Zonation 5: general introduction

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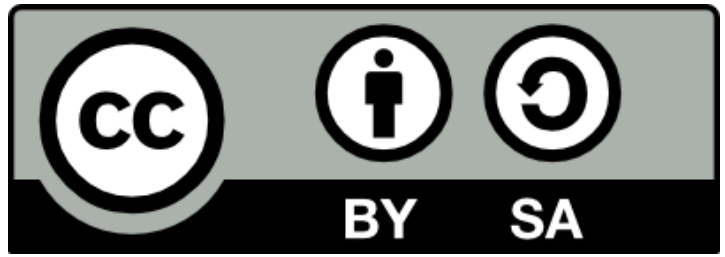

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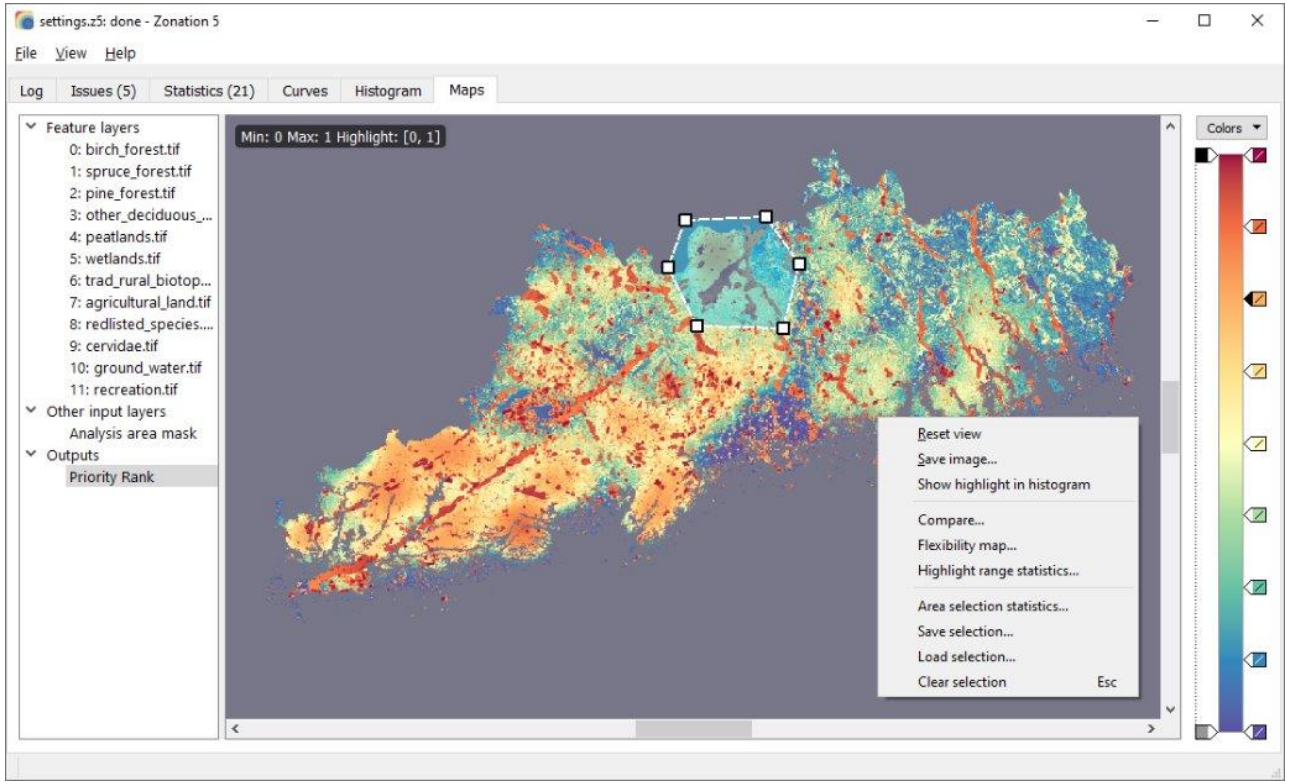
00 Outline

I. Zonation in a nutshell
II. Main Zonation inputs and outputs
III. Zonation 5 meta-algorithm (working principles)
IV. Balancing methods
V. A mention about weighting
VI. Connectivity in Zonation 5

I. Zonation 5 in a nutshell

- Software for spatial prioritization: priority ranking of a target landscape
  - to identify areas that jointly best cover biodiversity (etc.)
  - balanced representation of all input features' distributions
    → complementarity

- Common applications:
  i. Protected area network design
  ii. Planning for protected area network expansion
  iii. Protected area network evaluation
  iv. Planning for ecological impact avoidance
  v. Spatial planning for habitat restoration and / or maintenance
  vi. Decision support for land use zoning
  vii. Ecologically based land use planning
  viii. Evaluation of impacts from development



I. General working principles

i. More conservation coverage is better
ii. High local occurrence levels for features are preferable to low levels
iii. Habitat quality and connectivity are both desirable
iv. There needs to be a sensible balance between features (implied by concepts such as comprehensiveness, representativeness and adequacy)
v. Solutions need to be cost/area-efficient (effective)
vi. Minimizing loss maximizes what will remain

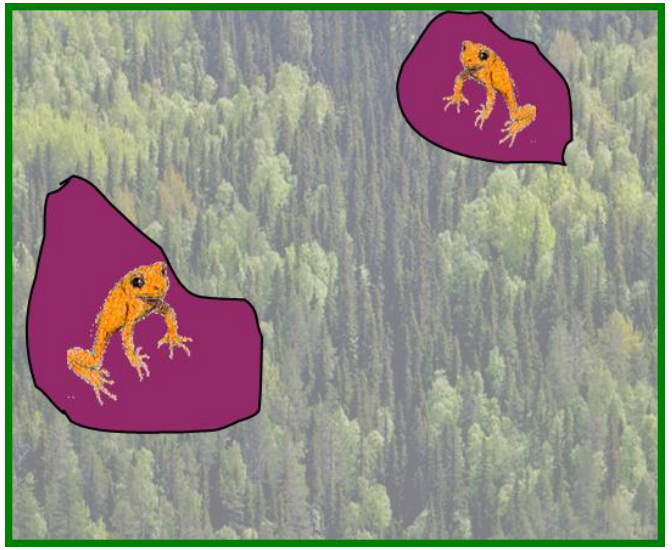
Moilanen et al. (2022)

II. Input features

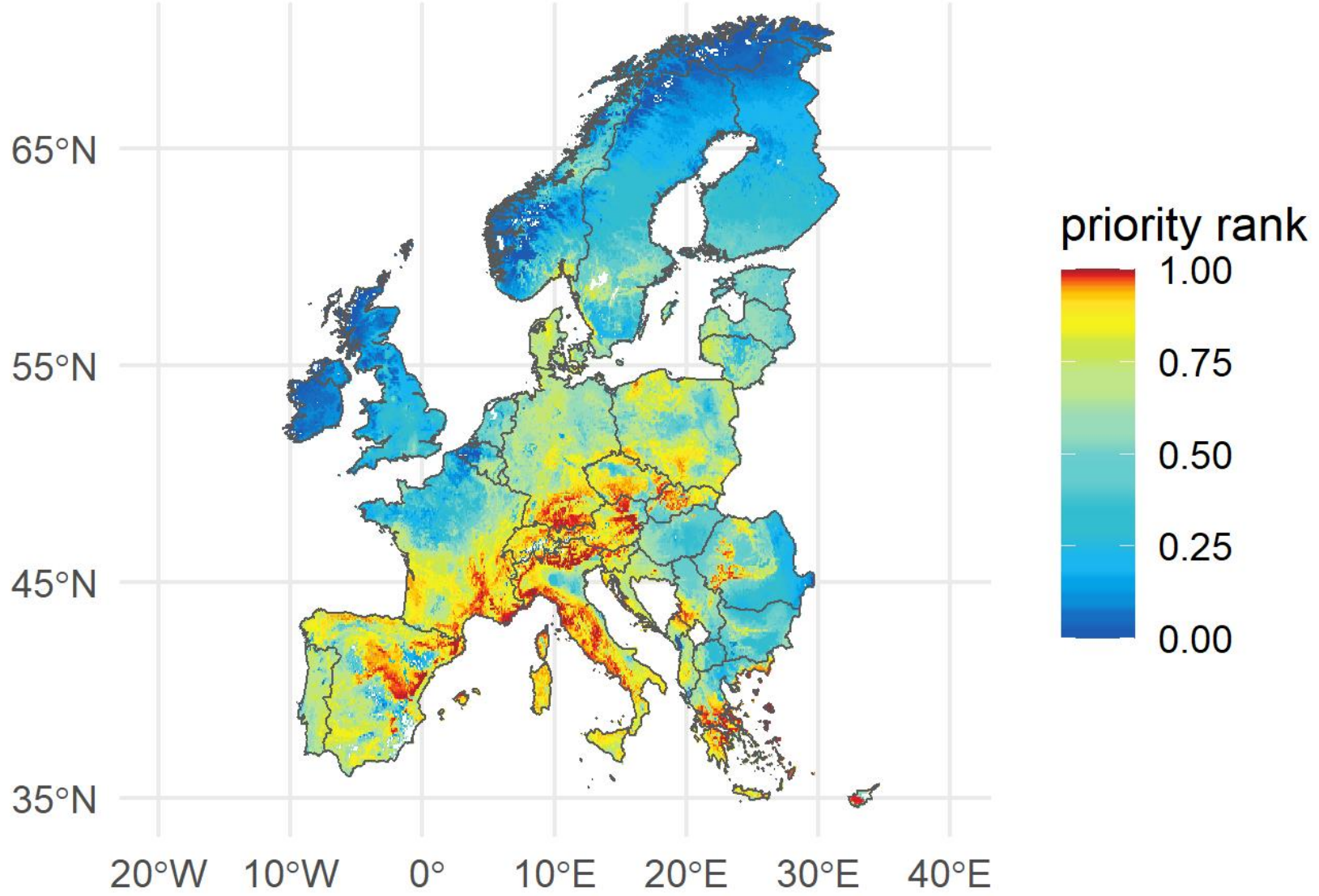
- GIS raster layers representing distributions of features you wish to account for in conservation/land-use planning
  - Species
  - Habitats/ecosystems
  - Ecosystem services (supply & demand)
  - etc.
- One layer per feature
- Can describe the presence-absence, habitat suitability, richness, local abundance, local density, or expected frequency of occurrence of the feature
  - Higher the value = “more” the feature (“higher density” etc.)
- Also threats, costs, current protected areas, restoration/management actions often included

