Contribution of a restored gravel pit lagoon system to the functional connectivity at landscape scale using European otters as indicators

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Introduction

Gravel pit lagoons

Ecological restoration

Wet lands

Landscape transformation
- Habitat availability
- Habitat isolation

Nutrient cycling
- Habitat
- Biodiversity

Connectivity
- Expansion and colonization
- Gene flow
- Resilience
Objectives

(1) to disentangle the role of a restored gravel pit lagoon system in the landscape functional connectivity

(2) to compare alternative restoration scenarios to improve the connectivity at landscape scale

Indicator species

European Otter (*Lutra lutra*)
Introduction. Study area

729 km²
Introduction. Study area

Gravel pit lagoon system

Duero river

Irrigation channel

Ditch
Introduction. Áridos Sanz gravel pit
Methods. Functional connectivity index

Probability of connectivity (PC)

Pascual-Hortal and Saura, 2006

Habitat availability concept
Interpatch dispersal probabilities
Graph structures

Assessment of restoration scenarios
Methods. Steps of analysis

1. Nodes identification

2. Links characterization

3. Determination of PC (and components)

4. Variation of PC with restoration scenarios

Analysis of the matrix

Otter habitat suitability model (HSM)
(Martin-Collado et al., in prep.)

Otter dispersion ability
Methods. HSM spraints sampling

7 monthly field works during 2016 and 2017

19 transects (600m)

Transects in the gravel quarry

6 Lagoons
- North
- Central
- Small
- Pre-Middle
- Middle
- Reticulada

1 Ditch

2 Duero River
East and West

2 Irrigation channel
East and West
Methods. HSM spraints sampling

Transects in the **gravel quarry surroundings**

- 4 Duero River
  - 5 & 15 km East and West
- 4 Irrigation channel
  - 5 & 15 km East and West
Methods. HSM statistical analysis

Data of 19 transects

- Habitat characteristics
- Marking intensity

Statistical analysis
- Correlation analysis
- Principal Components Analysis
- Zero Inflated Models

<table>
<thead>
<tr>
<th>Habitat degradation</th>
<th>Number of fresh feces/100m</th>
</tr>
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<tbody>
<tr>
<td>Low</td>
<td>No disturbances</td>
</tr>
<tr>
<td></td>
<td>Occasional disturbances</td>
</tr>
<tr>
<td></td>
<td>Common disturbances</td>
</tr>
<tr>
<td></td>
<td>Frequent intensive</td>
</tr>
<tr>
<td>High</td>
<td></td>
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</tbody>
</table>

Bush cover (5m) 70% 35% 0%
Forested buffer area (100m) 50% 25% 0%
Methods. Nodes identification

Habitat availability in the study area

HSM results

- Riparian vegetation cover
- Land use: Forest > Agriculture > Urban
- Human disturbance

Definition of nodes

100 meters buffer areas around water bodies
- At least 30m wide forested area
- Surface > 5,000 m²
- Without roads or tracks wider than 3m
Results. Nodes identification

Irrigation channel: 10 nodes  Lagoon system: 1 node  River: 18 nodes
Methods. Landscape matrix resistance

Permeability = \textbf{Land use quality} - \textit{Disturbances}

<table>
<thead>
<tr>
<th>Land use</th>
<th>Value</th>
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<tr>
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<td>Urban green areas</td>
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<tr>
<td>Meadows</td>
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<tr>
<td>Anthropic-non urban</td>
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<tr>
<td>Roads</td>
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<tr>
<td>Highways</td>
<td>0</td>
</tr>
<tr>
<td>Urban</td>
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## Methods: Landscape matrix resistance

### Disturbances

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<tr>
<td>Large town</td>
<td>58.2</td>
</tr>
<tr>
<td>Small town</td>
<td>58.2</td>
</tr>
<tr>
<td>Disperse urban</td>
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<tr>
<td>Urban green areas</td>
<td>41.9</td>
</tr>
<tr>
<td>Anthrooic non-urban</td>
<td>52.4</td>
</tr>
<tr>
<td>Roads</td>
<td>52.4</td>
</tr>
<tr>
<td>Highways</td>
<td>58.2</td>
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### Land use layer

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<td>Disperse urban</td>
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<td>300</td>
<td>11.6</td>
</tr>
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### Buffer

- Land use layer
- Disturbances
- Raster (10x10m)
Results. Landscape matrix resistance

Human Disturbance map

One third of the landscape is affected by disturbances from one or several land use types.
Results. Landscape matrix resistance

Matrix resistance map

High resistance (>75): 38%
Medium-high resistance (50-75): 32%
Medium-low resistance (25-50): 29%
Low resistance (<25): 1%
Methods. Links and nodes PC

Least cost distance analysis (Linkage mapper)

Otter average dispersion length 5 km

CONEFOR 2.6

Probability of connectivity among nodes

(PC)

\[ \delta PC_k = \delta PC_{\text{intra}} + \delta PC_{\text{flux}} + \delta PC_{\text{connector}} \]

Area
Flux
Steeping stones

McRae y Kavanagh 2011
### Connectivity analysis

\[ \delta PC_k = \delta PC_{intra_k} + \delta PC_{flux_k} + \delta PC_{connector_k} \]
Methods. Definition of restoration scenarios

Restoration areas:

- **Scenario 1**: Restoration of the best 3 areas
- **Scenario 2**: Restoration of the best 8 areas
- **Scenario 3**: Restoration of the 13 identified areas

Rank according to $\delta PC$

Scenarios selection

- Constant restored surface area

Restoration areas: areas that do not meet the “nodes” criteria but are close

PC y Equivalent Conected Area (ACE)
Results. Analysis of restoration scenarios

<table>
<thead>
<tr>
<th></th>
<th>total</th>
<th>dA</th>
<th>ACE</th>
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<td>Scenario 1: Rescate de los 3 mejores nodos</td>
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<td>Scenario 3: Rescate del aguas</td>
<td>0.6</td>
<td>dA&gt;dACE</td>
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</table>

Best restoration strategy

low number of areas in a good connectivity-wise location
Case study outcomes

- The studied **landscape**, is highly modified by **human activities**. However, is able to provide **habitat nodes** of enough quality for otter.

- The **matrix surrounding nodes** have, globally, **high resistance** to otter movements.

- The highest contribution to landscape **functional connectivity** comes from a low number of **habitat nodes, with the largest size, strategically located** and surrounded by “low” resistance matrix. These are **key to conserve**.

- The **gravel pit lagoon system** is well **connected** with other habitat nodes and therefore **contributed** to the maintenance of landscape functional connectivity.

- The **best strategy** is to **concentrate** the **restoration efforts** in a **low number of well-located areas**.
Implications for practice

• Spatial analysis is an useful approach to evaluate restoration projects (e.g. in gravel pits) in term of connectivity improvements at the landscape scale.

• GIS and CONEFOR software are ready to use technologies.

• The more field work to support the connectivity models, the best the results.
Thanks!