Wind energy infrastructures and bats: is coexistence possible?

Regional scale modelling as a promising solution

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ECOMODEL AUGMENTED ENVIRONMENT

UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

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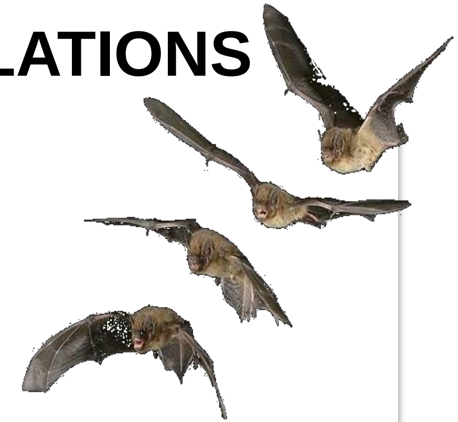
5TH INTERNATIONAL ECOSUMMIT
ECOLOGICAL SUSTAINABILITY
ENGINEERING CHANGE

IMPACTS OF WIND FARMS ON BAT POPULATIONS



- •COLLISIONS
- •INTERFERENCES WITH COMMUTING AND MIGRATION ROUTES
- •FORAGING HABITAT LOSS OR ALTERATION
- •INTERFERENCE WITH ROOSTS

Rodrigues et al. 2008

CUMULATIVE IMPACT

LARGE SCALE IMPACTS THAT ARE NOT DETECTABLE ON A LOCAL SCALE (foraging habitat loss, cumulative collision risk, connectivity alteration, barrier effect etc.)

Rodrigues et al. 2008; Jones et al. 2009

AIM

propose a landscape approach to evaluate the cumulative impact of wind farms on bat communities on a regional scale

OBJECTIVES

a) to produce risk maps by overlaying foraging habitat maps with existing and planned wind farms locations

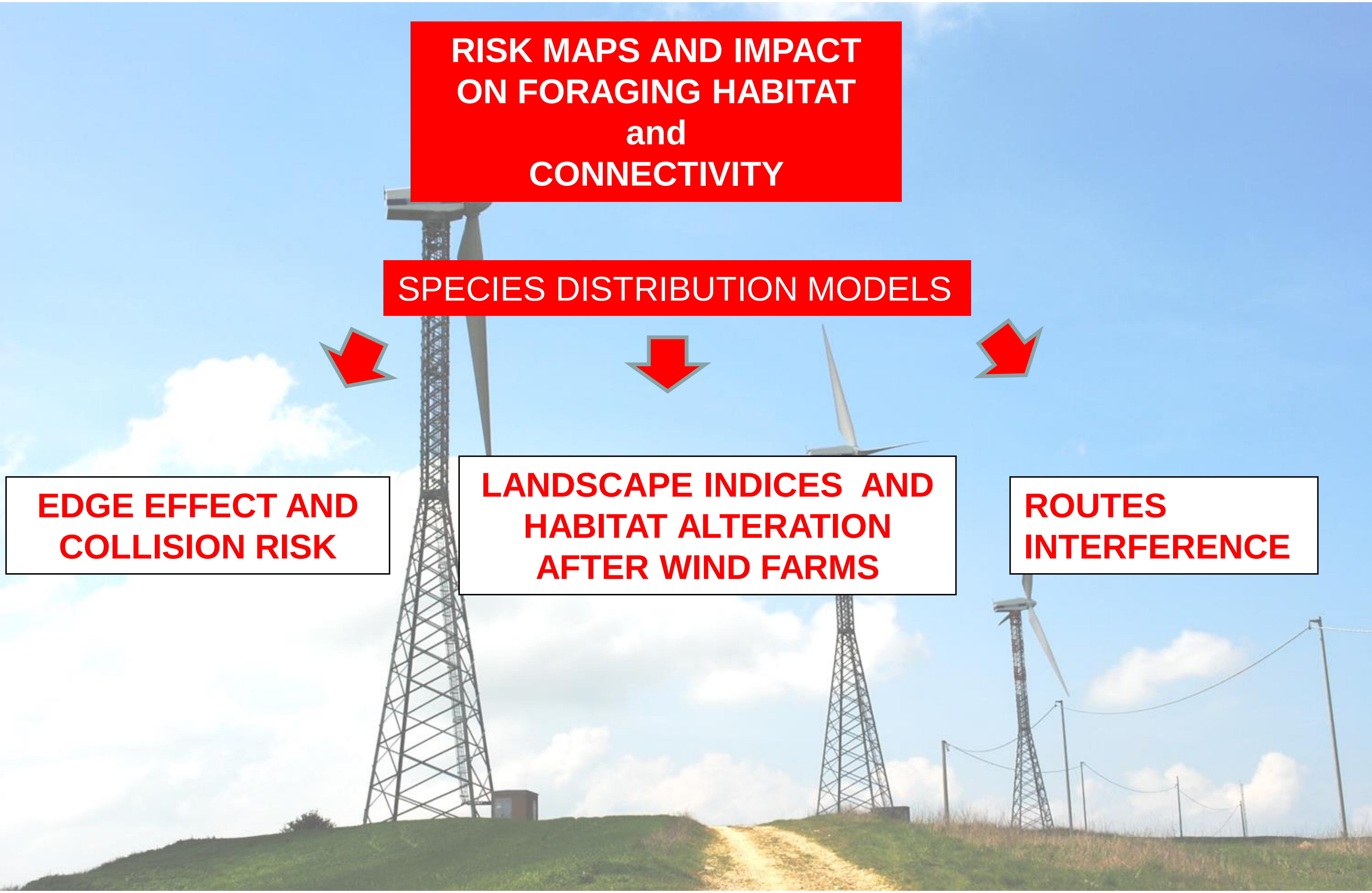
b) to assess changes in the spatial pattern of foraging habitat determined by existing and planned wind turbines

c) to identify the most impacting wind turbines that interfere with the most valuable connectivity routes

d) to provide mitigation measures for habitat alteration and connectivity disruption

