

1^{ères} Rencontres de l'Observatoire des EnR et de la Biodiversité

Vers une transition énergétique en harmonie avec la biodiversité, les sols et les paysages

Wind4Birds: un outil interactif pour optimiser les dimensions des éoliennes et leur distance aux nids, afin d'atténuer le risque de collision des oiseaux

Caroline De Zutter – ENGIE Lab CRIGEN



Projet EOLRAP

Tonio Schaub (IMBE)

Alexandre Million (IMBE)

Raymond Klaassen (University of Groningen, Dutch Montagu's Harrier Foundation)

Caroline De Zutter (ENGIE Lab CRIGEN)



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et d'écologie - marine et continentale -

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Aix Marseille Université

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Projet EOLRAP : un peu de contexte



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RESEARCH & INNOVATION



THÈSE DE DOCTORAT

Soutenue à Aix-Marseille Université
le 10 avril 2024 par

Tonio SCHAUB

**Reconciling wind energy development with bird
conservation: A comparative study of flight be-
haviour in raptors to understand and mitigate
wind turbine collision risk**

Discipline
Sciences de l'environnement

Spécialité
Écologie

École doctorale
ED 251 – Sciences de l'environnement

Laboratoire/Partenaires de recherche
Institut Méditerranéen de Biodiversité et
d'Écologie marine et continentale
ENGIE Lab CRIGEN
University of Groningen
Dutch Montagu's Harrier Foundation

Composition du jury

Beth SCOTT	Rapporteuse
Professeure, University of Aberdeen, UK	
Olivier DURIEZ	Rapporteur
Maître de conférences HDR, Université de Montpellier	
Virginie BALDY	Présidente du jury
Professeure des universités, Aix-Marseille Université	
Ana RODRIGUES	Examinatrice
Directrice de recherche, CNRS Montpellier	
Christian KERBIRIOU	Examineur
Maître de conférences, Sorbonne Université	
Alexandre MILLON	Directeur de thèse
Maître de conférences HDR, Aix-Marseille Université	
Raymond KLAASSEN	Co-encadrant
Maître de conférences, University of Groningen, NL	
Caroline DE ZUTTER	Co-encadrante
Ingénieure de recherche, ENGIE Lab CRIGEN	

Le projet EOLRAP exploite les résultats de la thèse
de Tonio Schaub, menée en partenariat entre :





Effects of wind turbine dimensions on the collision risk of raptors: A simulation approach based on flight height distributions

Tonio Schaub^{a,b,c,d,*}, Raymond H.G. Klaassen^{c,d}, Caroline De Zutter^b, Pascal Albert^e, Olivier Bedotti^f, Jean-Luc Bourrioux^e, Ralph Buij^g, Joël Chadœuf^e, Celia Grande^h, Hubertus Illnerⁱ, Jérôme Isambert^j, Kjell Janssens^{d,k}, Eike Julius^l, Simon Lee^{m,n}, Aymeric Mionnet^o, Gerard Müskens^p, Rainer Raab^l, Stef van Rijn^q, Judy Shamoun-Baranes^r, Geert Spanoghe^k, Benoît Van Hecke^e, Jonas Waldenström^s, Alexandre Millon^{a,e}



university of
groningen



Grauwe Kiekkendief
Kenniscentrum Akkervogels

En particulier les
résultats publiés dans
le journal Science of
the Total Environment.

Effects of wind turbine dimensions on the collision risk of raptors: A simulation approach based on flight height distributions

Tonio Schaub^{a,b,c,d,*}, Raymond H.G. Klaassen^{c,d}, Caroline De Zutter^b, Pascal Albert^e, Olivier Bedotti^f, Jean-Luc Bourrioux^e, Ralph Buij^g, Joël Chadœuf^e, Celia Grande^h, Hubertus Illnerⁱ, Jérôme Isambert^j, Kjell Janssens^{d,k}, Eike Julius^l, Simon Lee^{m,n}, Aymeric Mionnet^o, Gerard Müskens^b, Rainer Raab^l, Stef van Rijn^q, Judy Shamoun-Baranes^r, Geert Spanoghe^k, Benoît Van Hecke^e, Jonas Waldenström^s, Alexandre Millon^{a,e}

Le poster associé
est consultable
dans l'espace
Posters, venez le
voir pour plus
d'information.

Effects of wind turbine dimensions on the collision risk of raptors: a simulation approach based on flight height distributions

Raymond H. G. Klaassen^{a,d}, Caroline De Zutter^b, Pascal Albert^e, Olivier Bedotti^f, Jean-Luc Bourrioux^e, Ralph Buij^g, Joël Chadœuf^e, Celia Grande^h, Jérôme Isambert^j, Kjell Janssens^{d,k}, Eike Julius^l, Aymeric Mionnet^o, Gerard Müskens^b, Rainer Raab^l, Stef van Rijn^q, Judy Shamoun-Baranes^r, Geert Spanoghe^k, Benoît Van Hecke^e, Jonas Waldenström^s & Alexandre Millon^{a,s}



Figure 1: Illustration of the considered size parameters of wind turbines. OC = ground clearance; RD = rotor diameter.

RESULTS (1): Flight height distributions

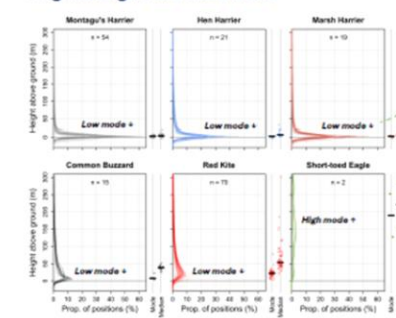


Figure 2: Flight height distributions per species in height bins of 5 m. Every line represents one individual bird; the mode and median per individual are indicated right of the panels (thick horizontal line: median across individuals; Prop. = proportion).

CONCLUSIONS:

Opposite effects of wind turbine dimensions on collision risk for different raptor species depending on the flight height distribution (low mode vs. high mode)

For species with low mode: Collision risk reduced when using

- turbines with higher ground clearance
- less turbines with larger diameter instead of more turbines with smaller diameter to achieve given total power (at fixed ground clearance)

RESULTS (2): Effects of turbine dimensions

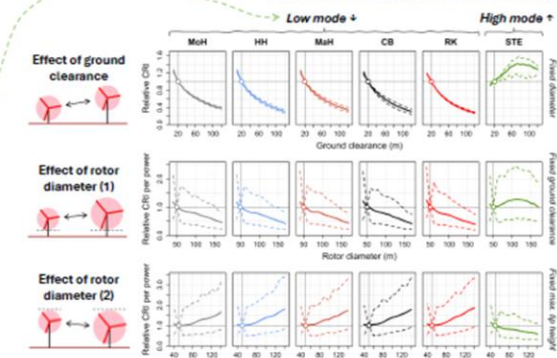


Figure 3: Effect of ground clearance and rotor diameter of wind turbines on collision risk relative to a reference level (thick vertical line). Panels show either collision risk index (CRI) per turbine (first row) or per rated power (second and third row). Thick lines: means; dashed lines: 95% confidence intervals.

FURTHER READING:

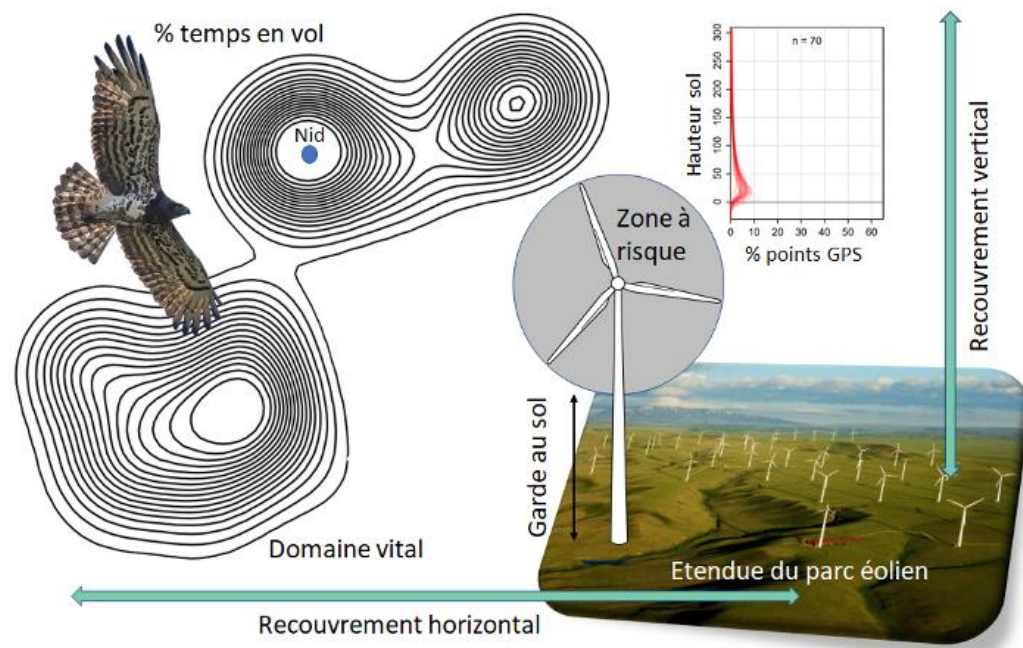
Schaub et al., 2024
Sci. Total Environ.

PhD thesis
Tonio Schaub

UP NEXT:

Development of publicly available online tool allowing to apply approach to real-world wind energy projects

If you want to keep updated, feel free to send an email! +



Pour ce faire, l'équipe du projet souhaite explorer un ensemble de mesures visant à éviter le risque de collision par une réflexion pré-implantation concernant le choix des sites et les dimensions des machines, mais aussi à réduire ce risque par des mesures post-implantation impliquant une stratégie de bridage des machines.

"Nous sommes en effet convaincus que la solution passe par la mise en place d'un ensemble de mesures, adaptées à la communauté d'oiseaux présente dans un environnement donné, plutôt que par la recherche d'une mesure unique applicable partout."



Impact des énergies renouvelables sur la biodiversité

Ce programme de financement de projets de recherche porté par la Fondation pour la recherche sur la biodiversité et le Mirova Research Center vise à mieux évaluer l'impact des énergies renouvelables sur la biodiversité et à produire des recommandations opérationnelles sur de meilleures pratiques à destination des acteurs de la filière.

Le programme de recherche sur les "Impact des énergies renouvelables sur la biodiversité" a pour ambition d'identifier les connaissances scientifiques actuelles sur les impacts des infrastructures de production d'énergie renouvelable sur la biodiversité, à travers, les cinq grands facteurs de perte de biodiversité identifiés par l'Ipbes, la plateforme intergouvernementale scientifique et politique sur la biodiversité et les services écosystémiques. Ces facteurs sont le changement d'occupation des sols, l'exploitation des espèces, les pollutions, le changement climatique et les espèces exotiques envahissantes. Les impacts de ces infrastructures surviennent à différentes échelles, que cela soit au niveau de l'individu (perturbations, blessures ou mort), des populations, des espèces, des communautés ou des écosystèmes.

Ce programme a pour ambition :

- D'améliorer la compréhension des impacts des infrastructures de production d'énergie éolienne, tant terrestres que marines, sur la biodiversité. Cela inclut la quantification de ces impacts, l'exploration de solutions d'évitement, de réduction et de compensation, ainsi que l'établissement de recommandations pratiques destinées aux acteurs de la filière éolienne.
- De mettre en lumière les pratiques bénéfiques tout en identifiant et en abandonnant celles qui sont nuisibles.
- De fournir des recommandations opérationnelles basées sur des données scientifiques solides afin de favoriser des méthodes de développement et d'exploitation optimales pour les infrastructures de production d'énergie renouvelable.