II. All GIS data must be uniform

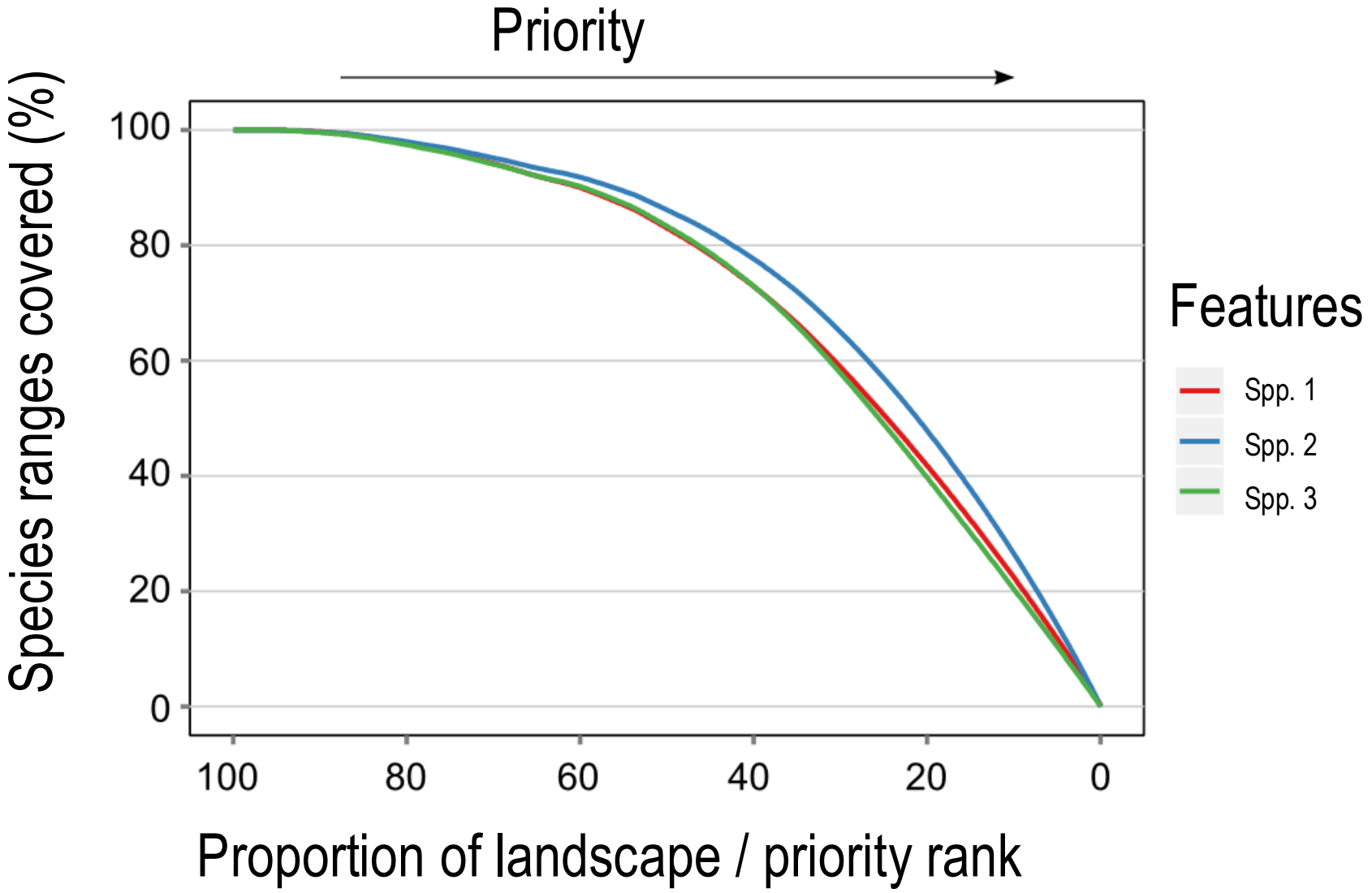
- Zonation only works with raster-type GIS layers (GEOTIFF etc.)
- All layers must be uniform:
  - Same projection
  - Same cell-size
  - Same extent