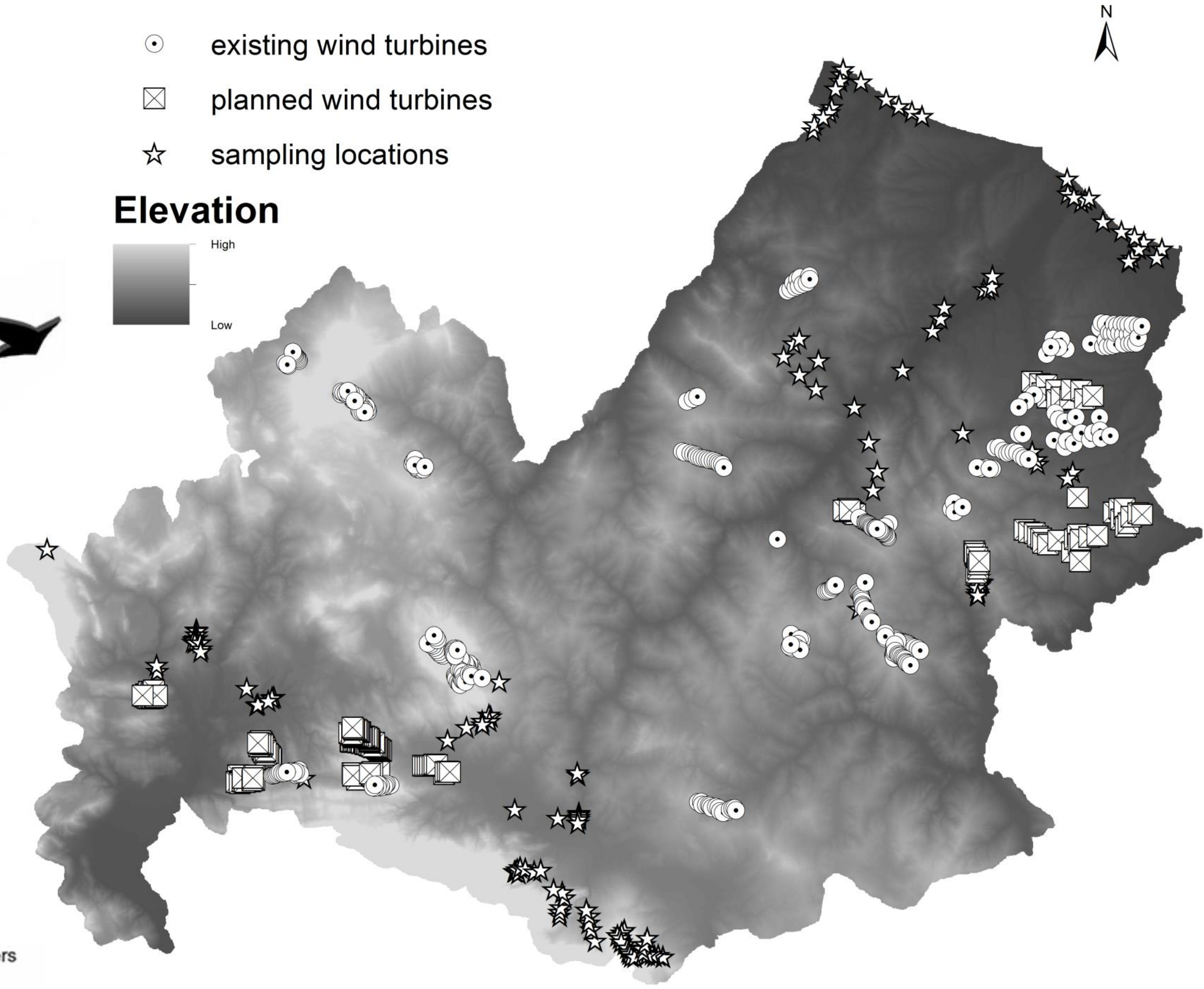
Based on research priorities evidenced by Rodrigues et al. 2008; Jones et al. 2009

PROJECT FRAMEWORK



STUDY AREA

4.437,58 km²



39 wind farms (28 operating and 11 planned), for a total of **543** wind turbines

MAXIMUM ENTROPY (MAXENT 3.3.3k, Phillips et al. 2004, 2006)

- **Maximum Entropy is a machine-learning non-parametric method which allows complex models to be developed even from small datasets**
- **Requires presence data only**
- **great performance when compared with other SDMs**

2010-2011 **Presence data**

P. pipistrellus	121	Autocorrelation analysis	29
N. leisleri	47		19

ENMTOOLS (*Warren et al. 2011*) → **Model selection** → **AICc** → **β = 2.0**

MAXIMUM ENTROPY (MAXENT 3.3.3k)

ENVIRONMENTAL VARIABLES

Type	Variables	Code	Source of data	Source of maps and scale
Topographical	Elevation (m)	DTM		cell size 40 m year 2005 MATTM Geoportale Nazionale
	Exposure north-south	Aspectns	Calculated from DTM	
	Distance in m to the maximum slope (40 degrees)	Euslope40		
	Distance in m to water courses	Euidro	Euclidean distance calculated from water courses	scale: 1:50.000 year 2008 MATTM-Geoportale Nazionale
Cover types	Reclassified Corine Land Cover	ReclCLC		1:100.000 year 2006 EEA CLC expanded to a IV level of detail developed for Italy (MATTM-Geoportale Nazionale)
	Distance to natural agriculture (2.4.3)	Euculna	Euclidean distance calculated from CLC categories	
	Distance to forests (3.1.1)	Euforest		
	Distance to riparian forests (3.1.1.6)	Eurip		
	Distance to complex cultivation patterns (2.4.2)	Eucomplex		
	Distance to olive groves (2.2.3)	Euolive		