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avec le soutien de



PROJET EN COURS DEPUIS 2024

Eolrap

Modéliser les comportements de vol des rapaces pour améliorer l'évitement et réduire le risque de collision avec les éoliennes.



Le projet **Eolrap** vise à réduire l'impact du développement des infrastructures éoliennes sur les rapaces diurnes, identifiés parmi les espèces d'oiseau les plus vulnérables. Pour cela, le projet prévoit :

- de développer une application dédiée aux développeurs éoliens et aux autorités environnementales qui permet d'identifier la distribution spatiale et les dimensions des éoliennes qui minimisent le risque de collision, en fonction des espèces présentes dans une zone donnée, en s'appuyant sur la modélisation des comportements de vol obtenus *via tracking* GPS.
- d'évaluer les coûts, soit la réduction de la production d'énergie, et les bénéfices, soit la réduction des collisions, de stratégies d'arrêt des éoliennes à des périodes (calendaire, journalière, météo-dépendante) concentrant le vol des rapaces à hauteur des pales.

Le projet **Eolrap** s'appuie sur les travaux de thèse de Tonio Schaub "*Towards ecologically sustainable renewable energy production : Using detailed information on bird flight and ranging behaviour to mitigate the impact of wind farm development on bird populations*".

La France compte actuellement quelque 9 000 éoliennes produisant 8 % de la consommation d'énergie du pays. En 2020, le Ministère de la Transition écologique et solidaire annoncé que l'objectif de la France était de doubler cette capacité d'ici à 2028. Le développement de la production d'énergie éolienne induira *de facto* l'augmentation des collisions avec l'avifaune. La collaboration tri-partite du projet **Eolrap**, entre un énergéticien et deux universités, a pour ambition de limiter cet impact supplémentaire à son strict minimum.

LES CHERCHEURS

Porteur principal :
Alexandre MILLON – Aix-Marseille Université, Imbe (France)

Co-porteuse :
Caroline De ZUTTER – Engie Lab Crigen (France)

Le projet **Eolrap** sera mené par le post-doctorant **Tonio SCHAUB**, en collaboration avec **Raymond KLAASSEN**, spécialiste du vol des oiseaux, de l'Université de Groningen aux Pays-Bas.

LE PROJET

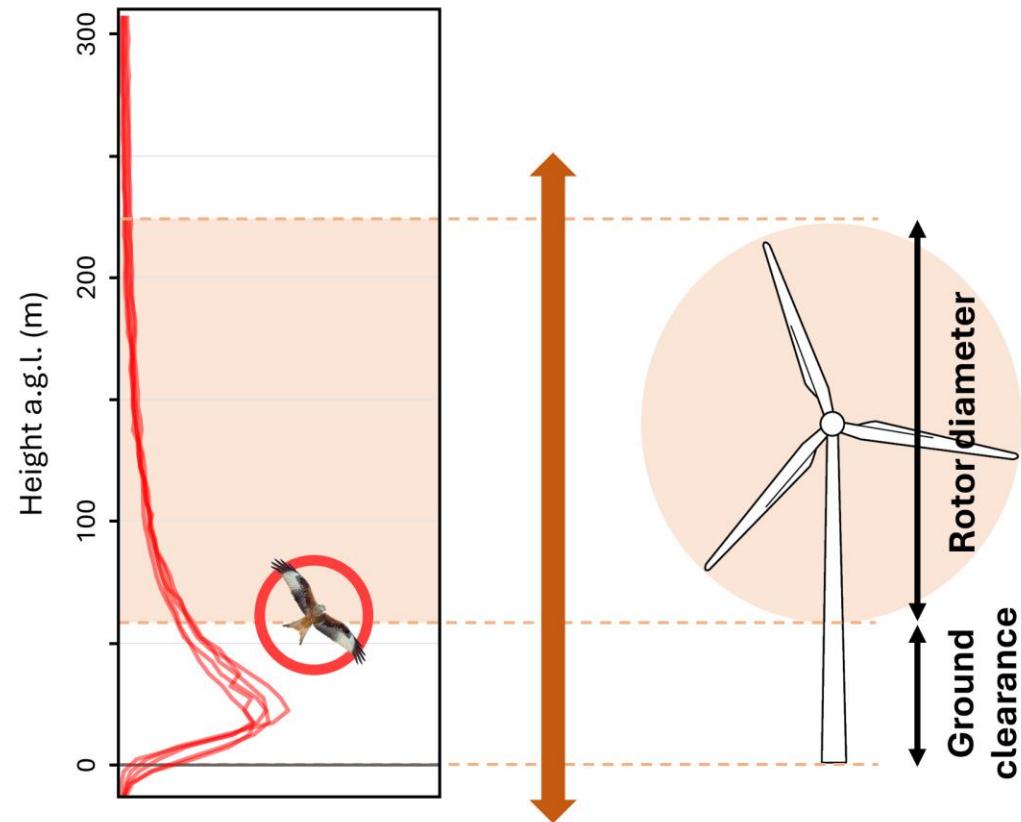
Le projet **Eolrap** est issu de l'appel **Impact des énergies éoliennes**. En partenariat avec **Mirova Foundation**, cet appel vise à mieux évaluer l'impact des énergies renouvelables sur la biodiversité et produire des recommandations opérationnelles pour de meilleures pratiques à destination des acteurs de la filière.

Module 1

Flight height distribution

+

Wind turbine dimensions



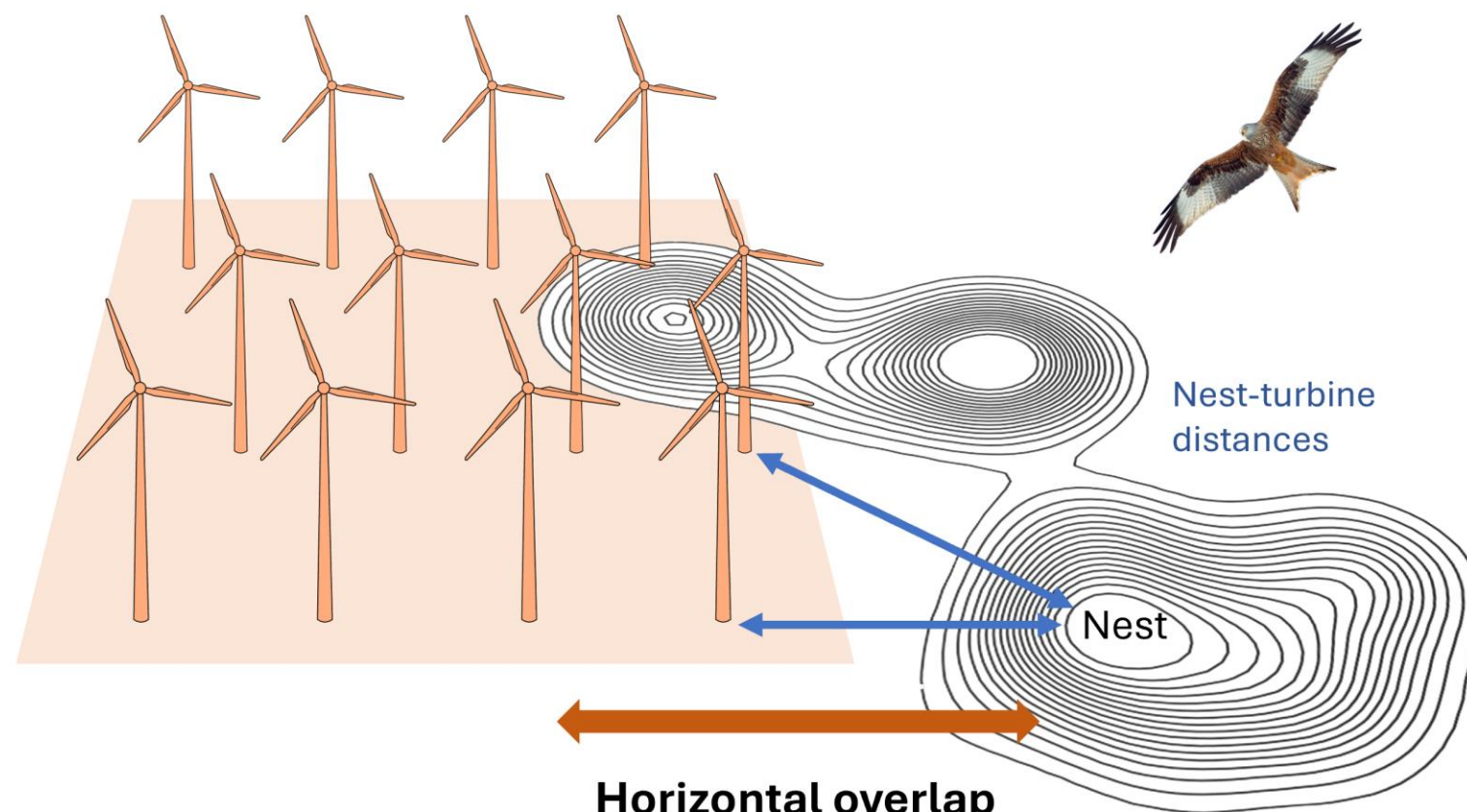
Vertical overlap
(between flight height distribution and rotor height range)

Module 2

Wind turbine locations

+

Home range



Horizontal overlap
(between home range and wind farm footprint based on nest-turbine distances)

Wind4Birds

Module 1

Eolrap - Wind Turbine Dimensions

Select Species: Custom

Bird Data

Flight Height Distribution

Browse... No file

[1] "No file uploaded yet. Please upload a .txt file."

Relationship Flight Speed Height

Browse... No file

[1] "No file uploaded yet. Please upload a .txt file."

Body Length (m) *

0,5

Wingspan: *

1

Flight Mode *

Gliding

Scenarios

Delete Scenario Add Scenario

scenario_1 scenario_2

Ground clearance (m) *

10

Rotor diameter (m) *

100

Maximum tip height (m)

110

Number of turbines *

5

Rotation speed (RPM) *

11,80096797525

Blade width (m) *

3,7951188204209

Rated power (MW) *

2,33100587475159

Annual energy production (GWh, optional)

Annual operation time (h, optional)

Blade profile file

☒ Use Default File ☐ Custom File


Flight speed (m/s) *

8

Launch calculation

Results

Export to CSV

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Wind4Birds

Module 1

Eolrap - Wind Turbine Dimensions

Select Species: Custom

Bird Data

Flight Height Distribution
Browse... No file
[1] "No file uploaded yet. Please upload a .txt file."

Relationship Flight Speed Height
Browse... No file
[1] "No file uploaded yet. Please upload a .txt file."

Body Length (m) * 0,5 ⓘ

Wingspan: * 1 ⓘ

Flight Mode * Gliding ⓘ

Scenarios

scenario_1 scenario_2

Ground clearance (m) * 10 ⓘ

Rotor diameter (m) * 100 ⓘ

Maximum tip height (m) 110 ⓘ

Number of turbines * 5 ⓘ

Rotation speed (RPM) * 11,80096797525 ⓘ

Blade width (m) * 3,7951188204209 ⓘ

Rated power (MW) * 2,33100587475159 ⓘ

Annual energy production (GWh, optional)

Annual operation time (h, optional)

Blade profile file ☒ Use Default File ☐ Custom File ⓘ

Flight speed (m/s) * 8 ⓘ

Launch calculation

Results

Export to CSV

Wind4Birds

Module 1

Eolrap - Wind Turbine Dimensions

Select Species:

Custom

Bird Data

Flight Height Distribution

Browse...No file

[1] "No file uploaded yet. Please upload a .txt file."

Relationship Flight Speed Height

Browse...No file

[1] "No file uploaded yet. Please upload a .txt file."