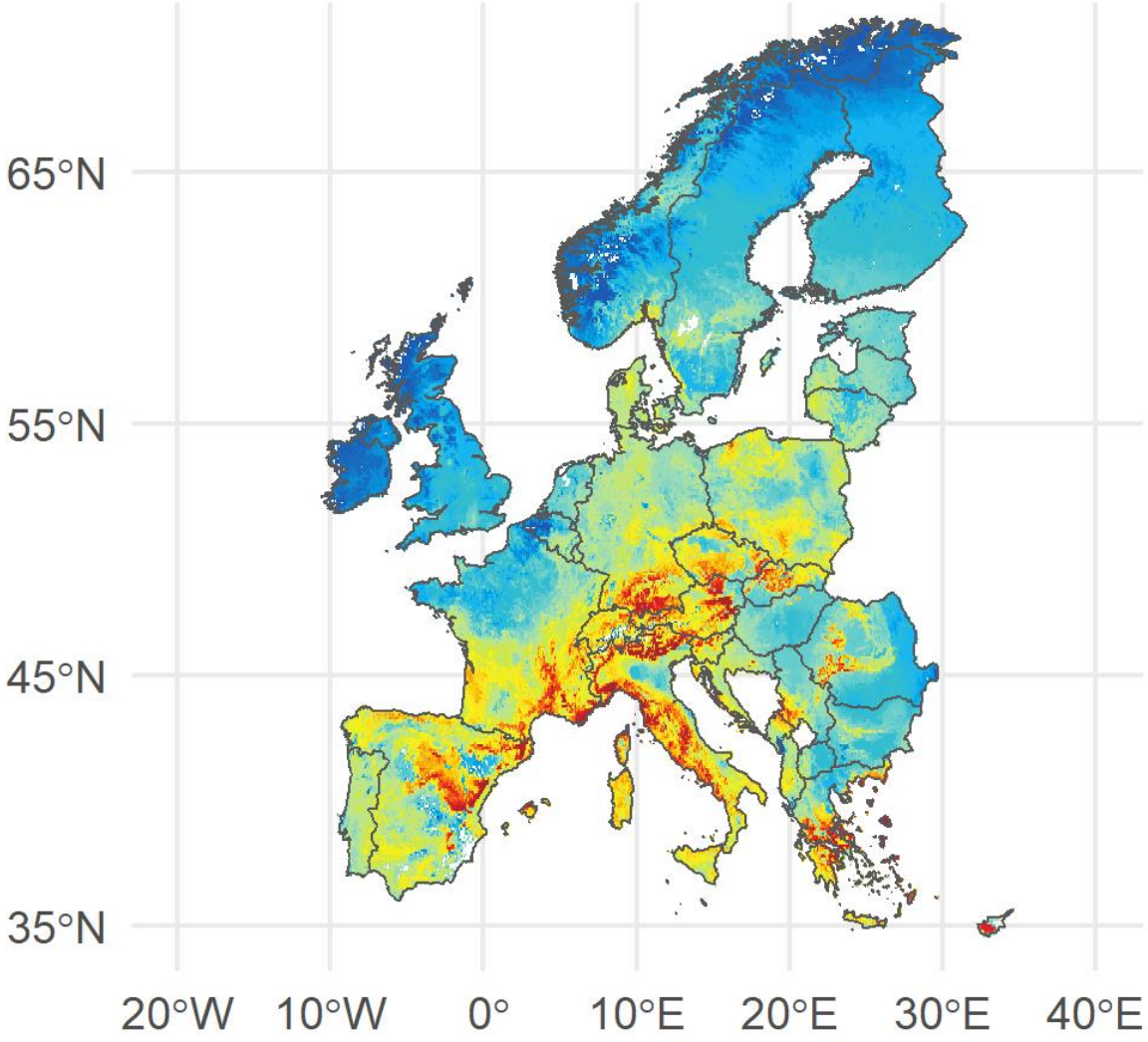
II. Basic output: priority rank map

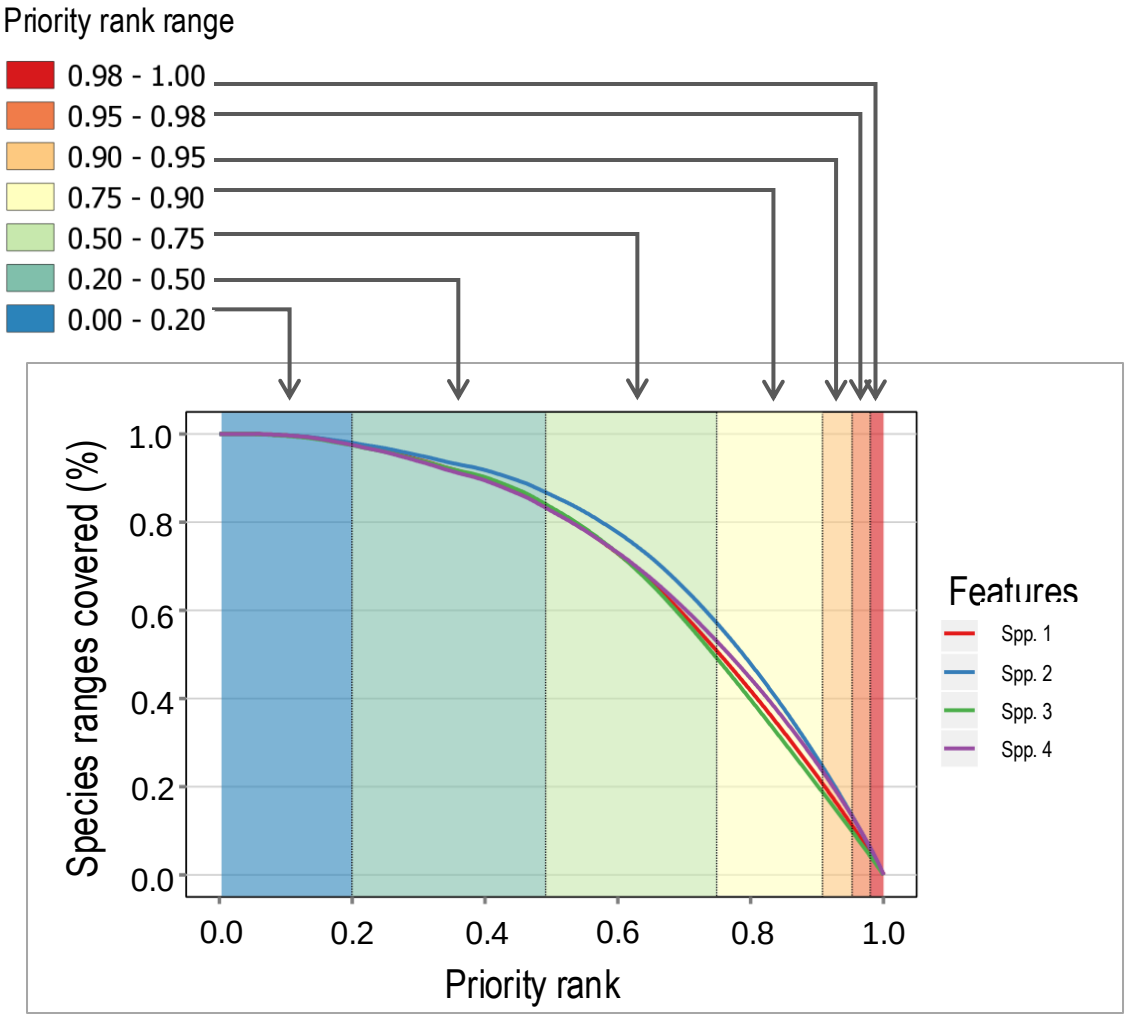


II. Basic output: performance curves



II. Map and curves should always be interpreted together!





III. How Zonation 5 works

Simplified meta-algorithm:

1. Normalizes distribution layers (occurrence levels)
2. Calculates an aggregate marginal loss value
3. By iteratively sorting the grid cells, tries to find the order of the pixels, where the marginal loss for biodiversity is constantly increasing

As a result, a priority ranking is produced: grid cells are ordered according to their importance for supporting biodiversity

III. (Re)normalization of feature rasters

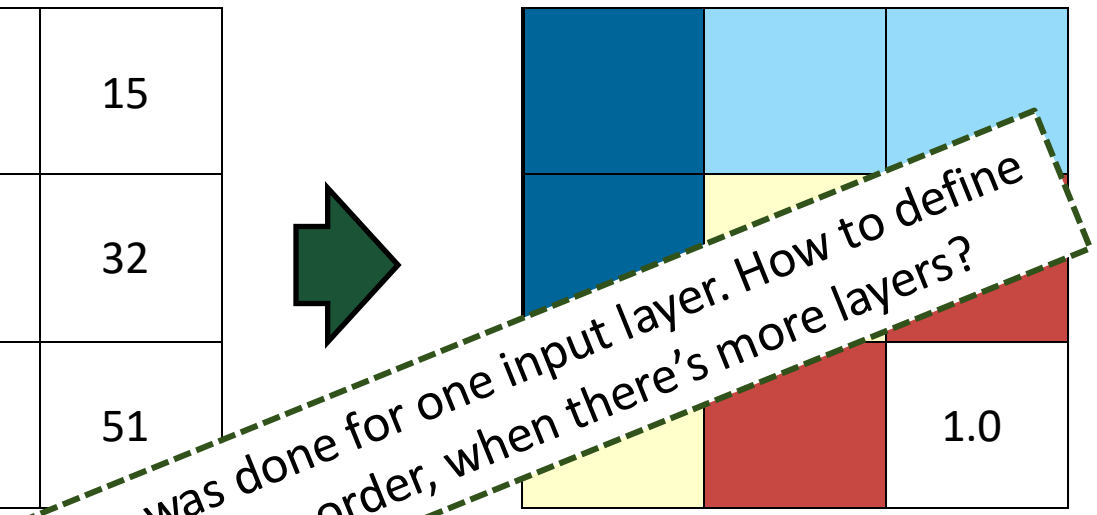
Zonation works with normalized distribution layers (occurrence levels)

- Layers sum to 1; each cell holds a fraction of the distribution

Absolute value in input grid (e.g. number of individuals)

4	10	15
5	23	32
20	40	51

Value renormalization as ranking proceeds



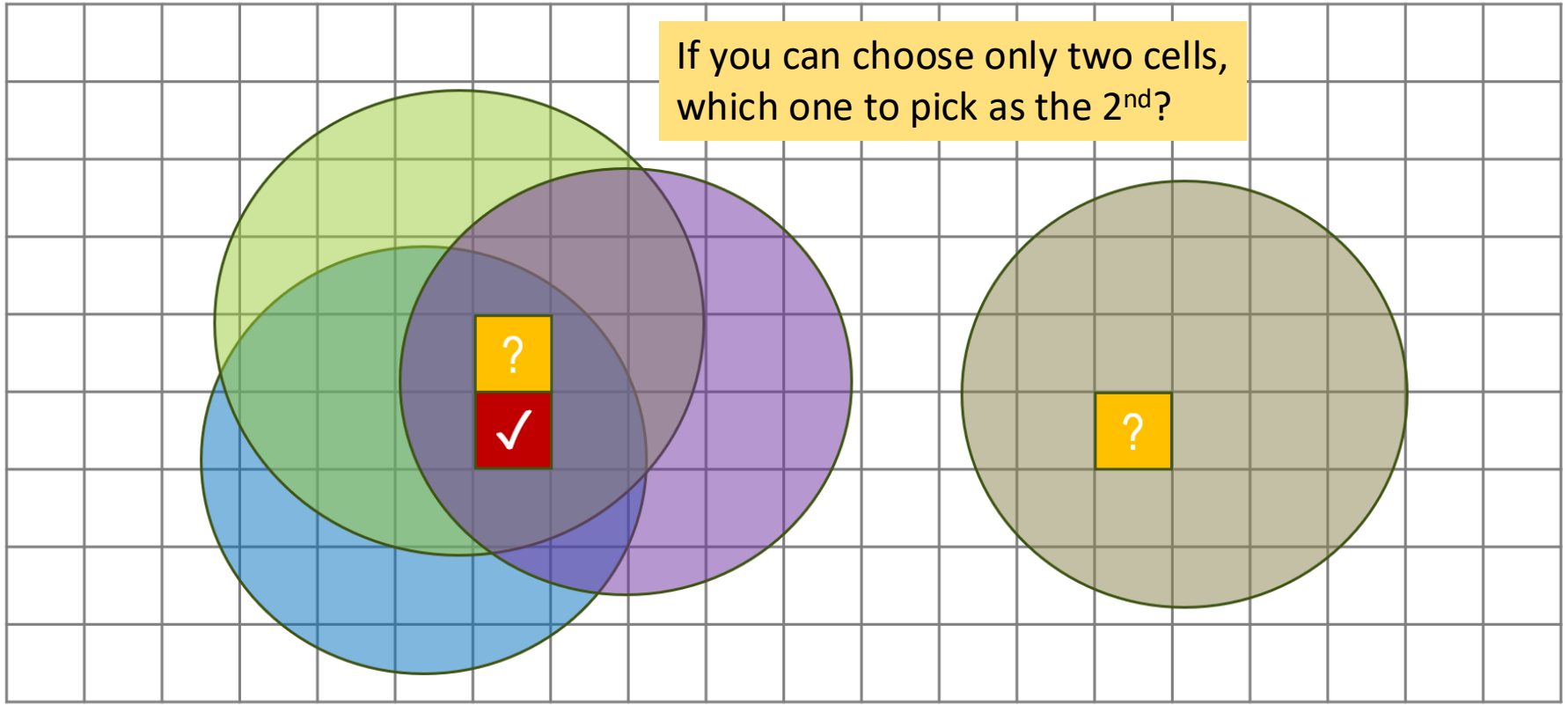
This was done for one input layer. How to define the ranking order, when there's more layers?