Landscape Pattern analysis

FRAGSTAT 3.3 Version (McGarigal&Marks, 1995) ran considering and omitting wind farms on binary SDMs:

- **suitable for *P. pipistrellus***
- **suitable for *N. leisleri***
- **suitable for both species.**

Landscape metrics

Class area (CA)	**Number of Patches (NP)**	**Mean Patch Size (MPS)**
the extension of each class in hectares	the number of patches present in the class of interest	the mean size of patches in the class of interest
Largest Patch Index (LPI)	**Area Weighted Mean Shape Index (AWMSI)**	**Aggregation Index(AI)**
landscape percentage occupied by the greatest patch of the interest class	quantifying the landscape configuration in terms of complexity of the patches that constitute it	describes the adjacencies of habitat “cells”

Connectivity procedures

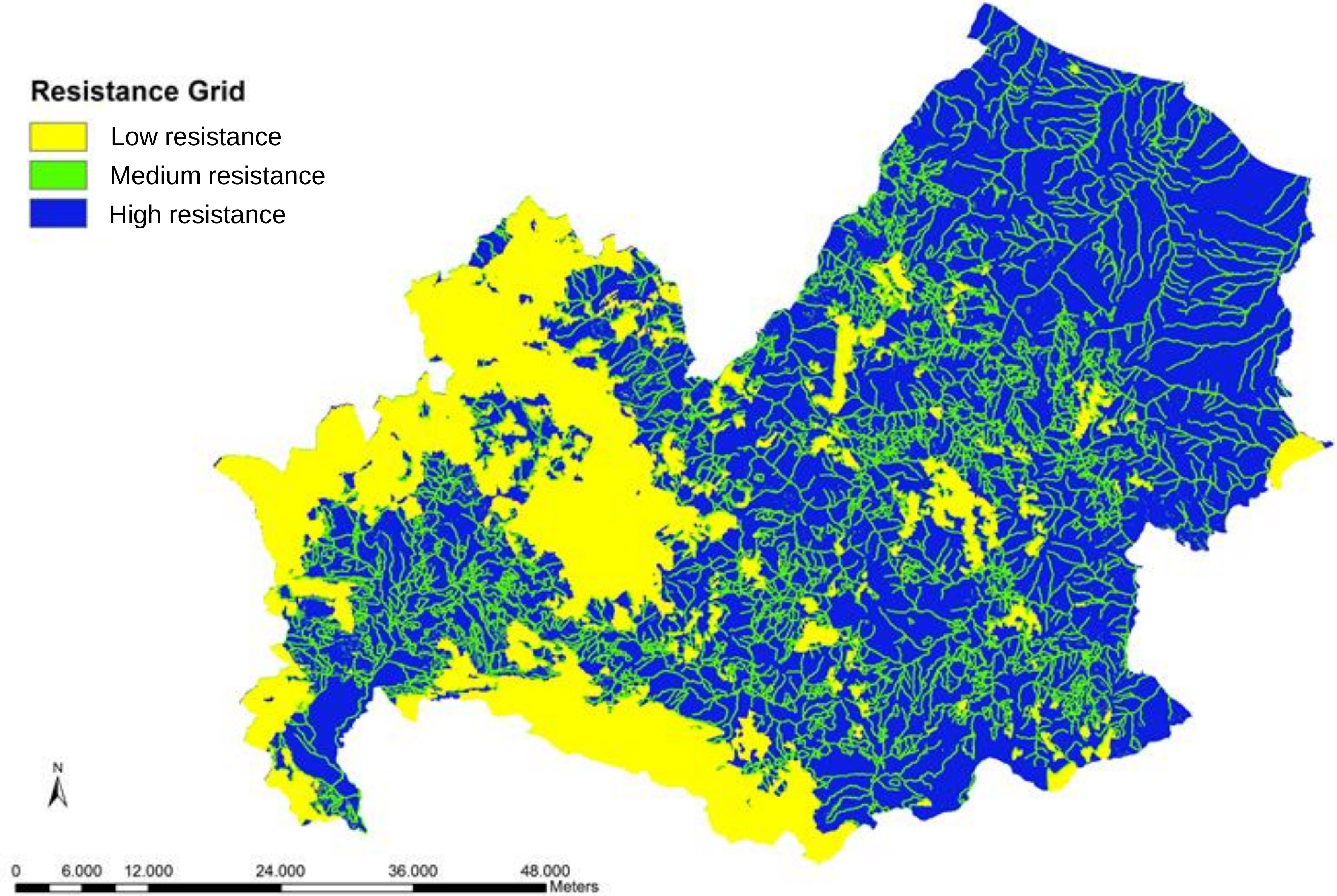
UNICOR which integrates least cost path and kernel predictions (Landguth et al. 2012) requires two input files as the first step: 1) a landscape resistance grid

suitable areas: low resistance

not suitable : high resistance value

slope, forest edges, hydrography: medium resistance

Connectivity procedures



Connectivity procedures

UNICOR which integrates least cost path and kernel predictions (Landguth et al. 2012) requires two input files as the first step: 2) point locations for each population or individual's location.

50 points, extracted by the predicted suitable areas for the species.

We repeated the extraction for 10 times to obtain 10 random dataset of point locations

Connectivity procedures

UNICOR which integrates least cost path and kernel predictions (Landguth et al. 2012) requires two input files as the first step: 1) a landscape resistance grid; 2) point locations for each population or individual's location.