Body Length (m) *

0,5

Wingspan: *

1

Flight Mode *

Gliding

Scenarios

Delete Scenario

scenario_1

scenario_2

Ground clearance (m) *

10

Rotor diameter (m) *

100

Maximum tip height (m)

110

Number of turbines *

5

Rotation speed (RPM) *

11,80096797525

Blade width (m) *

3,7951186204209

Rated power (MW) *

2,33100587475159

Annual energy production (GWh, optional)

Annual operation time (h, optional)

Blade profile file

☒ Use Default File ☐ Custom File

Flight speed (m/s) *

8

Laun

Select Species:

Red Kite

Bird Data

Flight Height Distribution

Browse...No fi

[1] "\"height\", \"R1\", \"R2\", \"R3\", \"R4\", \"R5\", \"R6\", \"R7\", \"R8\", \"R9\"

[2] "0,0.00344837716370137,0.00364865279500655,0.00400521440337913,0.00315818

[3] "1,0.00406440708297611,0.00426669705749565,0.00466036106922995,0.00373738

[4] "2,0.00471385107504733,0.00480759536948965,0.005352077395743,0.0044017105

Relationship Flight Speed Height

Browse...No fi

[1] "\"mean_ground_speed\"" "6.75519845482305" "7.26172184723346"

[4] "7.57343954083399" "7.77285876971577" "7.96048338052847"

[7] "8.15868280235877" "8.34431087672573" "8.46753195139934"

[10] "8.61877158583236" "8.7203683728929" "8.79871792758187"

[13] "8.88886070526696" "8.98817457766349" "9.04696263179823"

Body Length (m) *

0,66

i

Wingspan: *


1,57

i

Flight Mode *

Gliding

i

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Wind4Birds

Module 1

Eolrap - Wind Turbine Dimensions

Select Species:

Custom

Bird Data

Flight Height Distribution

Browse...No file

[1] "No file uploaded yet. Please upload a .txt file."

Relationship Flight Speed Height

Browse...No file

[1] "No file uploaded yet. Please upload a .txt file."

Body Length (m) *

0,5

Wingspan: *

1

Flight Mode *

Gliding

Scenarios

Delete Scenario

scenario_1

scenario_2

Ground clearance (m) *

10

Rotor diameter (m) *

100

Maximum tip height (m)

110

Number of turbines *

5

Rotation speed (RPM) *

11,80096797525

Blade width (m) *

3,7951188204209

Rated power (MW) *

2,33100587475159

Annual energy production (GWh, optional)

Annual operation time (h, optional)

Blade profile file

☒ Use Default File☐ Custom File

Flight speed (m/s) *

8

Laun

Select Species:

Red Kite

Bird Data

Flight Height Distribution

Browse...No fi

[1] "\"height\", \"R1\", \"R2\", \"R3\", \"R4\", \"R5\", \"R6\", \"R7\", \"R8\", \"R9\"
[2] \"0,0.00344837716370137,0.00364865279500655,0.00400521440337913,0.00315818
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[4] \"2,0.00471385107504733,0.00480759536948965,0.005352077395743,0.0044017105
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Relationship Flight Speed Height

Browse...No fi

[1] "\"mean_ground_speed\" \"6.75519845482305\" \"7.26172184723346\"
[4] \"7.57343954083399\" \"7.77285876971577\" \"7.96048338052847\"
[7] \"8.15868280235877\" \"8.34431087672573\" \"8.46753195139934\"
[10] \"8.61877158583236\" \"8.7203683728929\" \"8.79871792758187\"
[13] \"8.88886070526696\" \"8.98817457766349\" \"9.04696263179823\"
< >

Body Length (m) *

0,66

i

Wingspan: *


1,57

i

Flight Mode *

Gliding

i

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Wind4Birds

Module 1

Eolrap - Wind Turbine Dimensions

Select Species: Custom

Bird Data

Flight Height Distribution

Browse...

No file

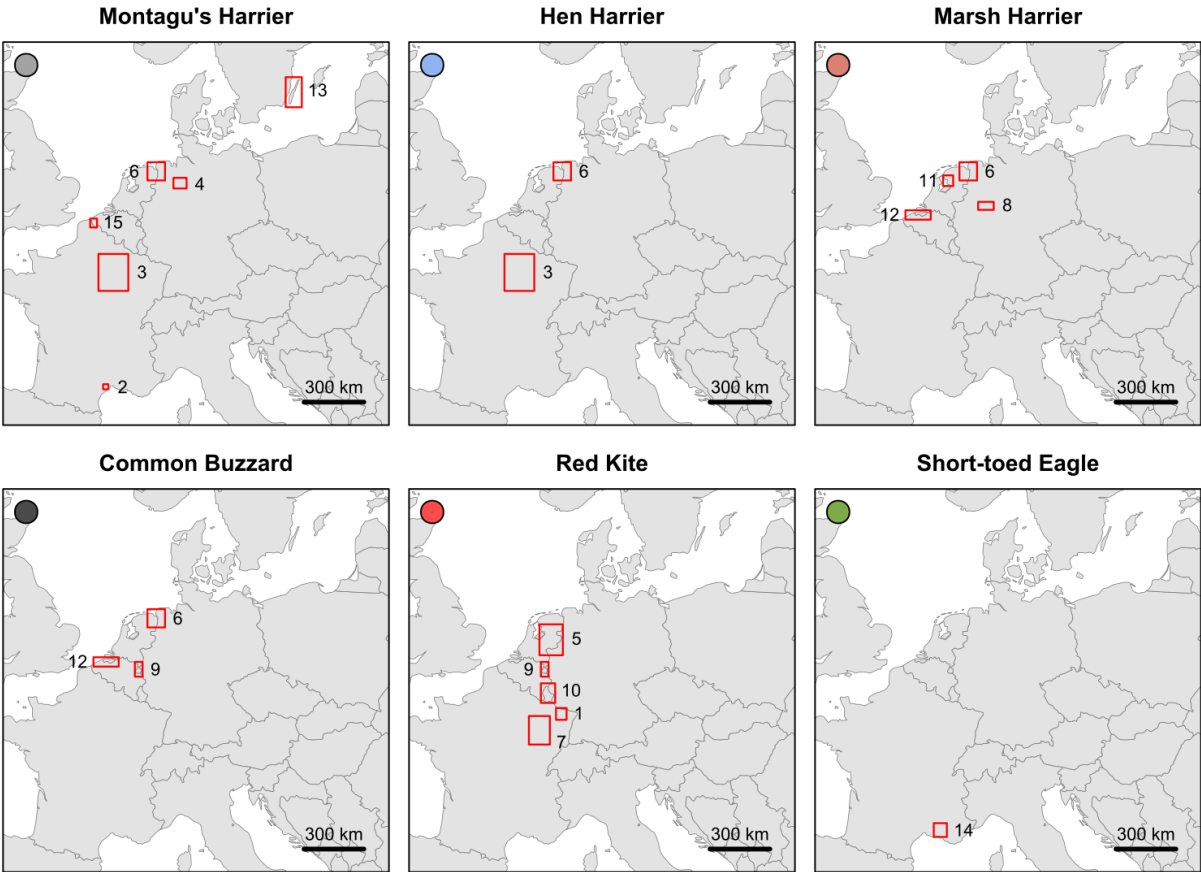
[1] "No file uploaded yet. Please upload a .txt file."

Relationship Flight Speed Height

Browse...

No file

[1] "No file uploaded yet. Please upload a .txt file."



Select Species:

Red Kite

Bird Data

Flight Height Distribution

Browse...

No fi

```
[1] "\"height\\",\"R1\\",\"R2\\",\"R3\\",\"R4\\",\"R5\\",\"R6\\",\"R7\\",\"R8\\",\"R9\\"  
[2] "0,0.00344837716370137,0.00364865279500655,0.00400521440337913,0.00315818  
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[4] "2,0.00471385107504733,0.00480759536948965,0.005352077395743,0.0044017105"
```

Relationship Flight Speed Height

Browse...

No fi

```
[1] "\"mean_ground_speed\\\" \"6.75519845482305\" \"7.26172184723346\"  
[4] \"7.57343954083399\" \"7.77285876971577\" \"7.96048338052847\"  
[7] \"8.15868280235877\" \"8.34431087672573\" \"8.46753195139934\"  
[10] \"8.61877158583236\" \"8.7203683728929\" \"8.79871792758187\"  
[13] \"8.88886070526696\" \"8.98817457766349\" \"9.04696263179823\"
```

Body Length (m) *

0,66

Wingspan: *

1,57

Flight Mode *

Gliding

Wind4Birds

Module 1

Eolrap - Wind Turbine Dimensions

Select Species: Custom

Bird Data

Flight Height Distribution

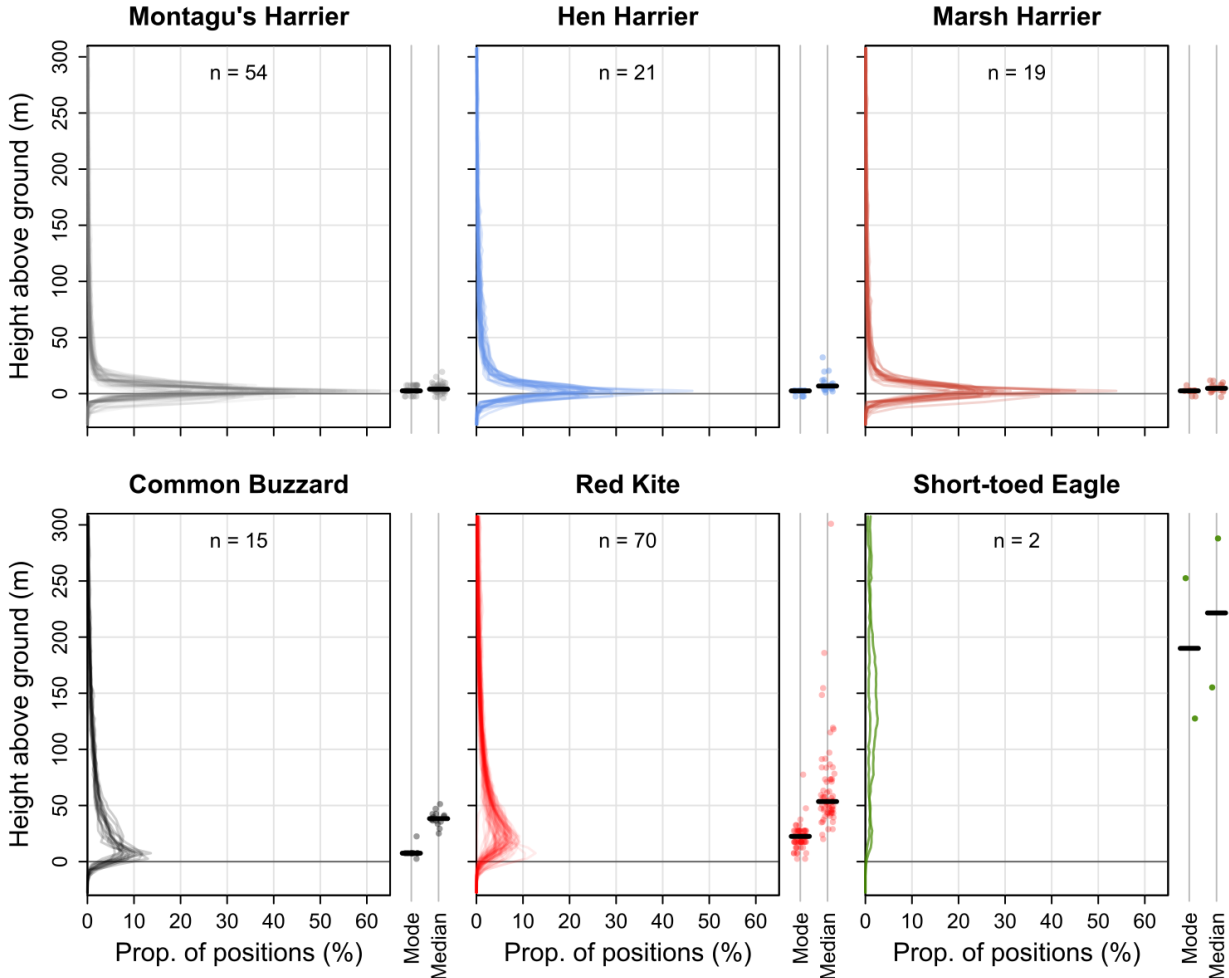
Browse... No file

[1] "No file uploaded yet. Please upload a .txt file."

