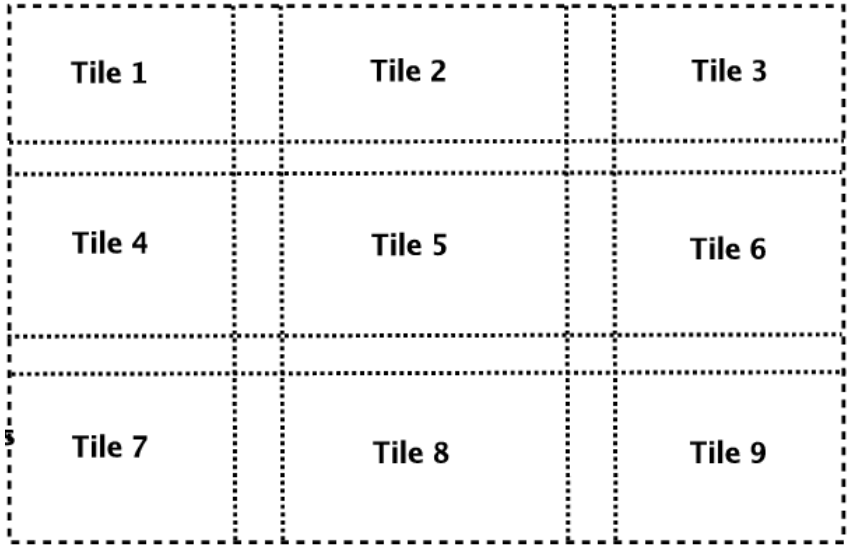
GTB: Help → GTB Documentation → MSPA Guide

MSPA: Maximum. size/dimension: MS-Windows: 100 MB ($10k^2$)

MSPA: Mac/Linux: 4, 8, 16, 128 GB RAM: $12k^2$, $18k^2$, $28k^2$, $75k^2$

SPA: GuidosToolbox: $30k^2$. If larger, use GWB

(*MSPA-Tiling:* automatic procedure of buffered tiling, MSPA- processing, appropriate reassembling of final result, same as MSPA cmdline version.)

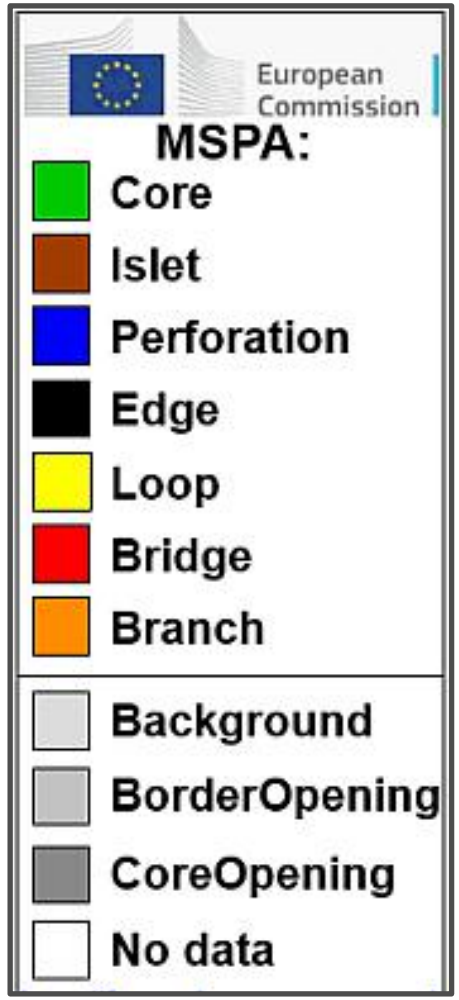


MSPA-tiling is a less than ideal and time-consuming solution, which is not guaranteed to provide exact results. Please only use **GWB** for MSPA processing of large images!

(M)SPA output data

GTB: Help → GTB Documentation → MSPA Guide

Binary raster data (GeoTiff, Tiff, LZW-compressed)
A) Visual result: maximum of 11 colors:
- 7 pattern classes of Foreground,
- White – Missing (optional),
- Gray – Background (mandatory, up to 3 colors).



Note:
MSPA class names are generic. Their meaning depends on the nature of the input data and should be amended by the user: i.e., *Perforation,* the outer perimeter of a Foreground *hole* in a forest mask could be a *Clearing* while for a water mask such an area is an *Island*.