Cells renormalized to sum to one
--> Value represents "fraction of remaining distribution"

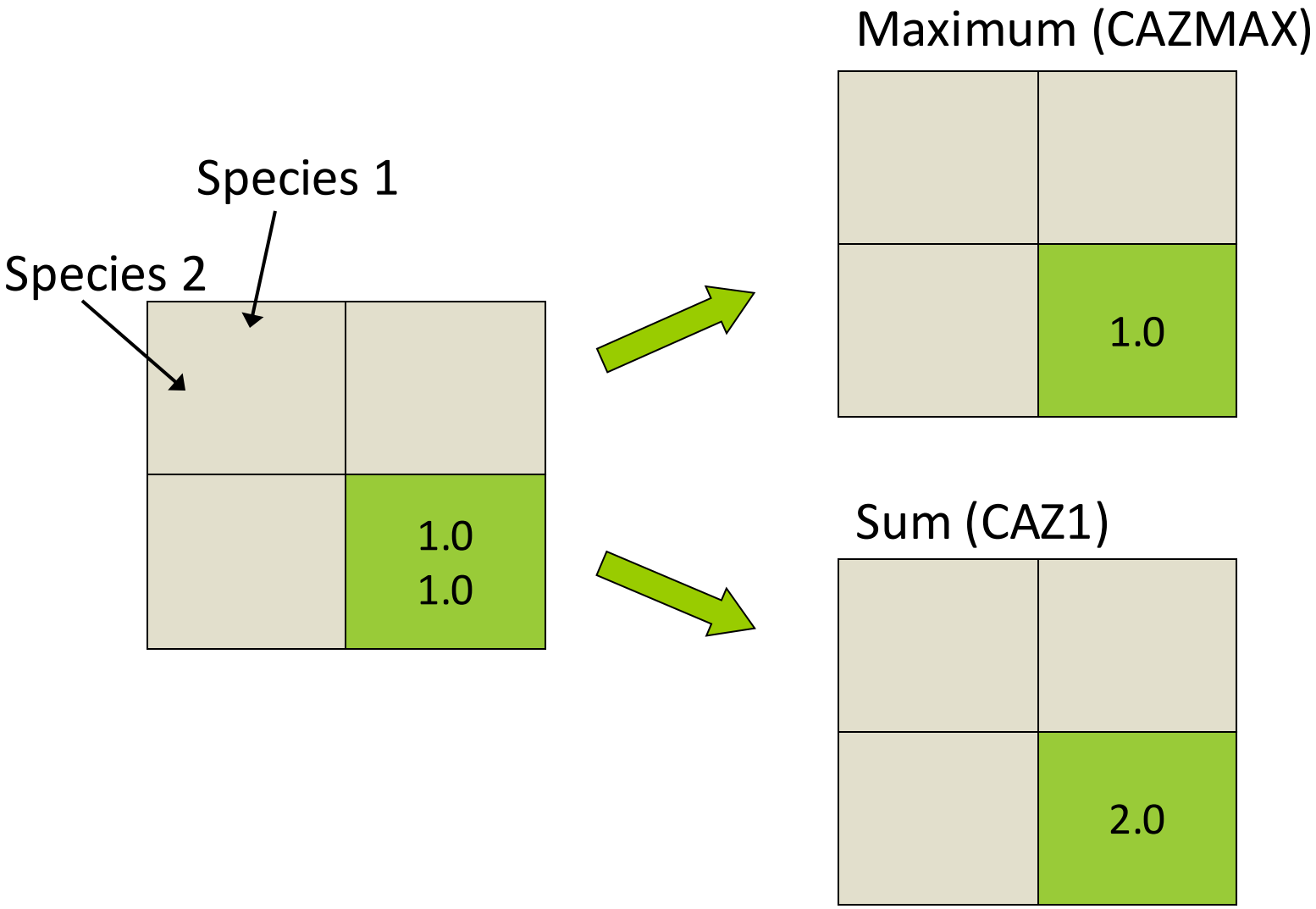
When only 1 cell remains, 100% of the remaining occurrences are found in that cell

IV. Marginal loss rules & ranking order

- Fundamental setting in Zonation: how is the marginal loss across multiple features calculated?
  - Why is there more than one option?



IV. Marginal loss rules & ranking order



IV. Marginal loss rule

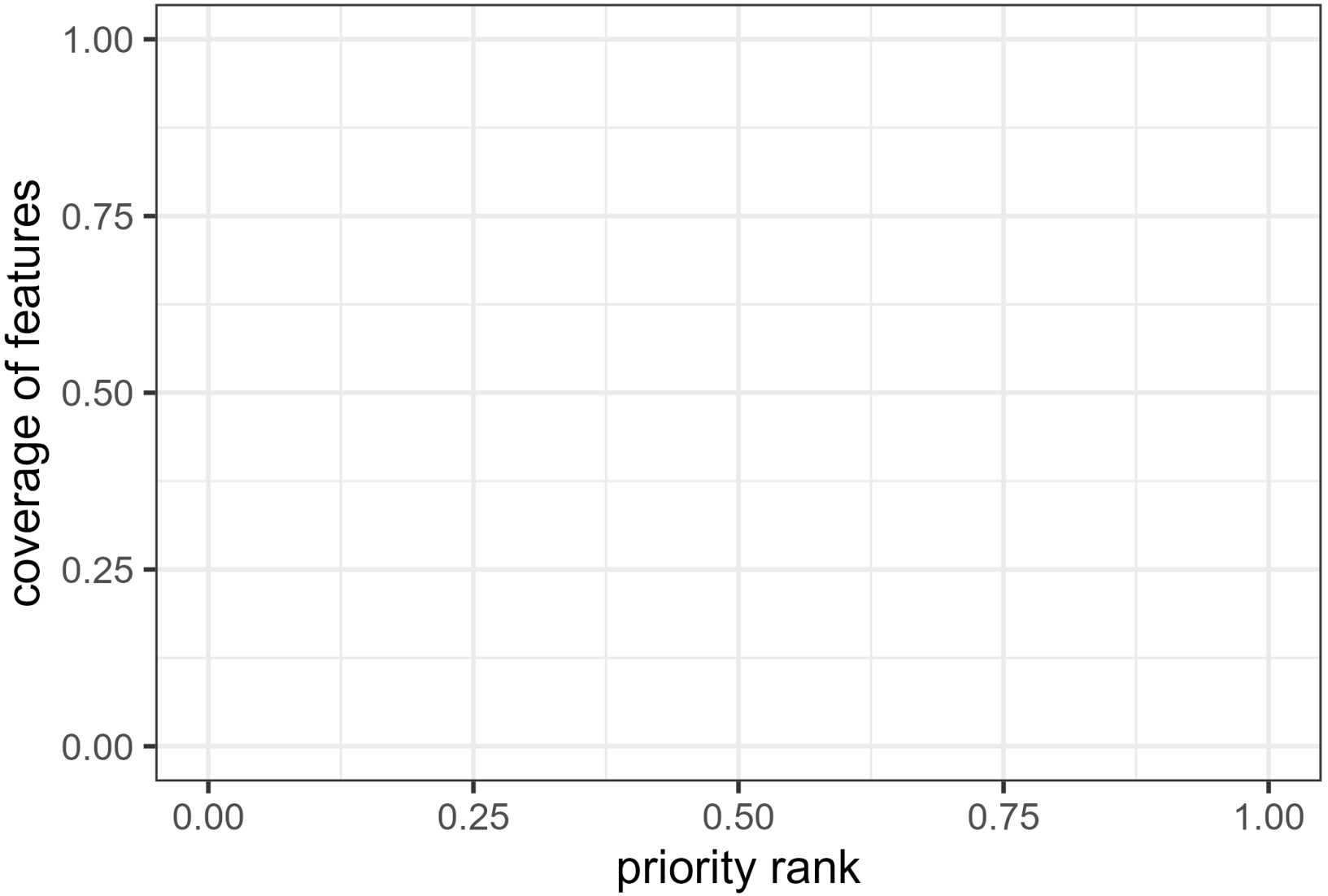
- How Zonation defines the marginal loss, i.e., chooses which cell should be ranked first during prioritization
- Trade-off between maximising the coverage of individual worst-off features vs. having a generally high coverage over all features
  - (i.e., trade-off between mean and minimum)
- Marginal loss rule impacts prioritization outcome, depending on the input data properties

IV. Marginal loss rule options

- CAZ2 – Ok balance between min and mean coverage. Default option & a good starting point.
  - Quadratic mean of (iteratively updated) weighted range-size rarity
- CAZMAX – Emphasis on min coverage.
  - Smallest (iteratively updated) maximum value over all features
- CAZ1 – Emphasis on mean coverage.
  - Sum of (iteratively updated) weighted range-size rarity
- ABF – Emphasis on mean coverage.
  - 'Additive Benefit Function', sum of feature-specific benefit functions

- Also available: CAZP, CAZPW (manual trade-off btw. mean and min coverage), random (for e.g. verification)