Relationship Flight Speed Height

Browse... No file

[1] "No file uploaded yet. Please upload a .txt file."



Select Species:

Red Kite

Bird Data

Flight Height Distribution

Browse...

No fi

```
[1] "\"height\\",\"R1\\",\"R2\\",\"R3\\",\"R4\\",\"R5\\",\"R6\\",\"R7\\",\"R8\\",\"R9\\"  
[2] "0,0.00344837716370137,0.00364865279500655,0.00400521440337913,0.00315818  
[3] "1,0.00406440708297611,0.00426669705749565,0.00466036106922995,0.00373738  
[4] "2,0.00471385107504733,0.00480759536948965,0.005352077395743,0.0044017105"
```

Relationship Flight Speed Height

Browse...

No fi

```
[1] "\"mean_ground_speed\\",\"6.75519845482305\", \"7.26172184723346\"  
[4] "7.57343954083399", \"7.77285876971577\", \"7.96048338052847\"  
[7] "8.15868280235877", \"8.34431087672573\", \"8.46753195139934\"  
[10] "8.61877158583236", \"8.7203683728929\", \"8.79871792758187\"  
[13] "8.88886070526696", \"8.98817457766349\", \"9.04696263179823"
```

Body Length (m) *

0,66

Wingspan: *

1,57

Flight Mode *

Gliding

Wind4Birds

Module 1

Eolrap - Wind Turbine Dimensions

Select Species:

Custom

Bird Data

Flight Height Distribution

Browse...No file

[1] "No file uploaded yet. Please upload a .txt file."

Relationship Flight Speed Height

Browse...No file

[1] "No file uploaded yet. Please upload a .txt file."

Body Length (m) *

0,5

Wingspan: *

1

Flight Mode *

Gliding

Scenarios

Delete ScenarioAdd Scenario

scenario_1scenario_2

Ground clearance (m) *

10

Rotor diameter (m) *

100

Maximum tip height (m)

110

Number of turbines *

5

Rotation speed (RPM) *

11,80096797525

Blade width (m) *

3,7951188204209

Rated power (MW) *

2,33100587475159

Annual energy production (GWh, optional)

Annual operation time (h, optional)

Blade profile file

☒ Use Default File☐ Custom File


Flight speed (m/s) *

8

Launch calculation

Results

Export to CSV

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Wind4Birds

Module 1

Eolrap - Wind Turbine Dimensions

Select Species: Custom

Bird Data

Flight Height Distribution

Browse... No file

[1] "No file uploaded yet. Please upload a .txt file."

Relationship Flight Speed Height

Browse... No file

[1] "No file uploaded yet. Please upload a .txt file."

Body Length (m) *

0,5

Wingspan: *

1

Flight Mode *

Gliding

Scenarios

Delete Scenario Add Scenario

scenario_1 scenario_2

Ground clearance (m) *

10

Rotor diameter (m) *

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Maximum tip height (m)

110

Number of turbines *

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Rotation speed (RPM) *

11,80096797525

Blade width (m) *

3,7951188204209

Rated power (MW) *

2,33100587475159

Annual energy production (GWh, optional)

Annual operation time (h, optional)

Blade profile file

☒ Use Default File ☐ Custom File

Flight speed (m/s) *

8

Launch calculation

Scenarios

Delete Scenario Add Scenario

scenario_1 scenario_2 scenario_3

Ground clearance (m) *

80

i

Rotor diameter (m) *

150

i

Maximum tip height (m)

230

i

Number of turbines *

3

i

Rotation speed (RPM) *

7,7171397051204

i

Blade width (m) *

4,18154063826314

i

Rated power (MW) *

4,29454337386609

i

Annual energy production (GWh, optional)

28

i

Annual operation time (h, optional)

6500

i

Blade profile file

☒ Use Default File ☐ Custom File

i

Flight speed (m/s) *

9,02510033472741

i

Launch calculation

Wind4Birds

Module 1

Eolrap - Wind Turbine Dimensions

Select Species:

Custom

Bird Data

Flight Height Distribution

Browse...

No file

MoH

HH

MaH

CB

RK

STE

Relative CRI

Ground clearance (m)

Relative CRI per power

Rotor diameter (m)

Rated power (MW) *

2,33100587475159

Annual energy production (GWh, optional)

Annual operation time (h, optional)

Blade profile file

☒ Use Default File ☐ Custom File

Flight speed (m/s) *

8

Launch calculation

Scenarios

Delete Scenario

Add Scenario

scenario_1

scenario_2

scenario_3

Ground clearance (m) *

80

i

Rotor diameter (m) *

150

i

Maximum tip height (m)

230

i

Number of turbines *

3

i

Rotation speed (RPM) *

7,7171397051204

i

Blade width (m) *

4,18154063826314

i

Rated power (MW) *

4,29454337386609

i

Annual energy production (GWh, optional)

28

i

Annual operation time (h, optional)

6500

i

Blade profile file

☒ Use Default File ☐ Custom File

i

Flight speed (m/s) *

9,02510033472741

i

Launch calculation

Wind4Birds Module 1

Eolrap - Wind Turbine Dimensions

Select Species:

Red Kite

Bird Data

Flight Height Distribution

Browse...

No file

[1] "\\height\\",\\"R1\\",\\"R2\\",\\"R3\\",\\"R4\\",\\"R5\\",\\"R6\\",\\"R7\\",\\"R8\\",\\"R9\\",\\"R10\\",\\"R11\\",\\"R12\\",\\"R13\\",\\"R14\\",\\"R15\\",\\"R16\\",\\"R17\\",\\"R18\\",\\"R19\\",\\"R20\\",\\"R21\\",\\"R22\\",\\"R23\\",\\"R24\\",\\"R25\\",\\"R26\\",\\"R27\\",\\"R28\\",\\"R29\\",\\"R30\\",\\"R31\\",\\"R32\\",\\"R33\\",\\"R34\\",\\"R35\\",\\"R36\\",\\"R37\\",\\"R38\\",\\"R39\\",\\"R40\\",\\"R41\\",\\"R42\\",\\"R43\\",\\"R44\\",\\"R45\\",\\"R46\\",\\"R47\\",\\"R48\\",\\"R49\\",\\"R50\\",\\"R51\\",\\"R52\\",\\"R53\\",\\"R54\\",\\"R55\\",\\"R56\\",\\"R57\\",\\"R58\\",\\"R59\\",\\"R60\\",\\"R61\\",\\"R62\\",\\"R63\\",\\"R64\\",\\"R65\\",\\"R66\\",\\"R67\\",\\"R68\\",\\"R69\\",\\"R70\\",\\"R71\\",\\"R72\\",\\"R73\\",\\"R74\\",\\"R75\\",\\"R76\\",\\"R77\\",\\"R78\\",\\"R79\\",\\"R80\\",\\"R81\\",\\"R82\\",\\"R83\\",\\"R84\\",\\"R85\\",\\"R86\\",\\"R87\\",\\"R88\\",\\"R89\\",\\"R90\\",\\"R91\\",\\"R92\\",\\"R93\\",\\"R94\\",\\"R95\\",\\"R96\\",\\"R97\\",\\"R98\\",\\"R99\\",\\"R100\\",\\"R101\\",\\"R102\\",\\"R103\\",\\"R104\\",\\"R105\\",\\"R106\\",\\"R107\\",\\"R108\\",\\"R109\\",\\"R110\\",\\"R111\\",\\"R112\\",\\"R113\\",\\"R114\\",\\"R115\\",\\"R116\\",\\"R117\\",\\"R118\\",\\"R119\\",\\"R120\\",\\"R121\\",\\"R122\\",\\"R123\\",\\"R124\\",\\"R125\\",\\"R126\\",\\"R127\\",\\"R128\\",\\"R129\\",\\"R130\\",\\"R131\\",\\"R132\\",\\"R133\\",\\"R134\\",\\"R135\\",\\"R136\\",\\"R137\\",\\"R138\\",\\"R139\\",\\"R140\\",\\"R141\\",\\"R142\\",\\"R143\\",\\"R144\\",\\"R145\\",\\"R146\\",\\"R147\\",\\"R148\\",\\"R149\\",\\"R150\\",\\"R151\\",\\"R152\\",\\"R153\\",\\"R154\\",\\"R155\\",\\"R156\\",\\"R157\\",\\"R158\\",\\"R159\\",\\"R160\\",\\"R161\\",\\"R162\\",\\"R163\\",\\"R164\\",\\"R165\\",\\"R166\\",\\"R167\\",\\"R168\\",\\"R169\\",\\"R170\\",\\"R171\\",\\"R172\\",\\"R173\\",\\"R174\\",\\"R175\\",\\"R176\\",\\"R177\\",\\"R178\\",\\"R179\\",\\"R180\\",\\"R181\\",\\"R182\\",\\"R183\\",\\"R184\\",\\"R185\\",\\"R186\\",\\"R187\\",\\"R188\\",\\"R189\\",\\"R190\\",\\"R191\\",\\"R192\\",\\"R193\\",\\"R194\\",\\"R195\\",\\"R196\\",\\"R197\\",\\"R198\\",\\"R199\\",\\"R200\\",\\"R201\\",\\"R202\\",\\"R203\\",\\"R204\\",\\"R205\\",\\"R206\\",\\"R207\\",\\"R208\\",\\"R209\\",\\"R210\\",\\"R211\\",\\"R212\\",\\"R213\\",\\"R214\\",\\"R215\\",\\"R216\\",\\"R217\\",\\"R218\\",\\"R219\\",\\"R220\\",\\"R221\\",\\"R222\\",\\"R223\\",\\"R224\\",\\"R225\\",\\"R226\\",\\"R227\\",\\"R228\\",\\"R229\\",\\"R230\\",\\"R231\\",\\"R232\\",\\"R233\\",\\"R234\\",\\"R235\\",\\"R236\\",\\"R237\\",\\"R238\\",\\"R239\\",\\"R240\\",\\"R241\\",\\"R242\\",\\"R243\\",\\"R244\\",\\"R245\\",\\"R246\\",\\"R247\\",\\"R248\\",\\"R249\\",\\"R250\\",\\"R251\\",\\"R252\\",\\"R253\\",\\"R254\\",\\"R255\\",\\"R256\\",\\"R257\\",\\"R258\\",\\"R259\\",\\"R260\\",\\"R261\\",\\"R262\\",\\"R263\\",\\"R264\\",\\"R265\\",\\"R266\\",\\"R267\\",\\"R268\\",\\"R269\\",\\"R270\\",\\"R271\\",\\"R272\\",\\"R273\\",\\"R274\\",\\"R275\\",\\"R276\\",\\"R277\\",\\"R278\\",\\"R279\\",\\"R280\\",\\"R281\\",\\"R282\\",\\"R283\\",\\"R284\\",\\"R285\\",\\"R286\\",\\"R287\\",\\"R288\\",\\"R289\\",\\"R290\\",\\"R291\\",\\"R292\\",\\"R293\\",\\"R294\\",\\"R295\\",\\"R296\\",\\"R297\\",\\"R298\\",\\"R299\\",\\"R300\\",\\"R301\\",\\"R302\\",\\"R303\\",\\"R304\\",\\"R305\\",\\"R306\\",\\"R307\\",\\"R308\\",\\"R309\\",\\"R310\\",\\"R311\\",\\"R312\\",\\"R313\\",\\"R314\\",\\"R315\\",\\"R316\\",\\"R317\\",\\"R318\\",\\"R319\\",\\"R320\\",\\"R321\\",\\"R322\\",\\"R323\\",\\"R324\\",\\"R325\\",\\"R326\\",\\"R327\\",\\"R328\\",\\"R329\\",\\"R330\\",\\"R331\\",\\"R332\\",\\"R333\\",\\"R334\\",\\"R335\\",\\"R336\\",\\"R337\\",\\"R338\\",\\"R339\\",\\"R340\\",\\"R341\\",\\"R342\\",\\"R343\\",\\"R344\\",\\"R345\\",\\"R346\\",\\"R347\\",\\"R348\\",\\"R349\\",\\"R350\\",\\"R351\\",\\"R352\\",\\"R353\\",\\"R354\\",\\"R355\\",\\"R356\\",\\"R357\\",\\"R358\\",\\"R359\\",\\"R360\\",\\"R361\\",\\"R362\\",\\"R363\\",\\"R364\\",\\"R365\\",\\"R366\\",\\"R367\\",\\"R368\\",\\"R369\\",\\"R370\\",\\"R371\\",\\"R372\\",\\"R373\\",\\"R374\\",\\"R375\\",\\"R376\\",\\"R377\\",\\"R378\\",\\"R379\\",\\"R380\\",\\"R381\\",\\"R382\\",\\"R383\\",\\"R384\\",\\"R385\\",\\"R386\\",\\"R387\\",\\"R388\\",\\"R389\\",\\"R390\\",\\"R391\\",\\"R392\\",\\"R393\\",\\"R394\\",\\"R395\\",\\"R396\\",\\"R397\\",\\"R398\\",\\"R399\\",\\"R400\\",\\"R401\\",\\"R402\\",\\"R403\\",\\"R404\\",\\"R405\\",\\"R406\\",\\"R407\\",\\"R408\\",\\"R409\\",\\"R410\\",\\"R411\\",\\"R412\\",\\"R413\\",\\"R414\\",\\"R415\\",\\"R416\\",\\"R417\\",\\"R418\\",\\"R419\\",\\"R420\\",\\"R421\\",\\"R422\\",\\"R423\\",\\"R424\\",\\"R425\\",\\"R426\\",\\"R427\\",\\"R428\\",\\"R429\\",\\"R430\\",\\"R431\\",\\"R432\\",\\"R433\\",\\"R434\\",\\"R435\\",\\"R436\\",\\"R437\\",\\"R438\\",\\"R439\\",\\"R440\\",\\"R441\\",\\"R442\\",\\"R443\\",\\"R444\\",\\"R445\\",\\"R446\\",\\"R447\\",\\"R448\\",\\"R449\\",\\"R450\\",\\"R451\\",\\"R452\\",\\"R453\\",\\"R454\\",\\"R455\\",\\"R456\\",\\"R457\\",\\"R458\\",\\"R459\\",\\"R460\\",\\"R461\\",\\"R462\\",\\"R463\\",\\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Scenarios