10 UNICOR run.

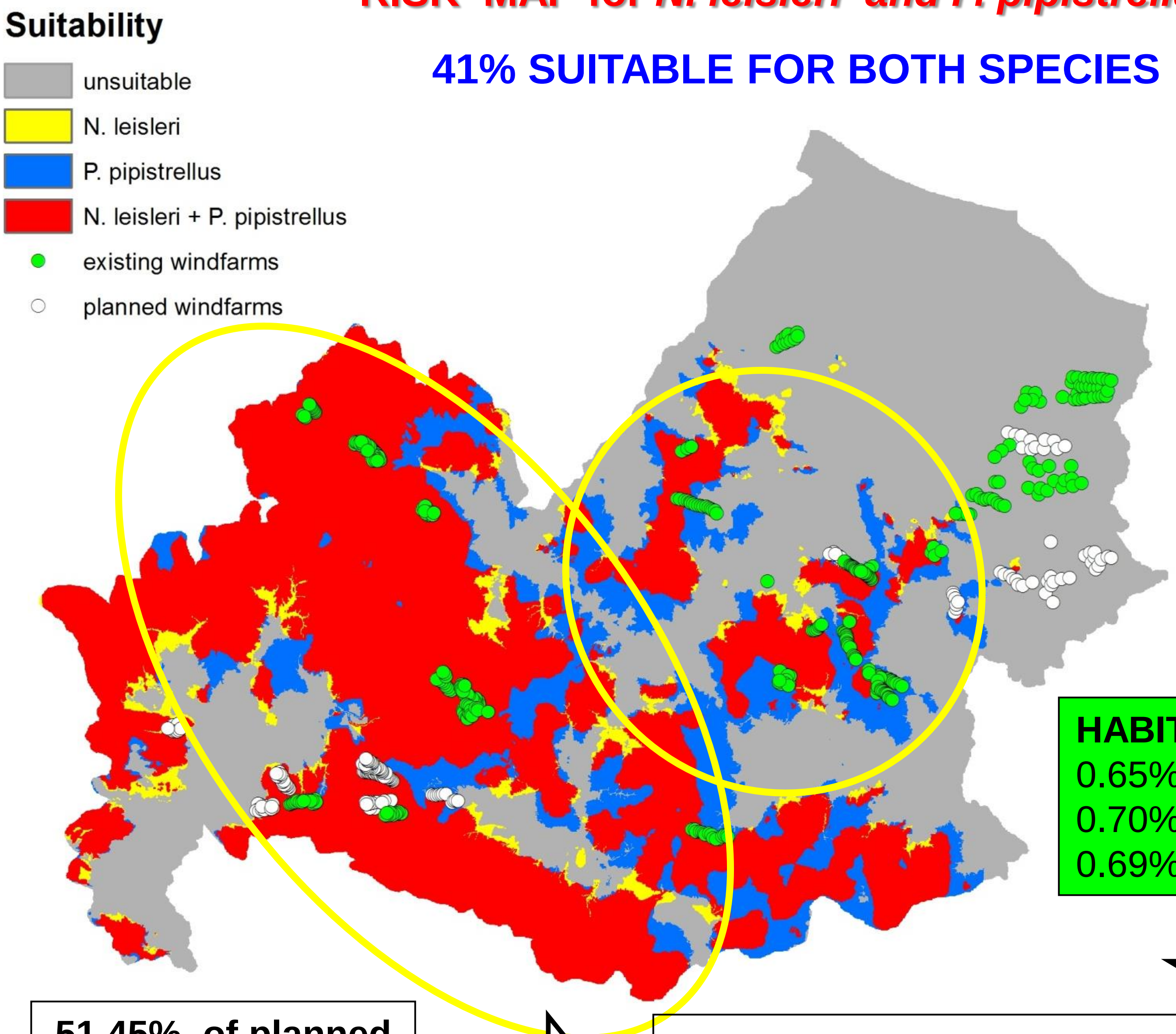
UNICOR output: reclassification considering as threshold the median (Cianfrani et al. 2013)

Overlap procedure: connectivity map overlaid with that containing the location of existing and planned turbines, each buffered 150 m, applying the zonal statistic function of ArcGis10

RESULTS

RISK MAP for *N. leisleri* and *P. pipistrellus*

41% SUITABLE FOR BOTH SPECIES



66.67% **of existing turbines on suitable areas-699ha subtracted**

HABITAT LOSS EXISTING W. F.:
0.65% for *N. leisleri*
0.70% for *P. pipistrellus*
0.69% for both species

51.45% of planned turbines on suitable areas-1092ha subtracted

HABITAT LOSS EXISTING + PLANNED W.F.:
1.00% for *N.leisleri*, 1.00% for *P. pipistrellus* and 1.06% for both species