IV. Properties of marginal loss rules



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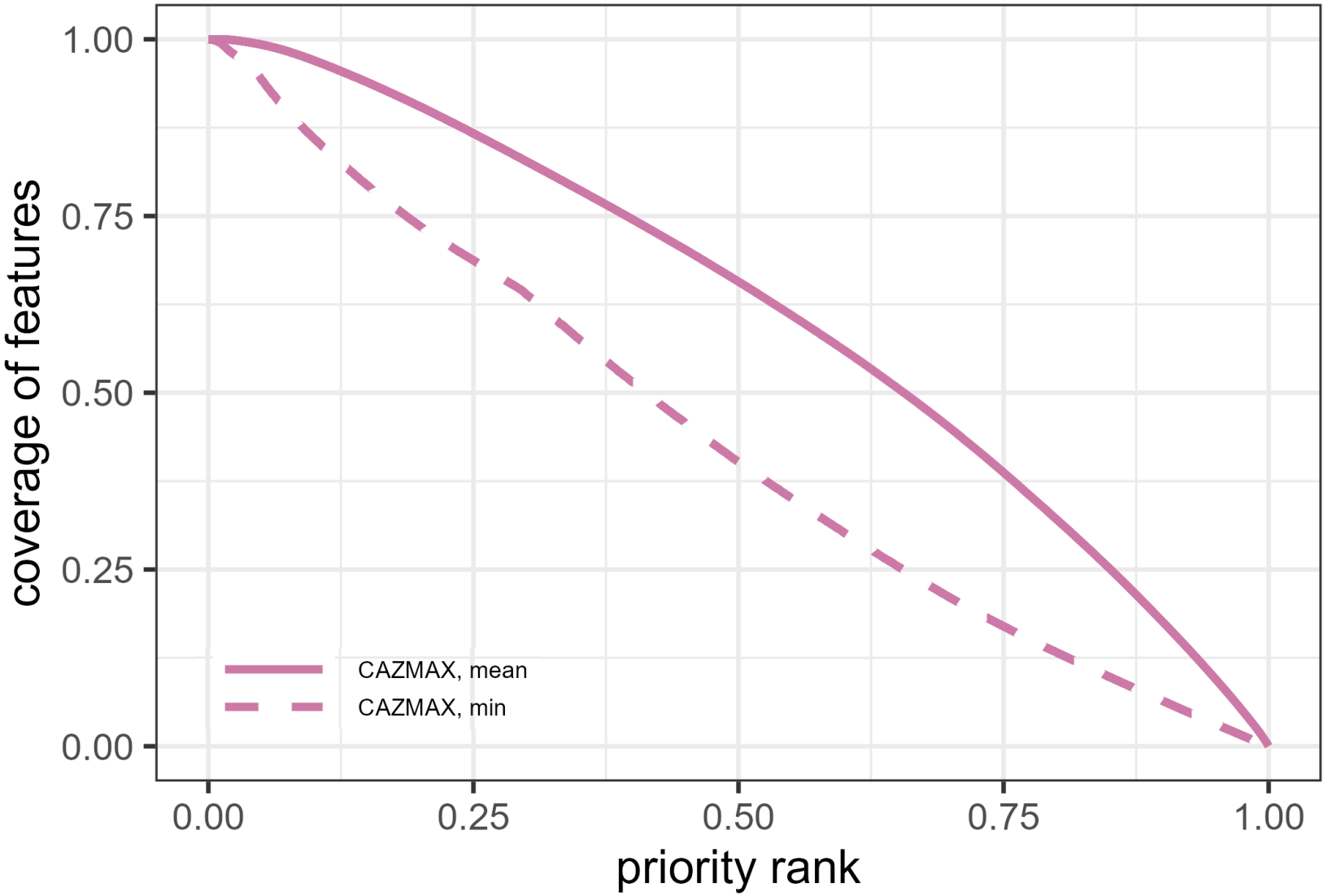

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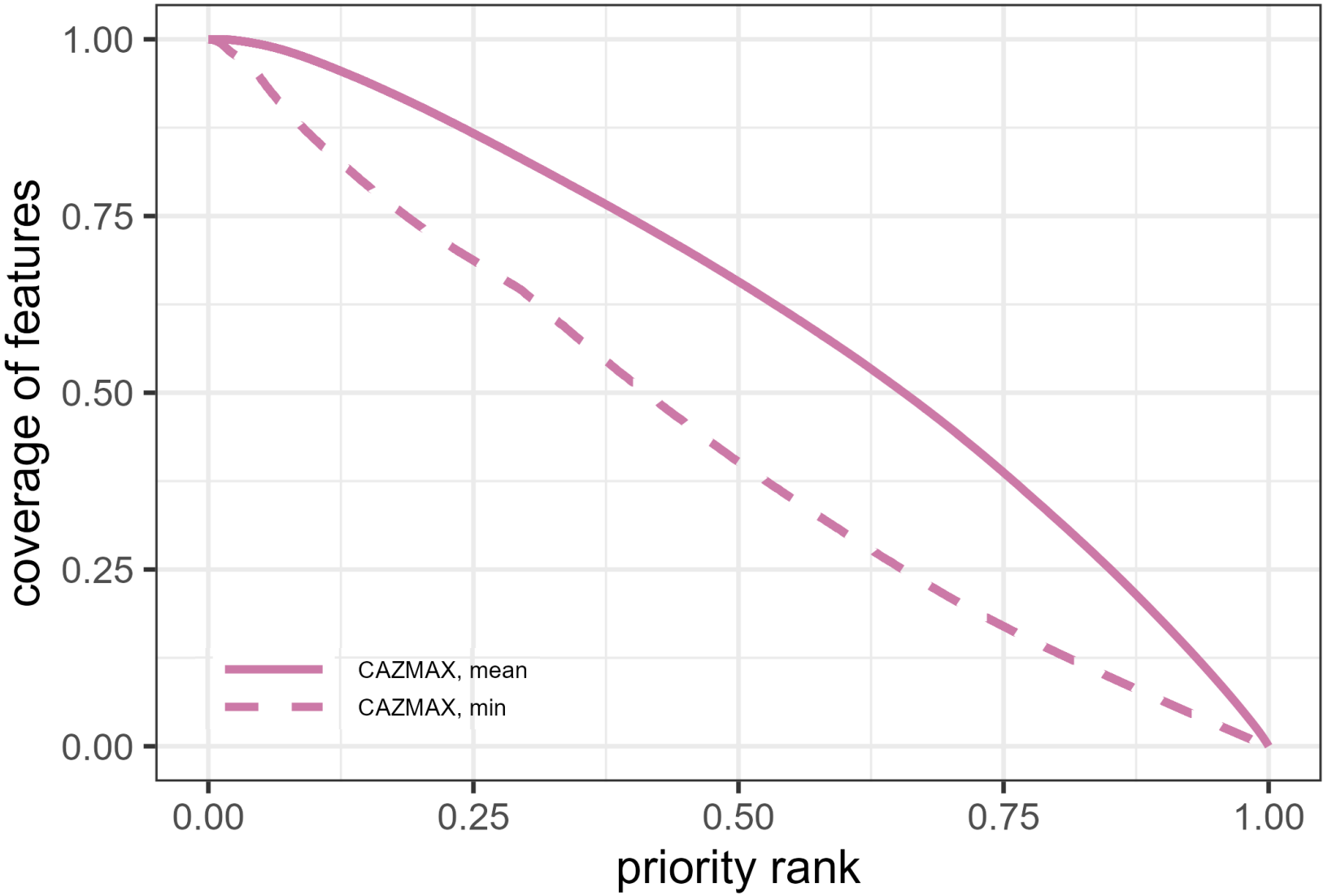

- CAZMAX: emphasis on good minimum coverage; relatively poor mean coverage

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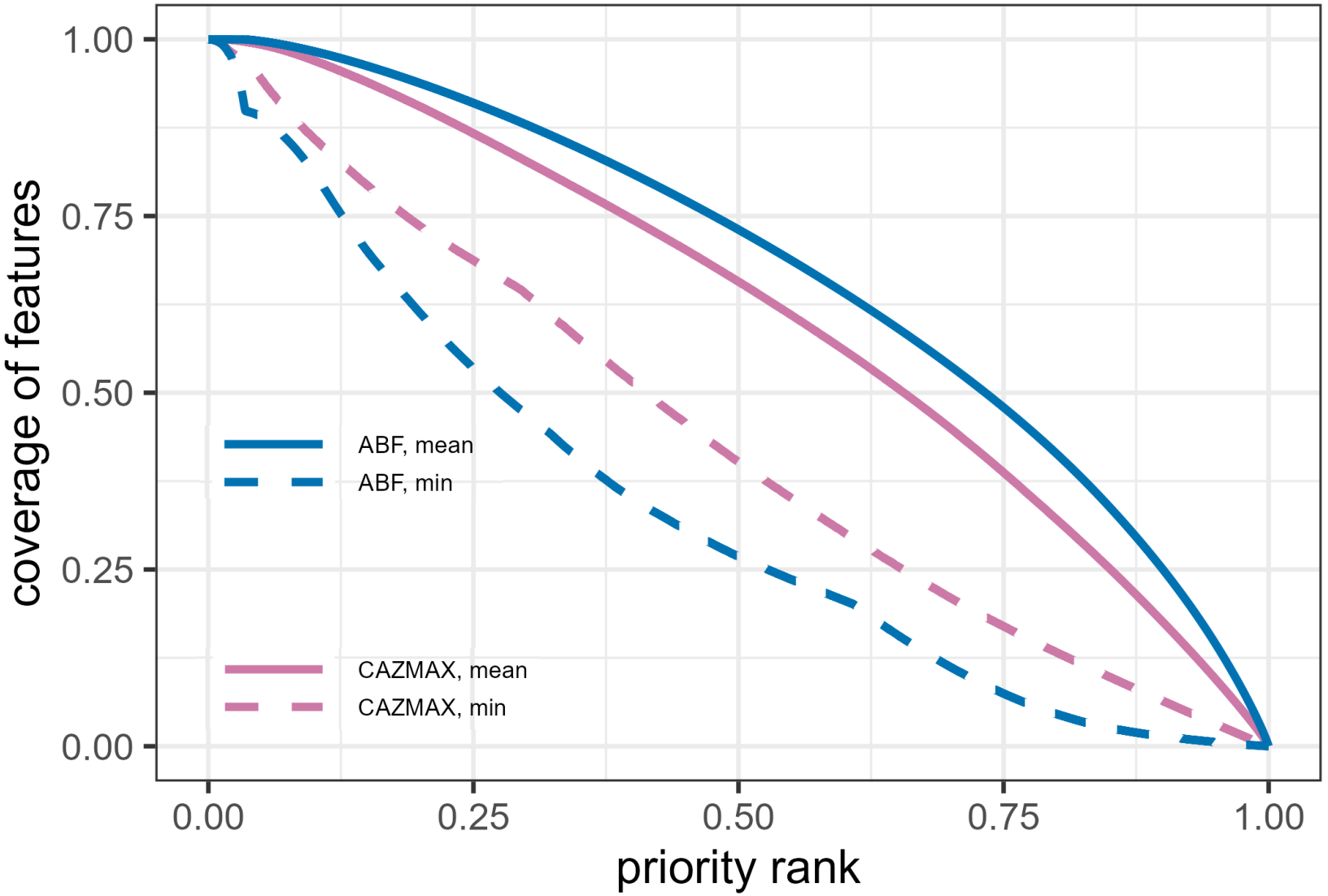