Delete Scenario
Add Scenario

scenario_1
scenario_2
scenario_3

Ground clearance (m) *

80

Rotor diameter (m) *

150

Maximum tip height (m)

230

Number of turbines *

3

Rotation speed (RPM) *

7,7171397051204

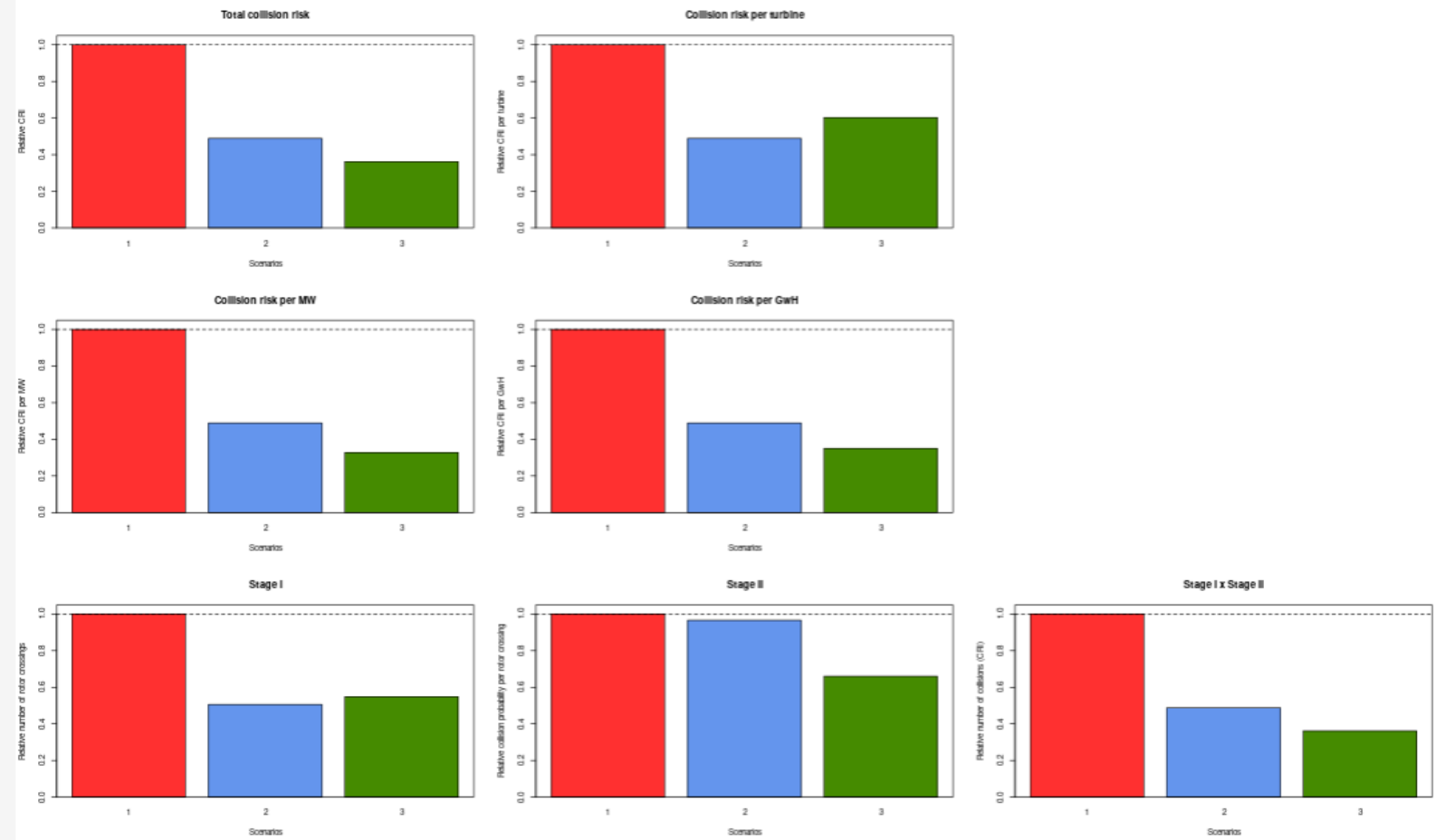
Blade width (m) *

4,18154063826314

Rated power (MW) *

4,29454337386609

Results



Wind4Birds Module 1

Eolrap - Wind Turbine Dimensions

Select Species:
Red Kite

Bird Data

Flight Height Distribution
Browse... No file

```
[1] "\"height\\\", \"R1\\\", \"R2\\\", \"R3\\\", \"R4\\\", \"R5\\\", \"R6\\\", \"R7\\\", \"R8\\\", \"R9\\\", \"R10\\\", \"R11\\\", \"R12\\\", \"R13\\\", \"R14\\\", \"R15\\\", \"R16\\\", \"R17\\\", \"R18\\\", \"R19\\\", \"R20\\\""
```

Relationship Flight Speed Height
Browse... No file

[1]	"\"mean_ground_speed\\\"" "6.75519845482305"	"7.26172184723346"
[4]	"7.57343954083399"	"7.77285876971577"
[7]	"8.15868280235877"	"8.34431087672573"
[10]	"8.61877158583236"	"8.7203683728929"
[13]	"8.88886070526696"	"8.98817457766349"

Body Length (m) *
0,66

Wingspan: *
1,57

Flight Mode *
Gliding

Scenarios

Delete Scenario
Add Scenario

scenario_1

scenario_2

scenario_3

Ground clearance (m) *

80

Rotor diameter (m) *

150

Maximum tip height (m)

230

Number of turbines *

3

Rotation speed (RPM) *

7,7171397051204

Blade width (m) *

4,18154063826314

Rated power (MW) *

4,29454337386609



Wind4Birds Module 1

Eolrap - Wind Turbine Dimensions

Select Species:

Red Kite

Bird Data

Flight Height Distribution

Browse...

No file

[1] "\\height\\",\\"R1\\",\\"R2\\",\\"R3\\",\\"R4\\",\\"R5\\",\\"R6\\",\\"R7\\",\\"R8\\",\\"R9\\

[2] "0,0.00344837716370137,0.00364865279500655,0.00400521440337913,0.00315818

[3] "1,0.00406440708297611,0.00426669705749565,0.00466036106922995,0.00373738

[4] "1,0.00471305107087733,0.004907093369002,0.005307077305743,0.0044077100

Relationship Flight Speed Height

Browse...

No file

[1] "\\mean_ground_speed\\", "6.75519845482305", "7.26172184723346"

[4] "7.57343954083399", "7.77285876971577", "7.96048338052847"

[7] "8.15868280235877", "8.34431087672573", "8.46753195139934"

[10] "8.61877158583236", "8.7203683728929", "8.79871792758187"

[13] "8.8886070526696", "8.98817457766349", "9.04696263179823"

Body Length (m) *

0,66

Wingspan: *

1,57

Flight Mode *

Gliding

Scenarios

scenario_1

scenario_2

scenario_3

Ground clearance (m) *

80

Rotor diameter (m) *

150

Maximum tip height (m)