RESULTS

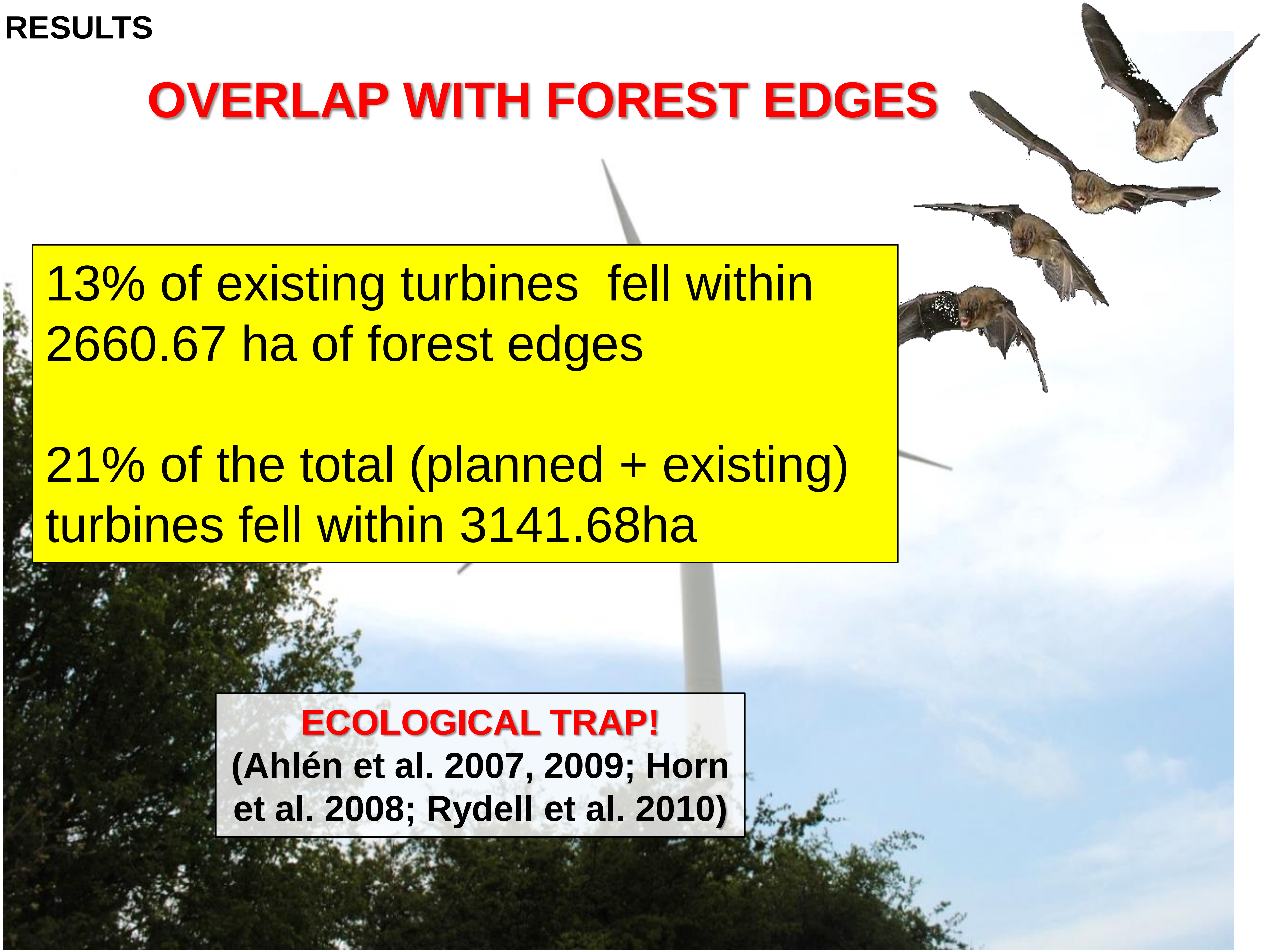
Landscape Pattern analysis

FRAGSTAT 3.3 Version (McGarigal & Marks, 1995)

Indices	**Species**	**no wind farms**	**% variation existing wind farms**	**% variation existing + planned wind farms**
CA (ha)	*P. pipistrellus*	22,8007.04	-0.70	-1.00
CA (ha)	*N. leisleri*	18,8803.84	-0.65	-1.00
CA (ha)	Both species	17,6754.40	-0.69	-1.06
NP	*P. pipistrellus*	103	+7.76	+12.62
NP	*N. leisleri*	174	+4.02	+7.47
NP	Both	169	+4.14	+7.69
LPI (%)	*P. pipistrellus*	44.85	-0.67	-1.00
LPI (%)	*N. leisleri*	34.69	-0.55	-0.94
LPI (%)	Both species	32.17	-0.59	-1.02
MPS (ha)	*P. pipistrellus*	2,213.6	-7.86	-12.09
MPS (ha)	*N. leisleri*	1,085.0	-4.49	-7.88
MPS (ha)	Both species	1,045.88	-4.49	-8.12
AWMSI	*P. pipistrellus*	8.75	+8.50	+12.11
AWMSI	*N. leisleri*	6.41	+7.29	+11.89
AWMSI	Both species	7.30	+6.59	+10.73
AI (%)	*P. pipistrellus*	99.11	-0.08	-0.12
AI (%)	*N. leisleri*	99.11	-0.07	-0.11
AI (%)	Both species	98.91	-0.08	-0.12