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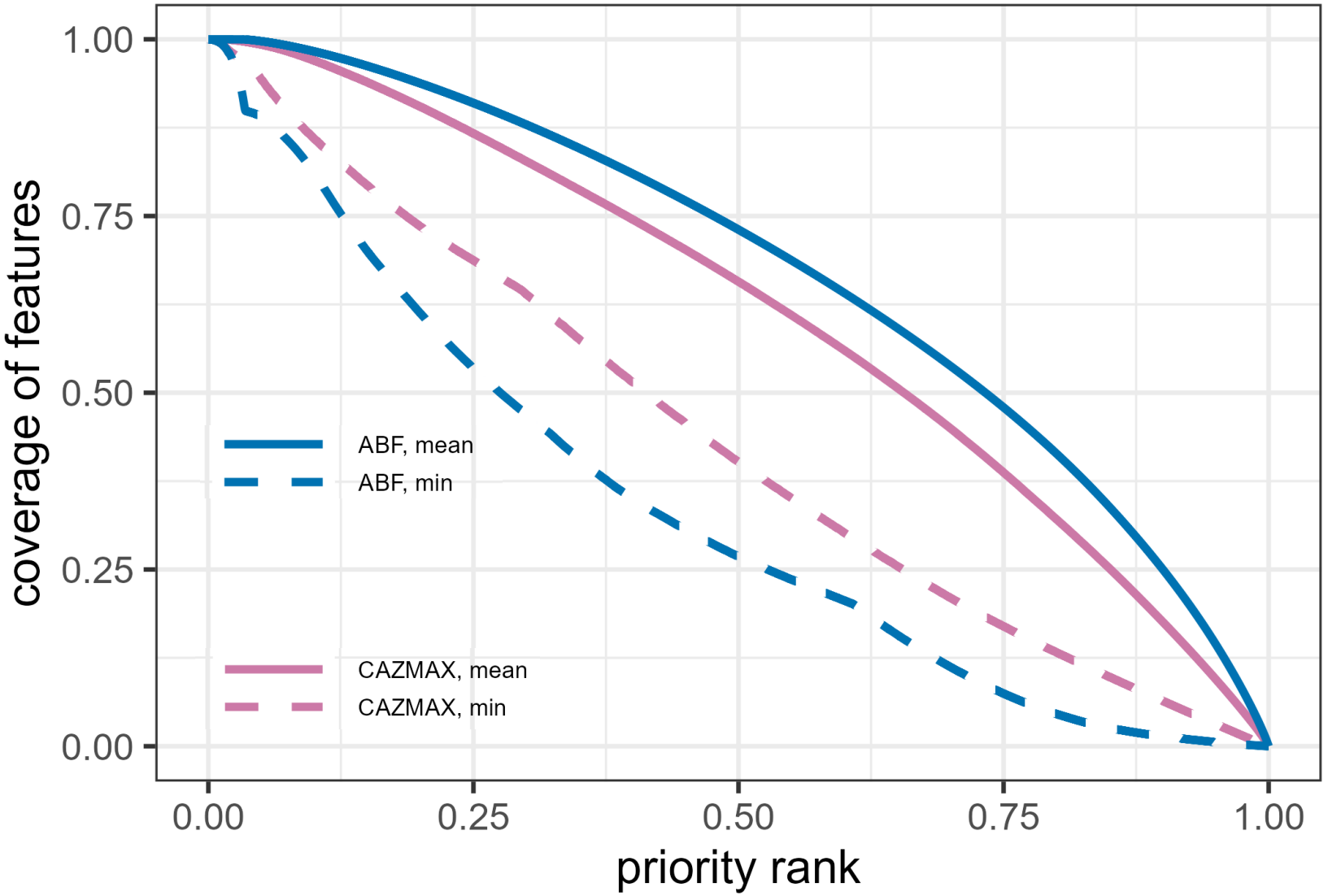

- CAZMAX: emphasis on good minimum coverage; relatively poor mean coverage
- ABF & CAZ1: emphasis on good mean coverage; relatively poor minimum coverage

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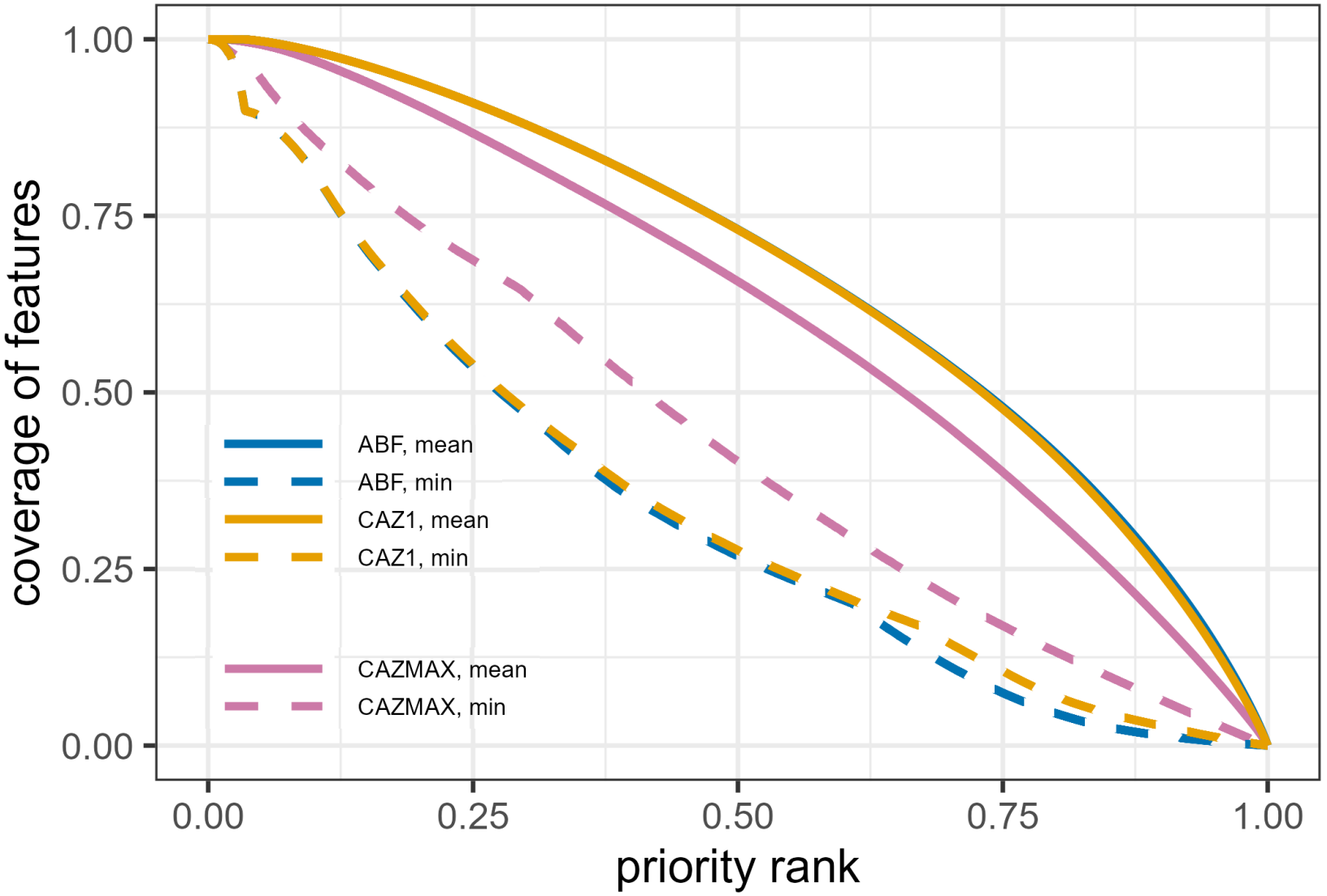