230

Number of turbines *

3

Rotation speed (RPM) *

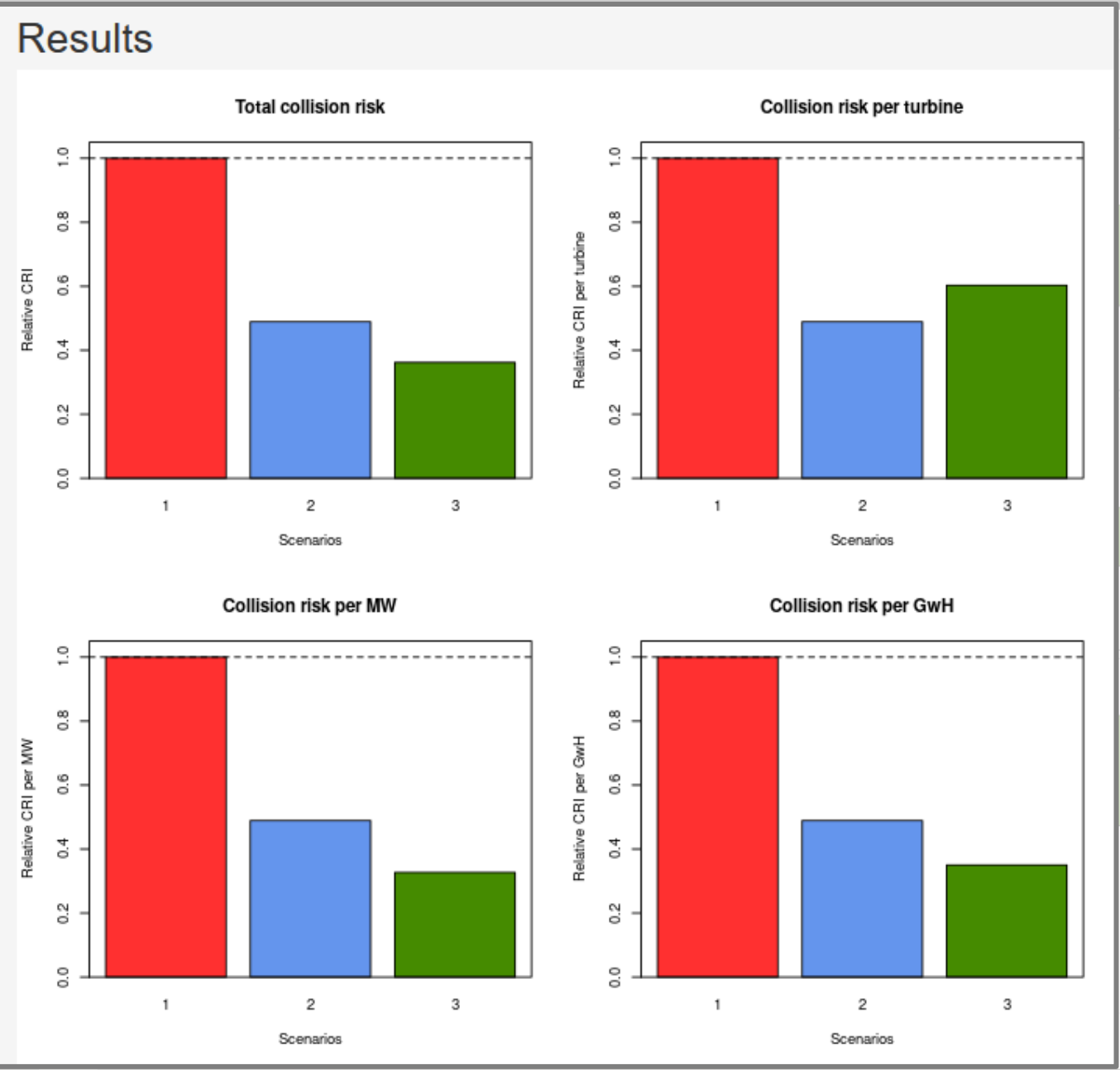
7,7171397051204

Blade width (m) *

4,18154063826314

Rated power (MW) *

4,29454337386609



Wind4Birds Module 1

Eolrap - Wind Turbine Dimensions

Select Species:

Red Kite
▼

Bird Data

Flight Height Distribution

Browse...
No fi

```
[1] "\"height\\\", \"R1\\\", \"R2\\\", \"R3\\\", \"R4\\\", \"R5\\\", \"R6\\\", \"R7\\\", \"R8\\\", \"R9\\\", \"R10\\\", \"R11\\\", \"R12\\\", \"R13\\\", \"R14\\\", \"R15\\\", \"R16\\\", \"R17\\\", \"R18\\\", \"R19\\\", \"R20\\\"
[2] "0,0.00344837716370137,0.00364865279500655,0.00400521440337913,0.00315818040514119,0.00364203912762089,0.0036000098630
[3] "1,0.00406440708297611,0.00426669705749565,0.00466036106922995,0.00373738862478565,0.0042424940037507,0.0042550552442
[4] "1,0.00471205107504722,0.00490750503040055,0.00535077205742,0.00440171054055577,0.00493220017174100,0.0048000300974557"
```

Relationship Flight Speed Height

Browse...
No fi

	"mean_ground_speed\""	"7.26172184723346"
[1]	"6.75519845482305"	"7.26172184723346"
[4]	"7.57343954083399"	"7.77285876971577"
[7]	"8.15868202235877"	"8.34431087672573"
[10]	"8.61877158583236"	"8.7203683728929"
[13]	"8.88886070526696"	"8.98817457766349"

Body Length (m) *

0,66
▲ ▼ ⓘ

Wingspan: *

1,57
▲ ▼ ⓘ

Flight Mode *

Gliding
▼ ⓘ

Scenarios

Delete Scenario

Add Scenario

scenario_1

scenario_2

scenario_3

Ground clearance (m) *

80

Rotor diameter (m) *

150

Maximum tip height (m)

230

Number of turbines *

3

Rotation speed (RPM) *

7,7171397051204

Blade width (m) *

4,18154063826314

Rated power (MW) *

4,29454337386609



Wind4Birds Module 1

Eolrap - Wind Turbine Dimensions

Select Species:

Red Kite

Bird Data

Flight Height Distribution

[1] "\\height\\",\\"R1\\",\\"R2\\",\\"R3\\

[2] "0,0.00344837716370137,0.003648

[3] "1,0.00406440708297611,0.004266

[4] "1,0.00471305107004733,0.004800"

Relationship Flight Speed Height

[1] "\\mean_ground_speed\\" "6.75519

[4] "7.57343954083399" "7.77285

[7] "8.15868280235877" "8.34433

[10] "8.61877158583236" "8.72036

[13] "8.8886070526696" "8.98817

Body Length (m) *

Wingspan: *

Flight Mode *

Scenarios

scenario_1

scenario_2

scenario_3

Ground clearance (m) *

80

Rotor diameter (m) *

150

Maximum tip height (m)

230

Number of turbines *

3

Rotation speed (RPM) *

7,717,139,705,1204

Blade width (m) *

4,181,540,638,263,14

Rated power (MW) *

4,294,543,373,866,09

Results

Export to CSV

Total collision risk

Collision risk per turbine

Stage I

Stage II

Stage I x Stage II

Relative number of rotor crossings

Relative collision probability per rotor crossing

Relative number of collisions (CRI)

1

2

3

Scenarios

Scenarios

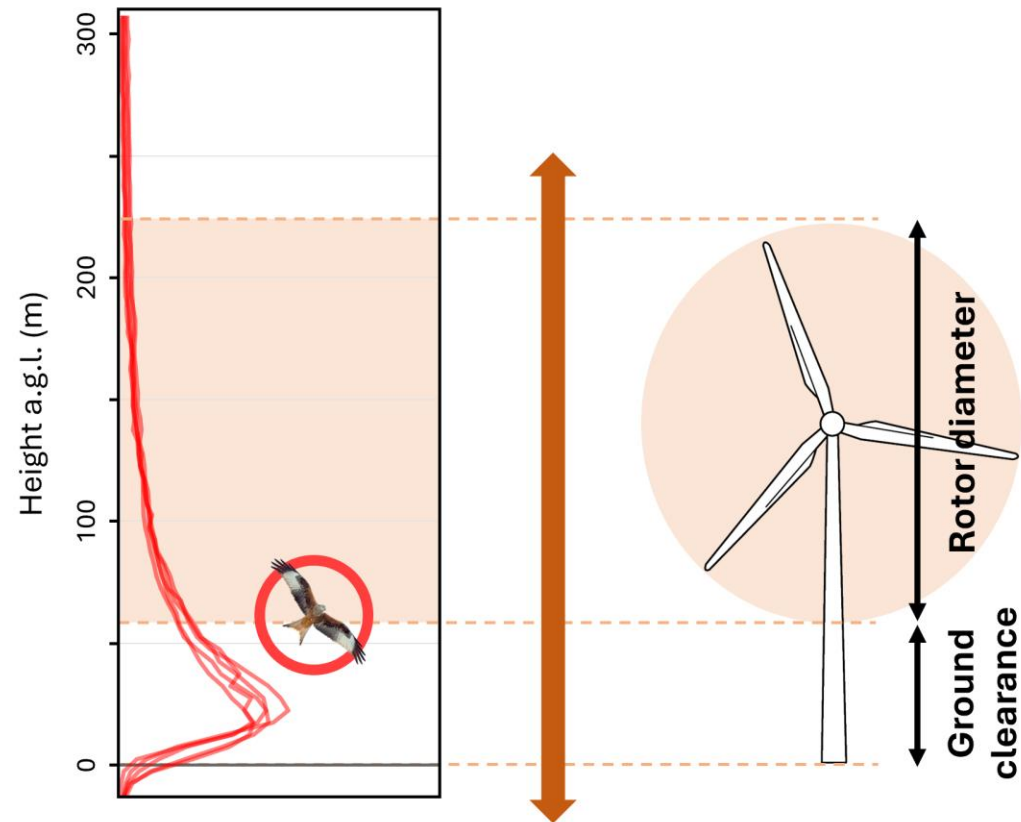
Scenarios

Module 1

Flight height distribution

+

Wind turbine dimensions



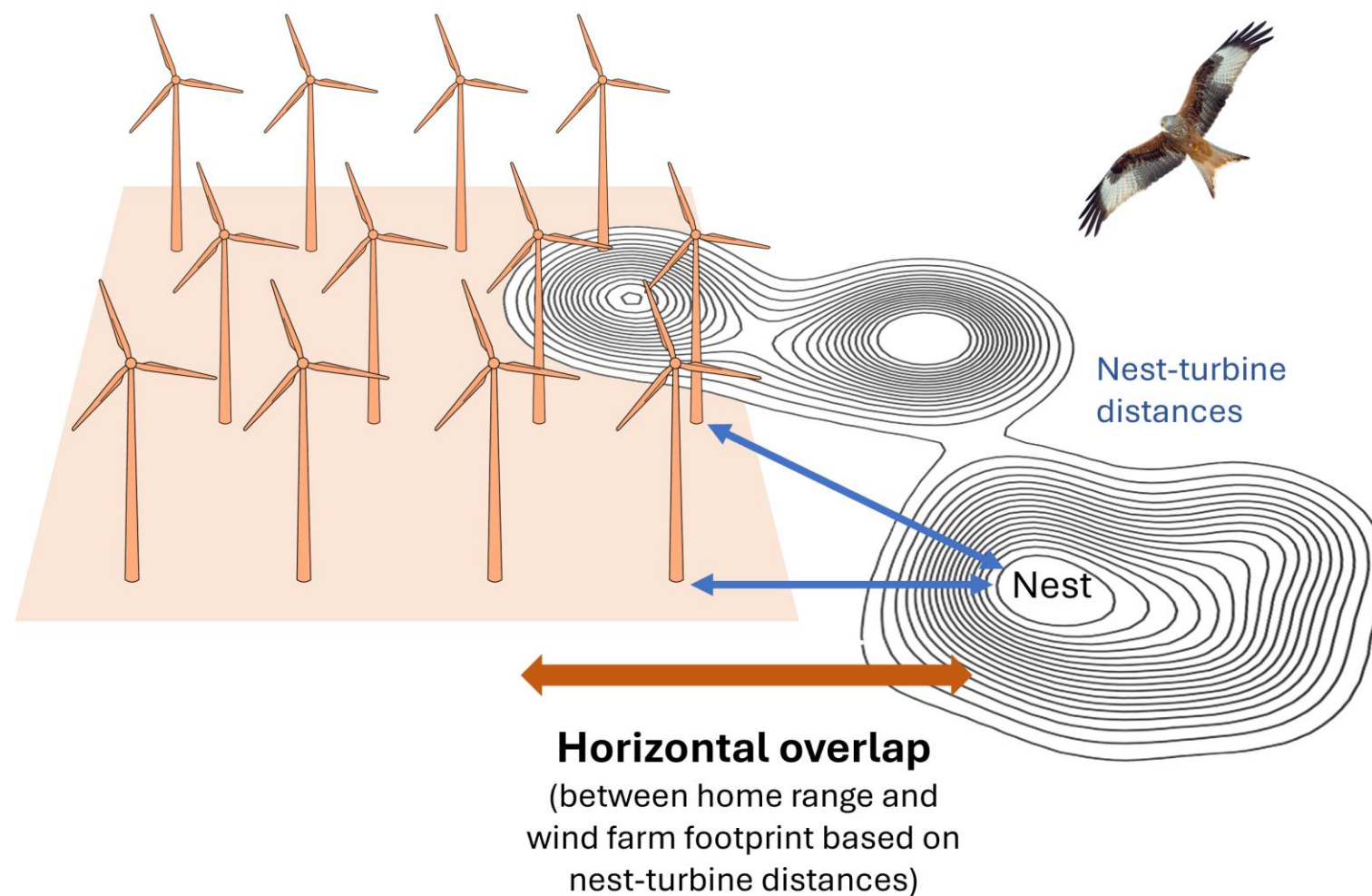
Vertical overlap
(between flight height distribution and rotor height range)

Module 2

Wind turbine locations

+

Home range



Horizontal overlap
(between home range and wind farm footprint based on nest-turbine distances)

Wind4Birds

Module 2

Eolrap - Wind Turbine Location

Select Species:

Custom

Bird Data

Time / distance matrix for female

Browse... No file selected

[1] "No file uploaded yet. Please upload a .csv file."