RESULTS

OVERLAP WITH FOREST EDGES



13% of existing turbines fell within 2660.67 ha of forest edges

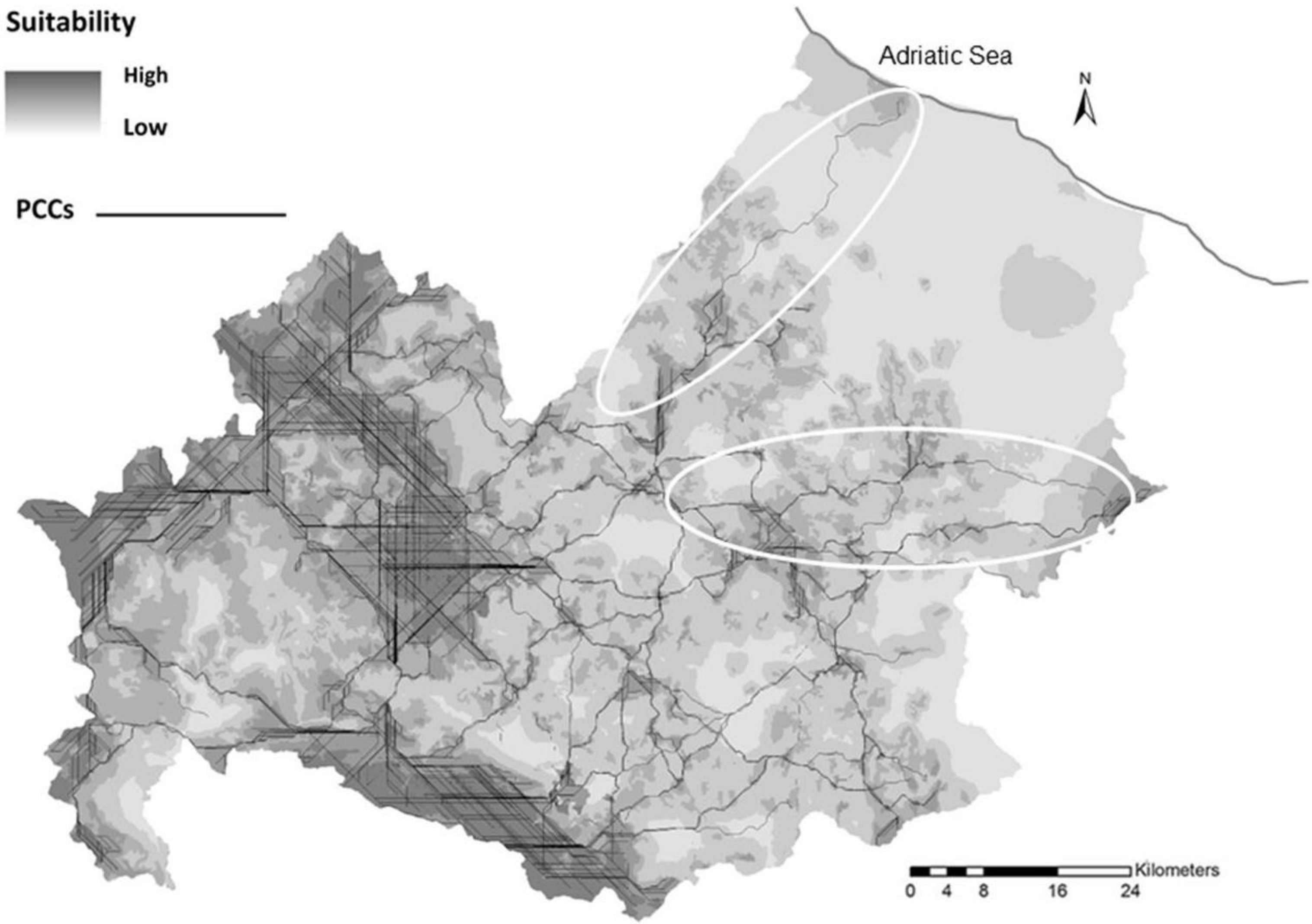
21% of the total (planned + existing) turbines fell within 3141.68ha

ECOLOGICAL TRAP!

(Ahlén et al. 2007, 2009; Horn et al. 2008; Rydell et al. 2010)