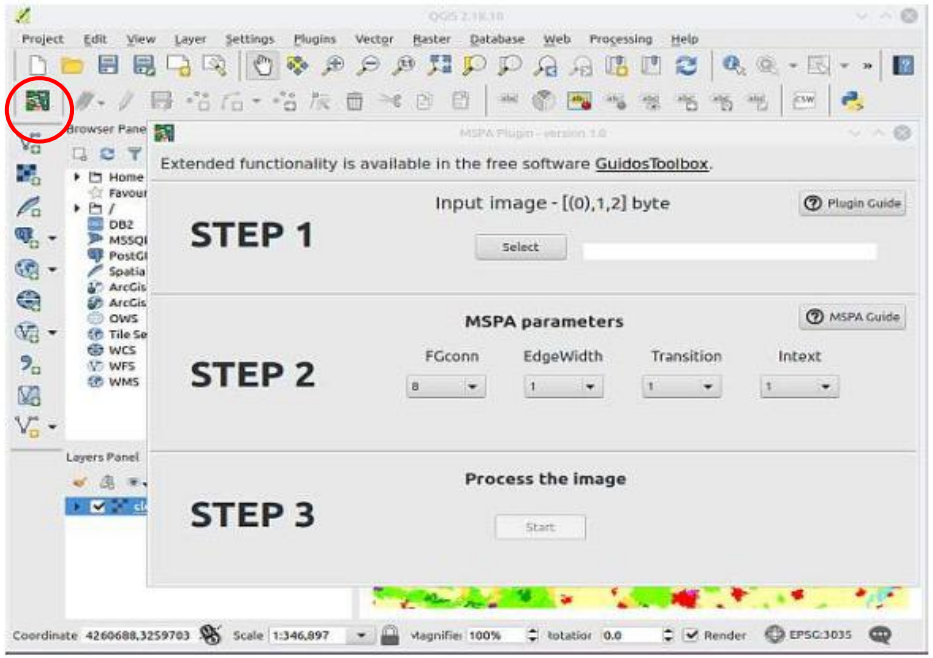
(M)SPA output data

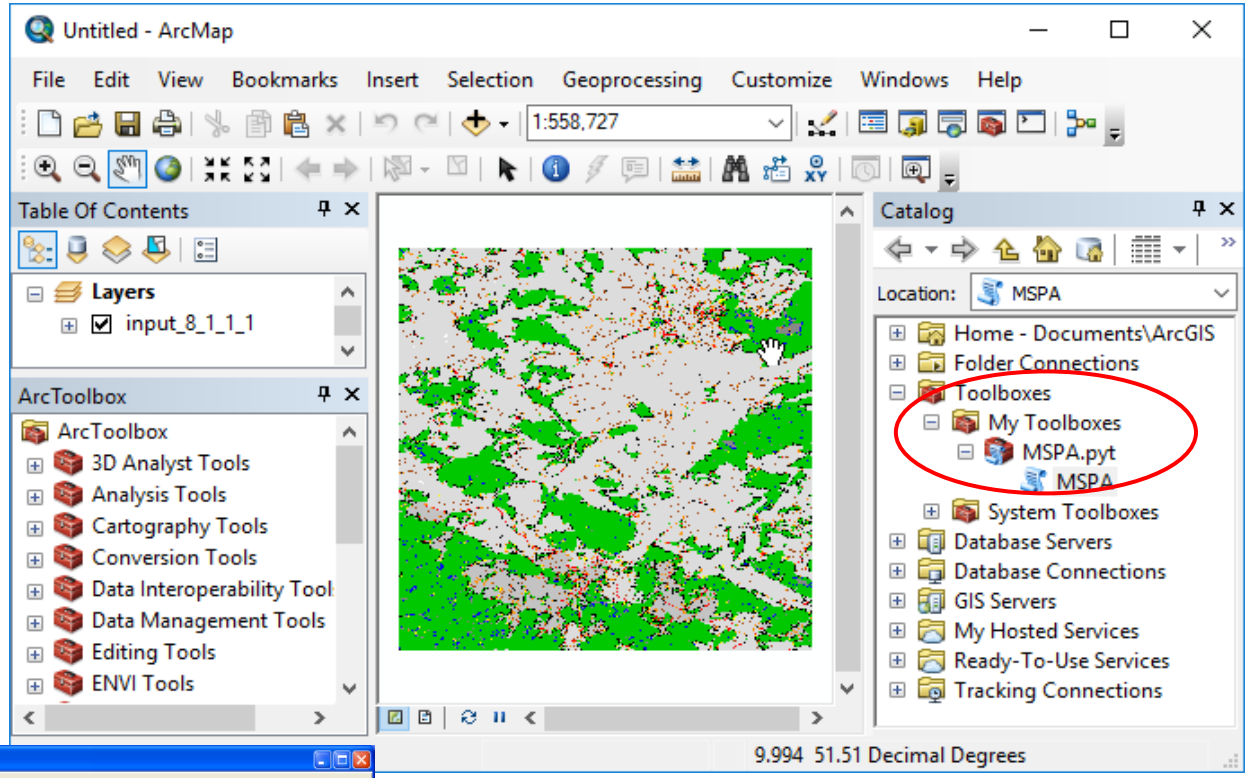
Class	Color	RGB	Intext = 0	Intext = 1
1) Core		000/200/000	17	17 / 117
2) Islet		160/060/000	9	9 / 109
3) Perforation		000/000/255	5	105
4) Edge		000/000/000	3	3 / 103
5a) Loop		255/255/000	65	65 / 165
5b) Loop in Edge		255/255/000	67	67 / 167
5c) Loop in Perforation		255/255/000	69	169
6a) Bridge		255/000/000	33	33 / 133
6b) Bridge in Edge		255/000/000	35	35 / 135
6c) Bridge in Perforation		255/000/000	37	137
7) Branch		255/140/000	1	1 / 101
Background		220/220/220	0	0
Border-Opening		194/194/194	N/A	220
Core-Opening		136/136/136	N/A	100
No Data		255/255/255	129	129

