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Connection corridors to alleviate biodiversity loss: conception through mathematical optimisation

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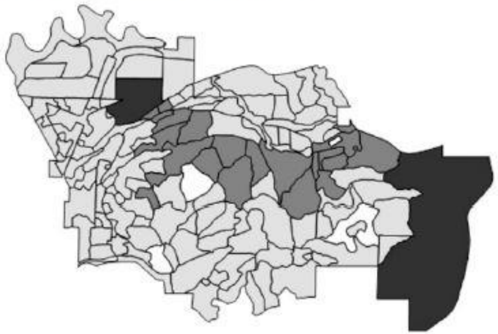
Keywords: biodiversity conservation, habitat fragmentation, ecological connectivity/continuity, natural resource management, land use planning, wildlife corridors, corridor modelling, corridor planning, operations research, path planning, piano movers' problem

"Wildlife movement corridors, also called dispersal corridors or landscape linkages as opposed to linear habitats, are linear features whose primary wildlife function is to connect at least two significant habitat areas" (Beier and Loe, 1992 *in* Bond, 2003, p.1)

Figure 1. A Landscape with a Corridor



(St John, Toth, Zabinsky, 2018)

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What species? What geographical scope? Existing reserves or from scratch?

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Objectives / Identified gaps:

- **Variation/Extension** of the optimal corridor construction (OCCA) (St John et al., 2018)
- **Managerial utility & applicability** of the solutions (Billionnet, 2013)
- Accurate treatment of **large size instances** (Billionnet, 2013)
- « **Research-implementation gap** » (Knight et al., 2008 *in* Billionnet 2013)

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Potential research questions:

How can we **determine the optimal path** that **links disconnected** protected **areas**, so as to **best preserve biodiversity**?

1. What **methods** have already been developed to geometrically optimize paths between given areas and what are their limits and (dis)advantages?
2. How can the issue be adequately **modelled**: what are the variables, objectives, parameters and constraints linked to this issue?
3. What **methods** should be developed to solve the issue?

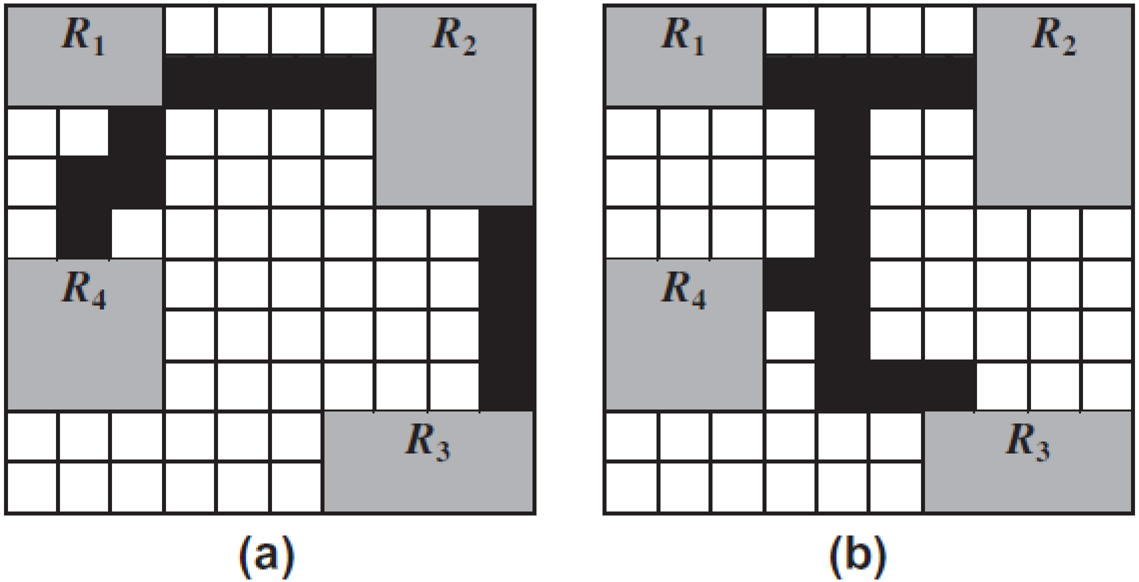


Fig. 4. (a) The restoration of 12 parcels connect the four reserves R_1, R_2, R_3, R_4. The length of the corridor connecting R_3–R_4 is 18. (b) The restoration of 13 parcels connect the four reserves. The length of the corridor connecting R_3–R_4 is equal to 6.

Problem

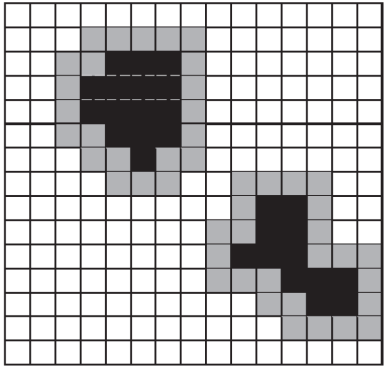
- Parameters:
  - Protected areas (a_1, a_2, …., a_n)
  - Species to protect (e_1, e_2, ….,e_m)
  - s_k= area allowing to protect e_k
- Variables
  - x_i=1 if a_i is selected; 0 otherwise
- Objective:
  - Min $\sum_{i=1}^{n}(c_i)x_i$

  s.t

  - $\sum_{i\in s_k} x_i \geq 1$ for all species e_k

Variations & extensions

- Objective: maximising the **number** of species
- **Priority** species
- **Budgetary** constraints
- Areas' **characteristics**
- **Probabilistic** aspects (*e.g.* uncertainties in species survival)
- ...



Two disjoint reserves with central area (black) and buffer zone (gray).

Thank you for your precious advice!

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