Time / distance matrix for male

Browse... No file selected

[1] "No file uploaded yet. Please upload a .csv file."

Nest locations

Browse...

No file uploaded yet. Please upload a .txt file.

Scenarios

Delete Scenario Add Scenario

scenario_1 scenario_2

Wind turbines location

Browse...

No data available

Launch calculation

Results

Wind4Birds

Module 2

Eolrap - Wind Turbine Location

Select Species:

Custom

Bird Data

Time / distance matrix for female

Browse...No file selected

[1] "No file uploaded yet. Please upload a .csv file."

Time / distance matrix for male

Browse...No file selected

[1] "No file uploaded yet. Please upload a .csv file."

Nest locations

Browse...

No file uploaded yet. Please upload a .txt file.

Scenarios

Delete ScenarioAdd Scenario

scenario_1scenario_2


Wind turbines location


Browse...

No data available

Launch calculation

Results

ENGIE

Lab Crigen
RESEARCH & INNOVATION

26

Wind4Birds

Module 2

Eolrap - Wind Turbine Location

Select Species:

Custom

Bird Data

Time / distance matrix for female

Browse...No file selected

[1] "No file uploaded yet. Please upload a .csv file."

Time / distance matrix for male

Browse...No file selected

[1] "No file uploaded yet. Please upload a .csv file."

Nest locations

Browse...

No file uploaded yet. Please upload a .txt file.

Scenarios

Delete Scenario

scenario_1scenario_2

Wind turbines location

Browse...

No data available

Launch

Select Species:

Red Kite
▼

Bird Data

Time / distance matrix for female

Browse...
No file selected
i

```
[1] "\"R1\"\",\"R2\"\",\"R3\"\",\"R4\"\",\"R5\"\",\"R6\"\",\"R7\"\",\"R8\"\",\"R9\"\",\"R10\"\",\"
[2] "1.36643372436059,1.31799825472951,1.61380236792303,1.27204937449428,1.336
[3] "0.230105839810274,0.247295247418451,0.229570671728722,0.214119005691438,0
[4] "0.115252975591184,0.121642373765907,0.100530446363834,0.112414382922946,0
```

Time / distance matrix for male

Browse...
No file selected
i

```
[1] "\"R1\"\",\"R2\"\",\"R3\"\",\"R4\"\",\"R5\"\",\"R6\"\",\"R7\"\",\"R8\"\",\"R9\"\",\"R10\"\",\"
[2] "0.325920360089739,0.336484396169372,0.344046579005981,0.3766536462035,0.3
[3] "0.101295793366702,0.111763215115198,0.116393720517159,0.123838401116662,0
[4] "0.0662312410153515,0.0670911602215712,0.0725240623145165,0.07925318829182
```

Nest locations

Browse...
i

Location	Longitude , Latitude
Location 1	6.931543 , 53.307126
Location 2	6.961100 , 53.296491
Location 3	6.983840 , 53.265292
Location 4	6.938467 , 53.261620
Location 5	7.007951 , 53.283989
Location 6	6.951100 , 53.308673

Wind4Birds Module 2

Eolrap - Wind Turbine Location

Select Species:

Bird Data

Time / distance matrix for female No file selected

[1] "No file uploaded yet. Please upload a .csv file."

Time / distance matrix for male No file selected

[1] "No file uploaded yet. Please upload a .csv file."

Nest locations

No file uploaded yet. Please upload a .txt file.

Scenarios

Wind turbines location

No data available

Select Species:

Red Kite

Bird Data

Time / distance matrix for female

No file selected

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[3] "0.230105839810274,0.247295247418451,0.229570671728722,0.214119005691438,0
[4] "0.115252975591184,0.121642373765907,0.100530446363834,0.112414382922946,0

Time / distance matrix for male

No file selected

[1] "\\R1\\",\\"R2\\",\\"R3\\",\\"R4\\",\\"R5\\",\\"R6\\",\\"R7\\",\\"R8\\",\\"R9\\",\\"R10\\",\\"
[2] "0.325920360089739,0.336484396169372,0.344046579005981,0.3766536462035,0.3
[3] "0.101295793366702,0.111763215115198,0.116393720517159,0.123838401116662,0
[4] "0.0662312410153515,0.0670911602215712,0.0725240623145165,0.07925318829182

Nest locations

Location	Longitude	Latitude
Location 1	6.931543	53.307126
Location 2	6.961100	53.296491
Location 3	6.983840	53.265292
Location 4	6.938467	53.261620
Location 5	7.007951	53.283989
Location 6	6.951100	53.308673

Eolrap - Wind Turbine Location



Red Kite

Bird Data

Time / distance matrix for female

Browse...

[illegible]

Time / distance matrix for male

Browse...

[illegible]

Nest locations

Browse...

Location	Longitude , Latitude
Location 1	6.931543 , 53.307126
Location 2	6.961100 , 53.296491
Location 3	6.983840 , 53.265292
Location 4	6.938467 , 53.261620
Location 5	7.007951 , 53.283989
Location 6	6.951100 , 53.308673

Wind4Birds

Module 2

Eolrap - Wind Turbine Location

Select Species: Custom

Bird Data

Time / distance matrix for female

Browse... No file selected

[1] "No file uploaded yet. Please upload a .csv file."

Time / distance matrix for male

Browse... No file selected

[1] "No file uploaded yet. Please upload a .csv file."

Nest locations

Browse...

No file uploaded yet. Please upload a .txt file.

Scenarios

Delete Scenario Add Scenario

scenario_1 scenario_2

Wind turbines location

Browse...

No data available

Launch calculation

Results

Wind4Birds Module 2

Eolrap - Wind Turbine Location

Select Species:

Bird Data

Time / distance matrix for female No file selected

[1] "No file uploaded yet. Please upload a .csv file."

Time / distance matrix for male No file selected

[1] "No file uploaded yet. Please upload a .csv file."

Nest locations

No file uploaded yet. Please upload a .txt file.

Scenarios

Wind turbines location

No data available

Scenarios

Wind turbines location



Location	Longitude , Latitude
Location 1	6.978106 , 53.289920
Location 2	6.982075 , 53.288988
Location 3	6.977125 , 53.286000
Location 4	6.981004 , 53.285256
Location 5	6.975906 , 53.281111
Location 6	6.979645 , 53.280409
Location 7	6.974987 , 53.277392

Wind4Birds Module 2

Eolrap - Wind Turbine Location

Select Species:

Red Kite

Bird Data

Time / distance matrix for female

Browse...

No file selected

Time / distance matrix for male

Browse...

No file selected

Nest locations

Browse...

scenario_1

scenario_2

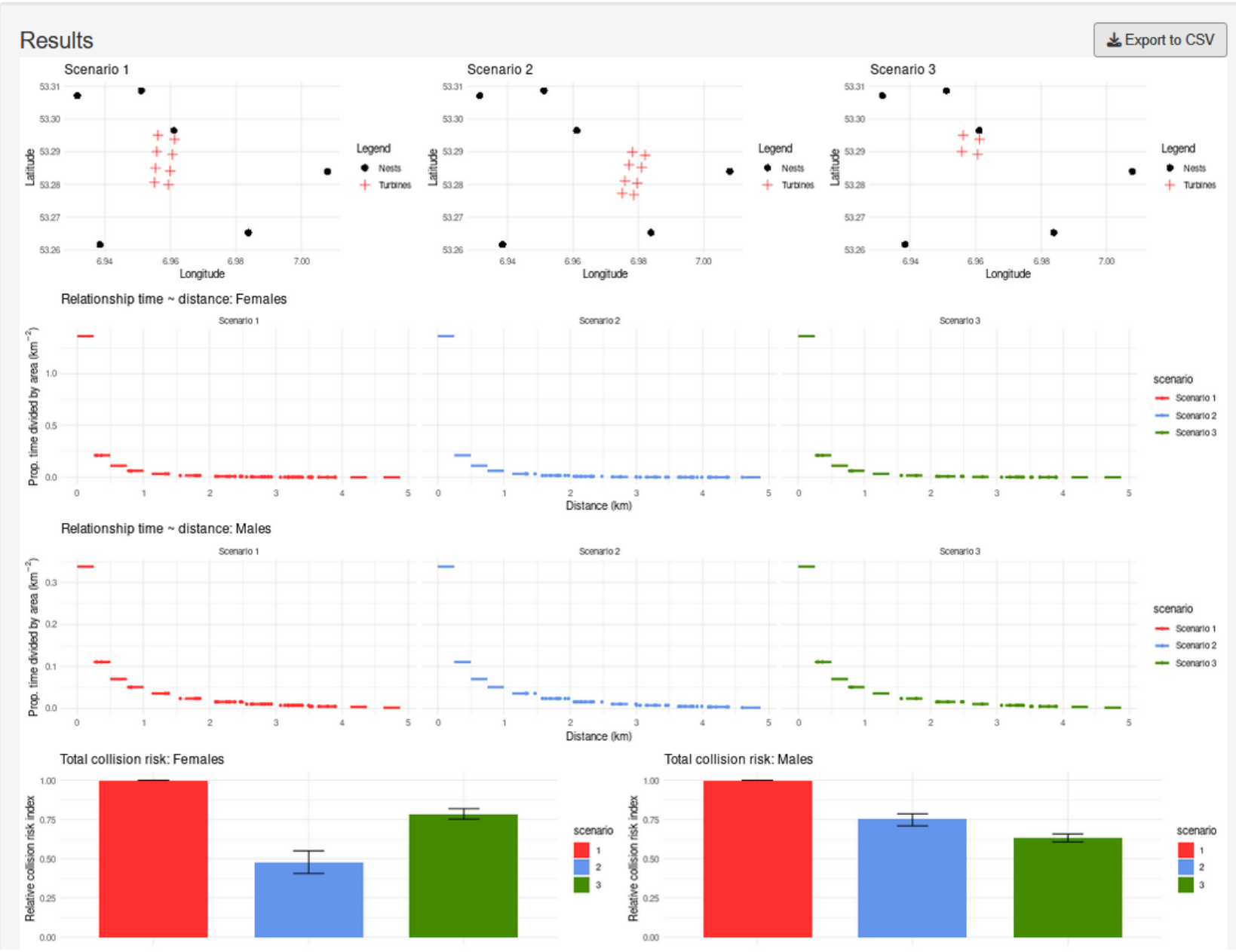
scenario_3

Wind turbines location

Browse...

Location	Longitude	Latitude
Location 1	6.931543	53.307126
Location 2	6.961100	53.296491
Location 3	6.983840	53.265292
Location 4	6.938467	53.261620
Location 5	7.007951	53.283989
Location 6	6.951100	53.308673

Location	Longitude	Latitude
Location 1	6.956211	53.295010
Location 2	6.961249	53.293840
Location 3	6.955829	53.290087
Location 4	6.960627	53.289163



Wind4Birds Module 2

Eolrap - Wind Turbine Location

Select Species:

Red Kite

Bird Data

Time / distance matrix for female

Browse...