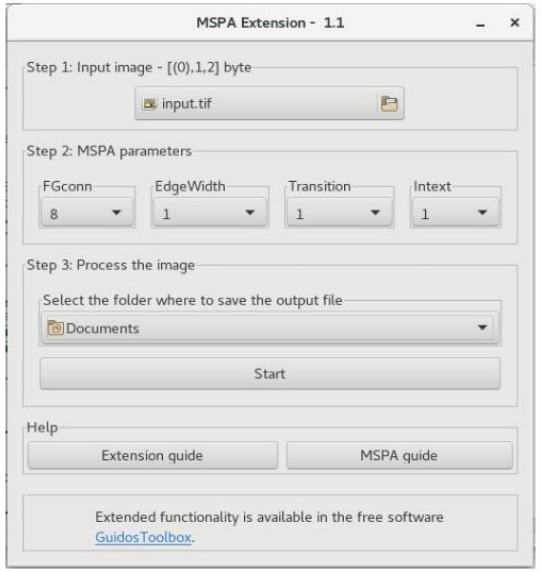
B) Numeric result:
- 13 classes, *Intext*=0
- **23 classes**, *Intext*=1

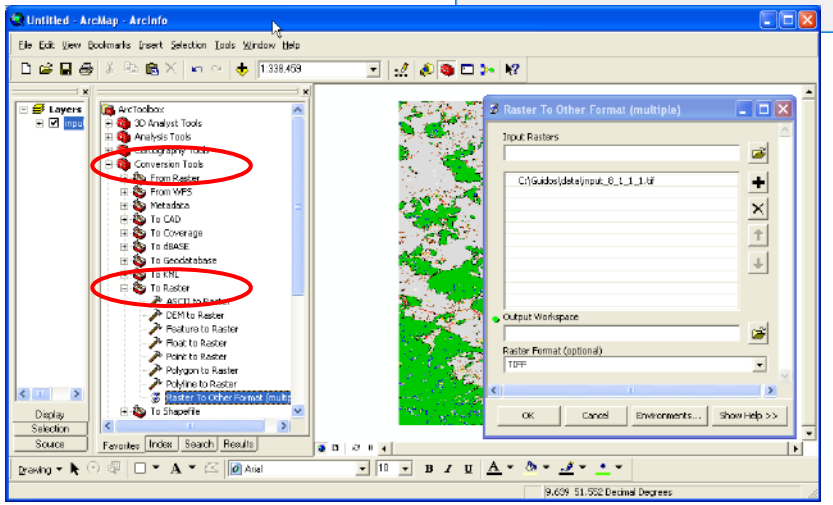
Detailed information:
GTB: Help →
GTB Documentation →
MSPA Guide

Standalone MSPA plugins on the MSPA website for: QGIS, R, ArcGIS and GWB









Conversion to/from grid in arc terminal:
imagegrid / gridimage

Import: *File → Add Data*
Export: see to the left

European Commission

Thank you

European Commission