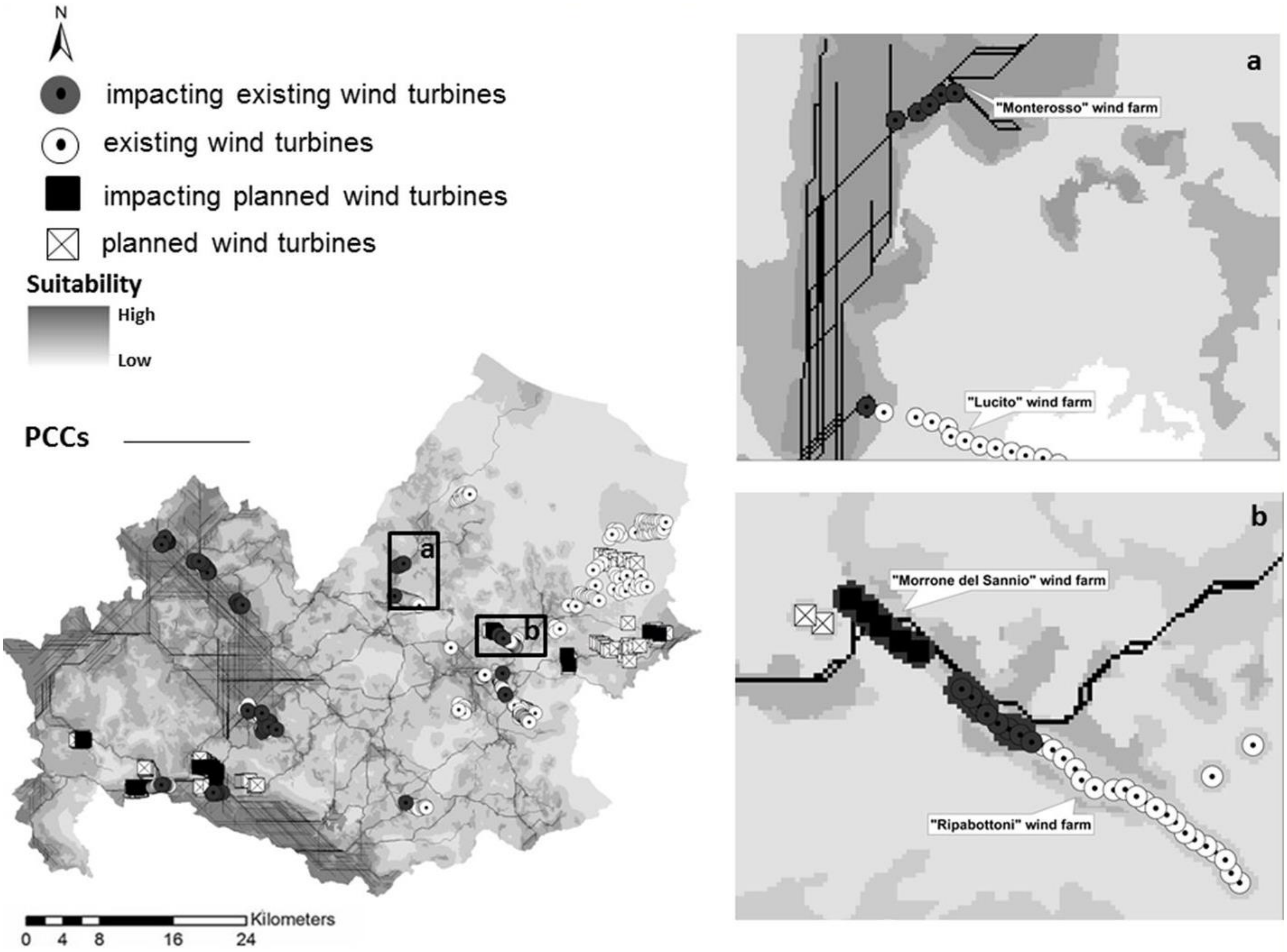
RESULTS

CONNECTIVITY MAP for N. leisleri



RESULTS

BARRIER IMPACT ASSESSMENT



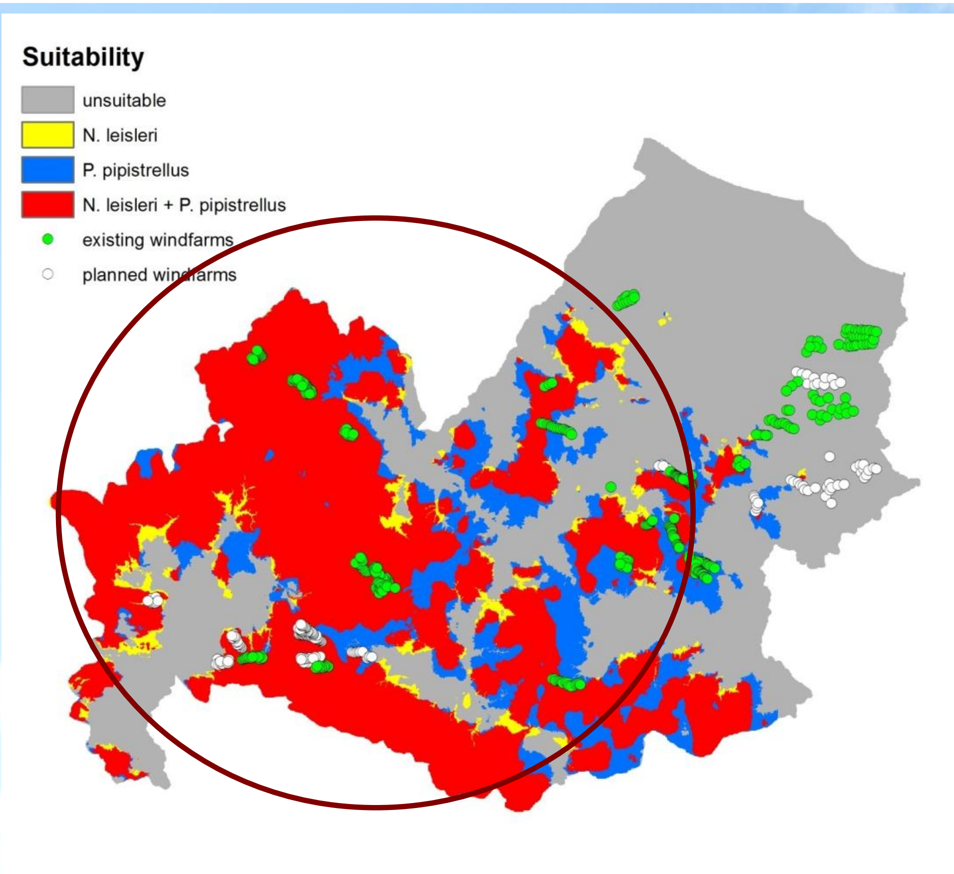
RESULTS

WIND FARMS IMPACT ASSESSMENT

Wind Farm	Sector location in Molise	Existing	Planned	Habitat Alteration	N wind turbines	N wind turbines intersecting PCCs	Meters impacted (150 buffer around each turbine)
Capracotta	NW	x		x	16	7	1361.59
Vastogirardi	N	x		x	18	11	1734.47
San Pietro Avellana	NW	x		x	12	12	1806.37
Pietrabbondante	E	x		x	13	9	1424.94
Carpinone	W	x		x	11	2	469.12
Frosolone	W	x		x	19	8	1120.46
Frosolone	W	x		x	8	8	932.22
Macchiagodena	W	x		x	19	7	1774.12
Montaquila	NW		x	x	16	6	808.65
Monteroduni	W		x	x	20	5	1653.54
Monteroduni-S. Agapito	W		x	x	22	-	-
Castelpizzuto	SW		x	x	21	12	1914.76
Roccamandolfi	SW		x	x	20	1	339.87
Longano	SW	x		x	18	3	679.43
Roccamandolfi	SW	x		x	12	6	1331.15
Cantalupo del Sannio	E		x		11		-
Cerce picolla-S.Giuliano-Vinchiaturo	E	x		x	16	1	310.20
San Giovanni in Galdo	E	x		x	18	-	-
Campolieto	E	x		x	7	-	-
Lucito	E	x		x	17	1	361.79
Monterosso	NE	x		x	5	5	1300.33
Acquaviva-Collecroce	NE	x			11	-	-
Morrone del Sannio	SE		x	x	7	5	1032.20
Ripabottoni	SE	x		x	30	8	1018.10
Castellino	E	x			1	-	-
Monacilioni	SE	x		x	16	3	764.26
Monacilioni	SE	x		x	4	-	-
Pietracatella	SE	x		x	18	-	-
Macchia Val Fortore	SE	x		x	12	-	-
S. Elia a Pianisi “Colle delle Brecce”	SE		x	x	7	2	708.32
Bonefro	SE	x		x	4	-	-
S. giuliano di Puglia	SE		x	x	16	2	652.92
S. Croce di Magliano	SE		x		11	2	686.12
Montelongo-Montorio dei Frentani Rotello	E	x		x	21	-	-
Rotello	E	x			15	-	-
Ururi	E		x		13	-	-
San Benedetto	E	x			6	-	-
San Martino in Pensilis	E	x			29	-	-