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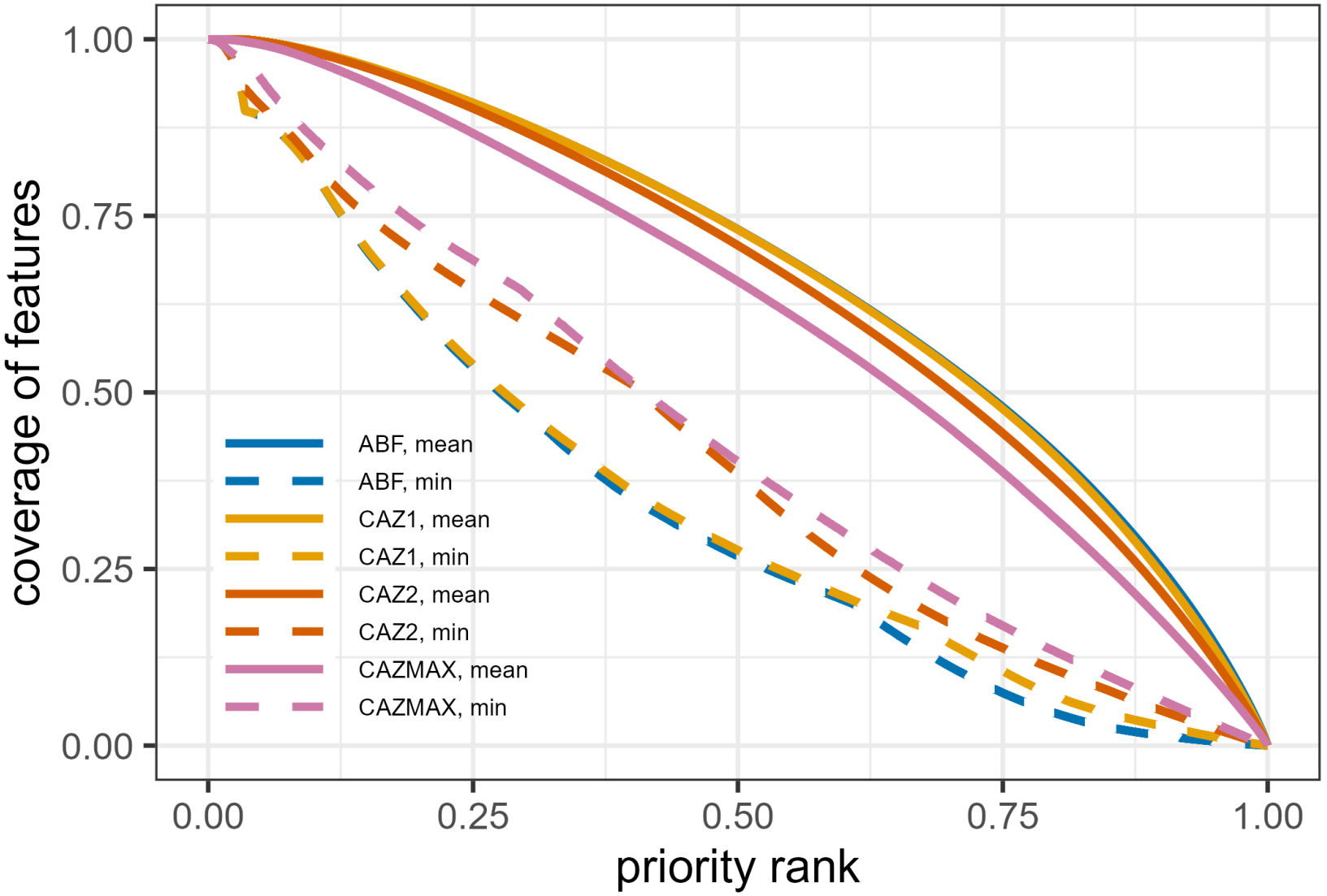

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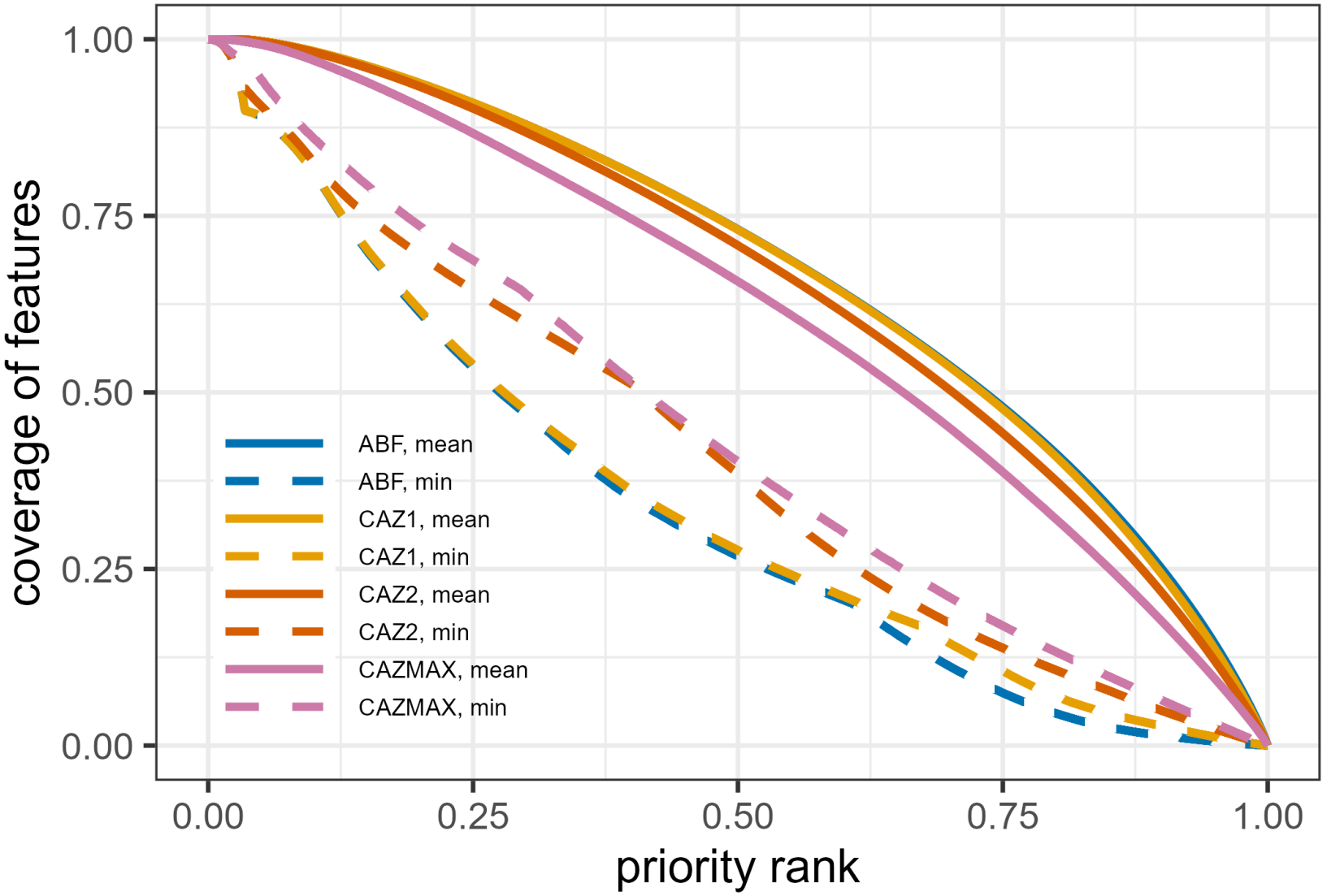

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- ABF & CAZ1: emphasis on good mean coverage; relatively poor minimum coverage
- CAZ2: intermediate in both regards

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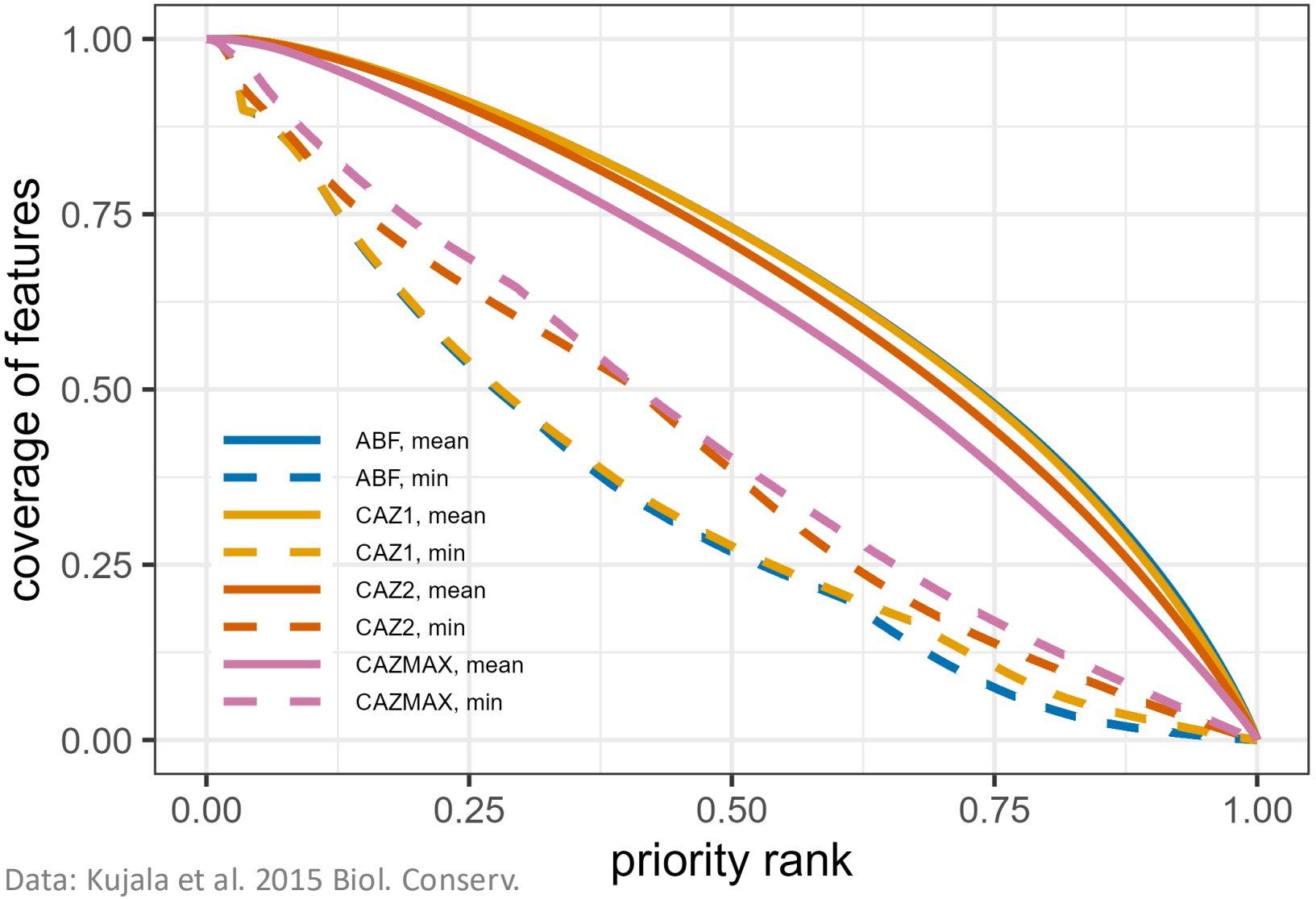