15 existing and 8 planned wind farms impact both in term of landscape pattern alteration and barrier effect

IMPLICATION FOR CONSERVATION



The western part of the Molise region is the most vulnerable area

⇩

critical area in wind farm planning and in conservation strategies

IMPLICATION FOR CONSERVATION

AVOID CONSTUCTION

- **Planned turbines falling within forest edges (Rodrigues et al.2008)**
- **8 planned wind farms that fall in suitable areas and encounters high connectivity routes**

MITIGATION MEASURES

- **The 15 existing wind farms falling in high connectivity migratory routes and in suitable habitats at wind speed lower than 7 m/s turbines have to be shut down (Johnson et al 2003; Arnett et al. 2005; Horn and Arnett 2005; Brinkmann et al. 2006)**

SURVEYS FOR MONITORING BAT FATALITIES

- **Concentration of field effort on wind farms that affect bat assemblages both in terms of habitat alteration and barrier effect.**

PUBLICATIONS

Biodivers Conserv
DOI 10.1007/s10531-013-0515-3

ORIGINAL PAPER

Regional-scale modelling of the cumulative impact of wind farms on bats

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M. L. Carranza · A. Loy

Landscape Ecol
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RESEARCH ARTICLE

A modelling approach to infer the effects of wind farms on landscape connectivity for bats

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Maria Laura Carranza · Mirko Di Febbraro ·
Anna Loy

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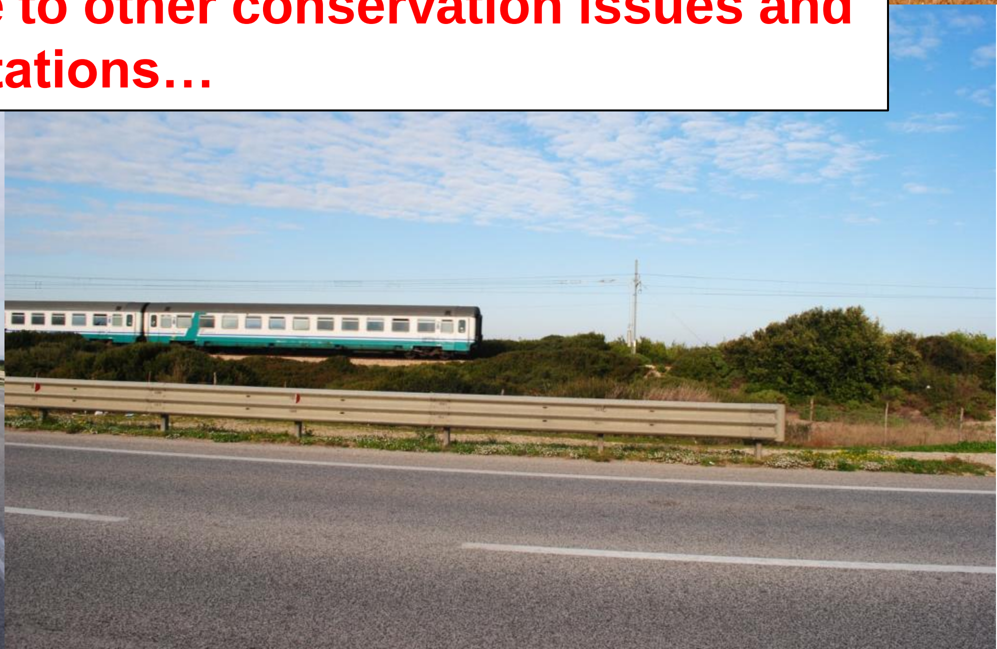
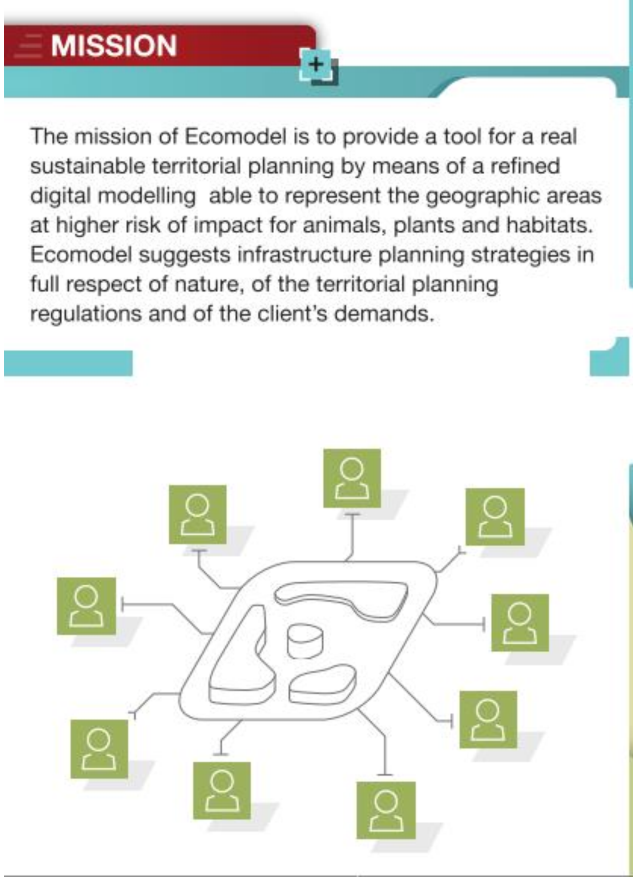
…APPLICATIONS

Flexible and transferable to other conservation issues and infrastructure implementations…



…APPLICATIONS



THANK YOU!