Data: Kujala et al. 2015 Biol. Conserv.

- CAZMAX: emphasis on good minimum coverage; relatively poor mean coverage
- ABF & CAZ1: emphasis on good mean coverage; relatively poor minimum coverage
- CAZ2: intermediate in both regards

- **The degree to which these patterns emerge depends a lot on the data set!**

V. Weighting

- Weighting should be based on higher-level considerations of conservation planning:
  - Red-list status
  - Endemicity
  - Quality of the data
  - Economic value
  - Preferences
- Note: rarity alone **not** a reason for higher weights

Note that Zonation treats weights as relative!

1.0 Species1.tif		10 Species1.tif
2.0 Species2.tif	=	20 Species2.tif
4.0 Species3.tif		40 Species3.tif

V. Weighting features

- Features can be weighted in many different ways
  - Positive weights → prefer
  - Negative weights → avoid
  - Zero weights → include but ignore (e.g. surrogacy analysis)
- Zonation 5 automatically creates outputs (curves, statistics) separately for pos., zero. & neg. weighted features
- Weight groups: give a combined weight to a subset of features
  - E.g. total 200 points to habitats, 100 to species

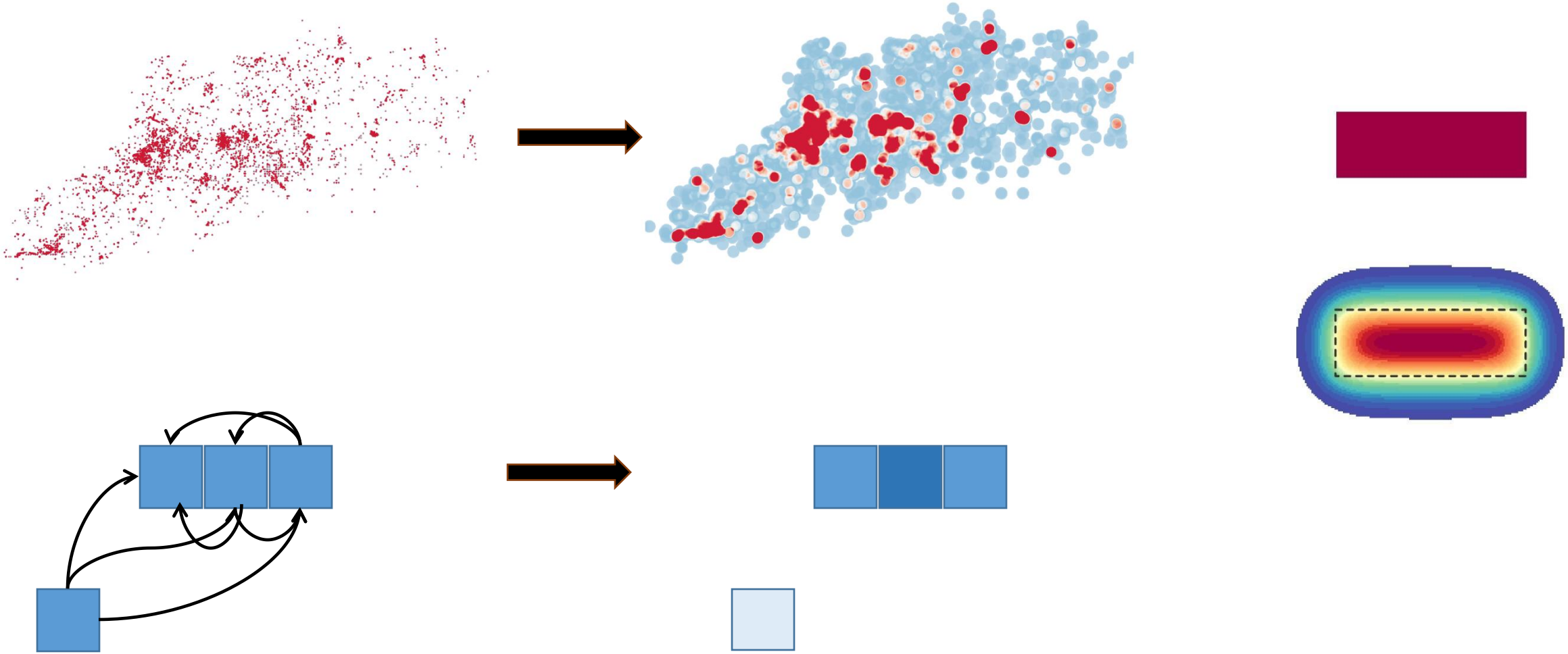
VI. Connectivity in Zonation 5

- Zonation 5 includes feature-specific connectivity transformations, based on dispersal kernels → Functional connectivity!
- Can be applied to
  - Distribution smoothing
  - Interaction connectivity
  - Matrix connectivity

- Zonation 5 does not include structural connectivity methods like Boundary Length Penalty or Corridor Retention method as in Zonation 4

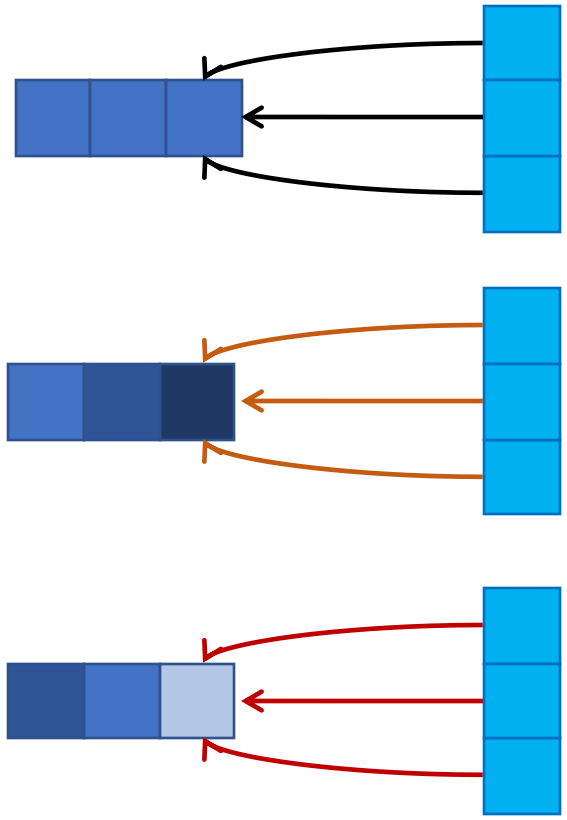
VI. Single-feature connectivity

Distribution 'smoothed' based on a dispersal kernel:

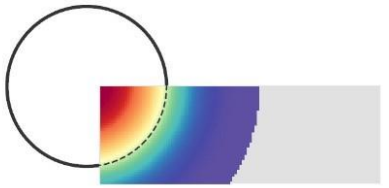


VI. Interaction connectivity

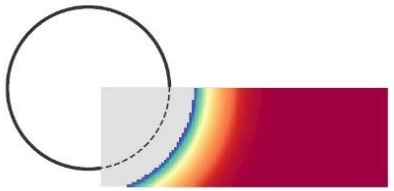
INTERACTION CONNECTIVITY:
Connectivity between two DIFFERENT features



Positive interactions (resource-consumer, climate change, protected areas)



Negative interactions (pollutants, invasive species, other threats)



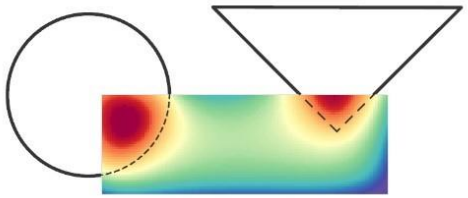
VI. Matrix connectivity

MATRIX CONNECTIVITY:

Pair-wise connectivity between MANY different features

E.g. ”how well different forest types support each other?”

	Pine	Spruce	Birch	Decid.
Pine	1.0	0.7	0.4	0.2
Spruce	0.7	1.0	0.6	0.4
Birch	0.3	0.6	1.0	0.8
Decid.	0.5	0.5	1.0	1.0



Lehtomäki et al. 2009. For. Ecol. Mgmt 258: 2439-2449