No file selected

[1] "\\R1\\",\\"R2\\",\\"R3\\",\\"R4\\",\\"R5\\",\\"R6\\",\\"R7\\",\\"R8\\",\\"R9\\",\\"R10\\",\\"R11\\",\\"R12\\",\\"R13\\",\\"R14\\",\\"

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[3] "0.230105839810274,0.247295247418451,0.229570671728722,0.214119005691438,0.232487824944099,0.214588498226

[4] "0.115252975591184.0.121642373765907.0.100530446363834.0.112414382922946.0.108474284693799.0.115198779804

Time / distance matrix for male

Browse...

No file selected

[1] "\\R1\\",\\"R2\\",\\"R3\\",\\"R4\\",\\"R5\\",\\"R6\\",\\"R7\\",\\"R8\\",\\"R9\\",\\"R10\\",\\"R11\\",\\"R12\\",\\"R13\\",\\"R14\\",\\"

[2] "0.325920360089739,0.336484396169372,0.344046579005981,0.3766536462035,0.340098214252789,0.34172017880201

[3] "0.101295793366702,0.111763215115198,0.116393720517159,0.123838401116662,0.107141555616659,0.117396032471

[4] "0.0662312410153515.0.0670911602215712.0.0725240623145165.0.079253188291824.0.0666838062853348.0.07725824

Nest locations

Browse...

Location	Longitude , Latitude
Location 1	6.931543 , 53.307126
Location 2	6.961100 , 53.296491
Location 3	6.983840 , 53.265292
Location 4	6.938467 , 53.261620
Location 5	7.007951 , 53.283989
Location 6	6.951100 , 53.308673

Scenarios

scenario_1

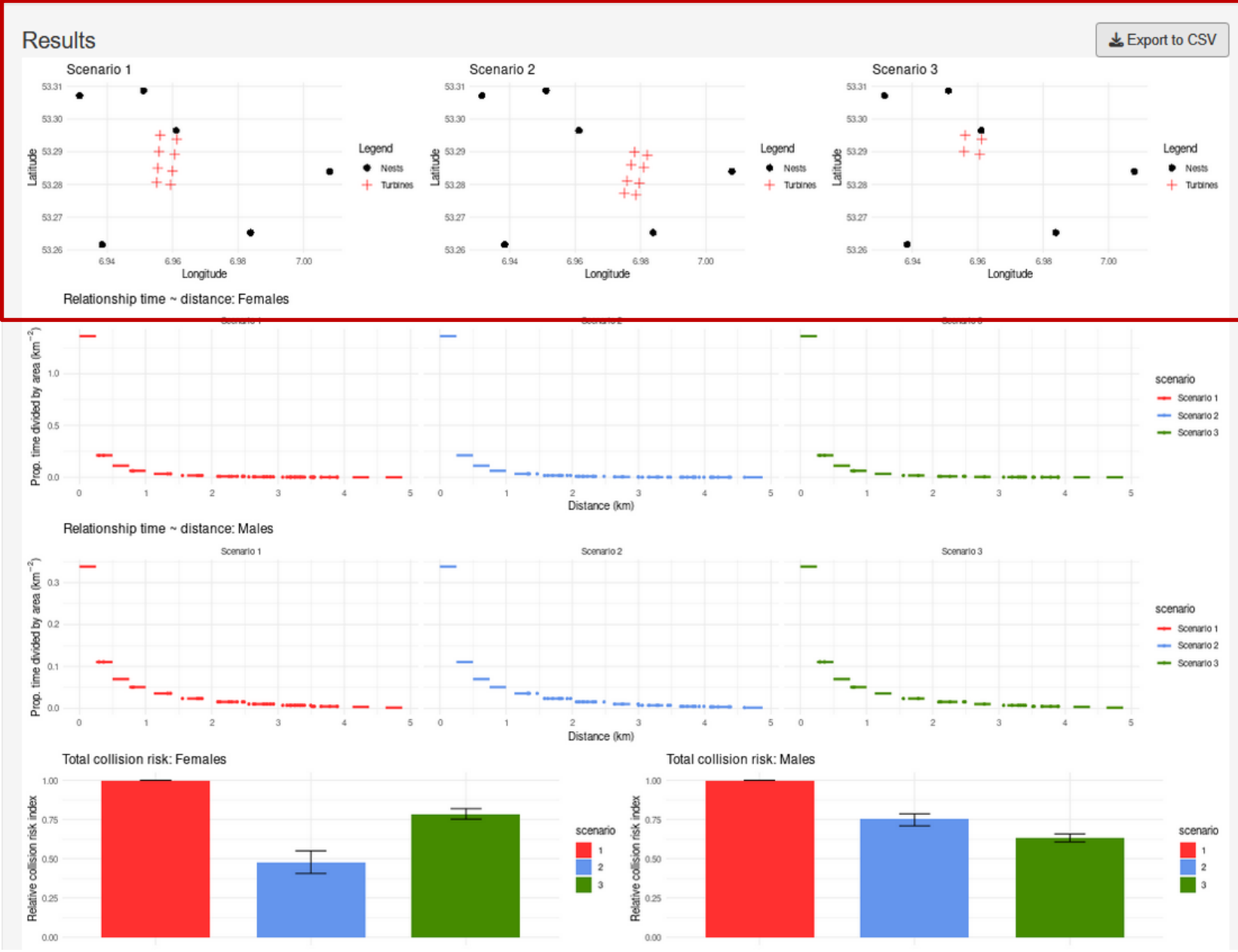
scenario_2

scenario_3

Wind turbines location

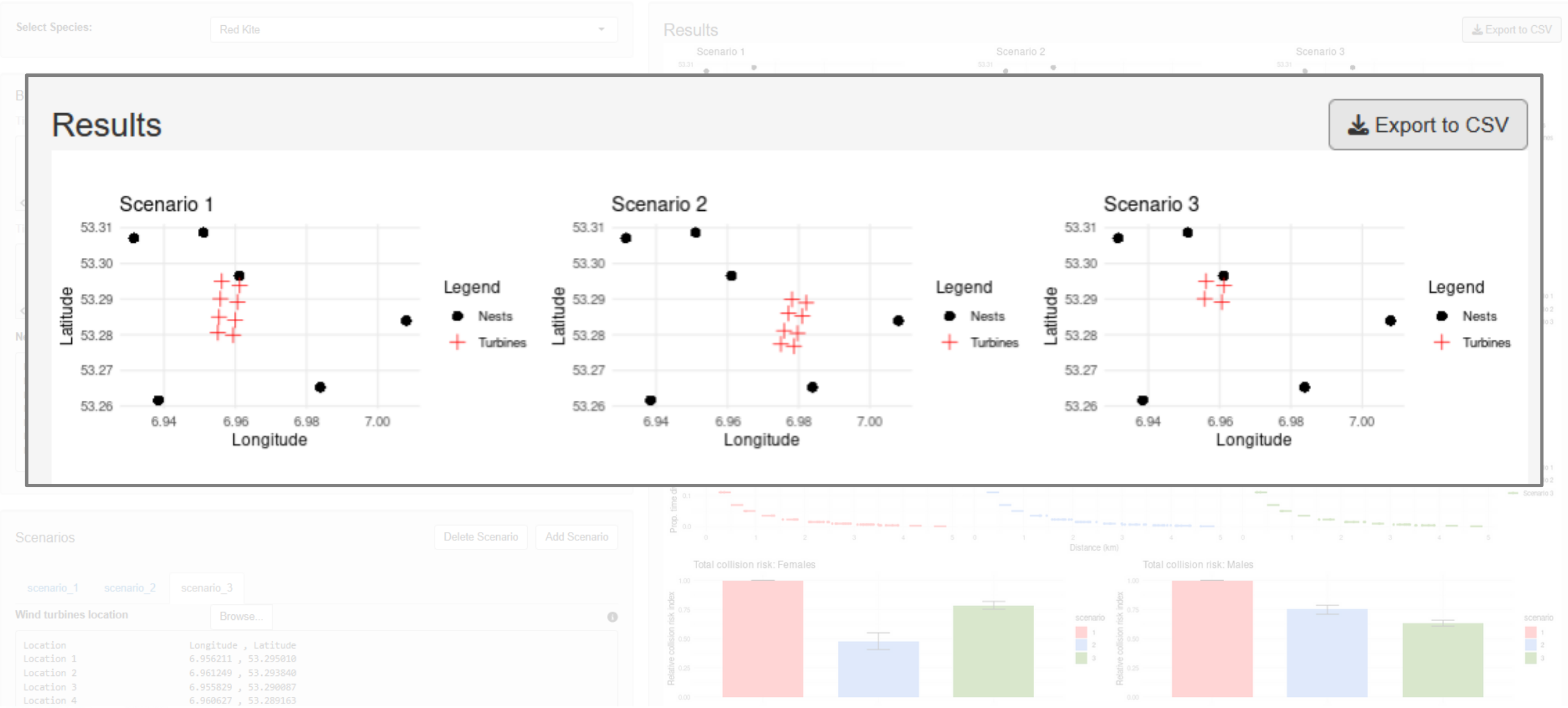
Browse...

Location	Longitude , Latitude
Location 1	6.956211 , 53.295010
Location 2	6.961249 , 53.293840
Location 3	6.955829 , 53.290087
Location 4	6.960627 , 53.289163

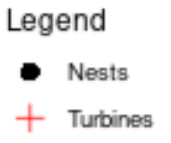
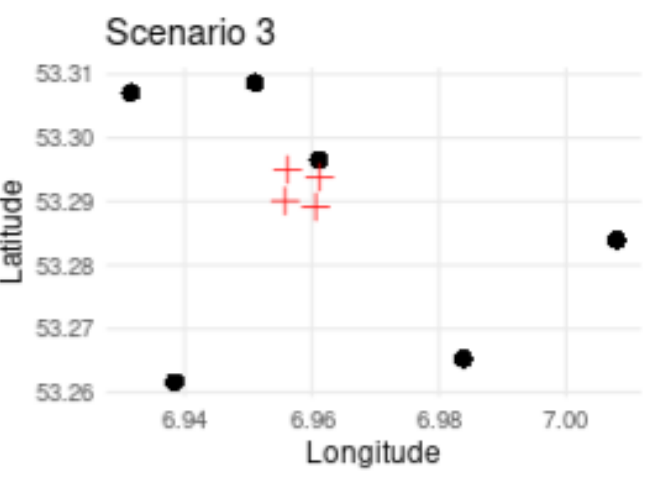
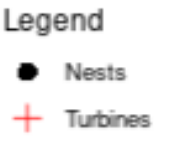
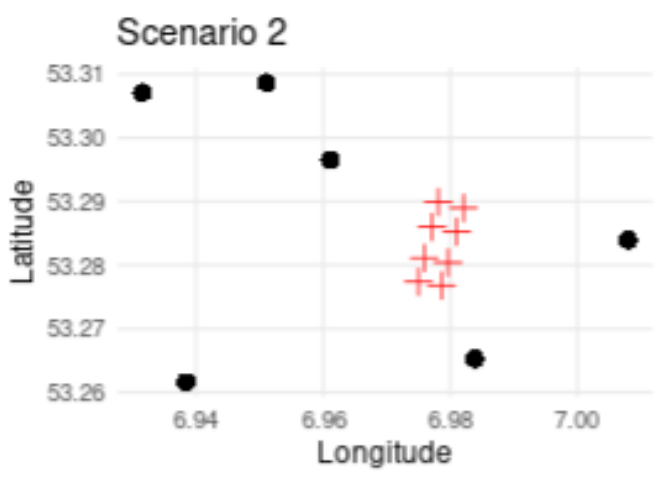
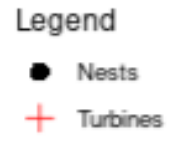
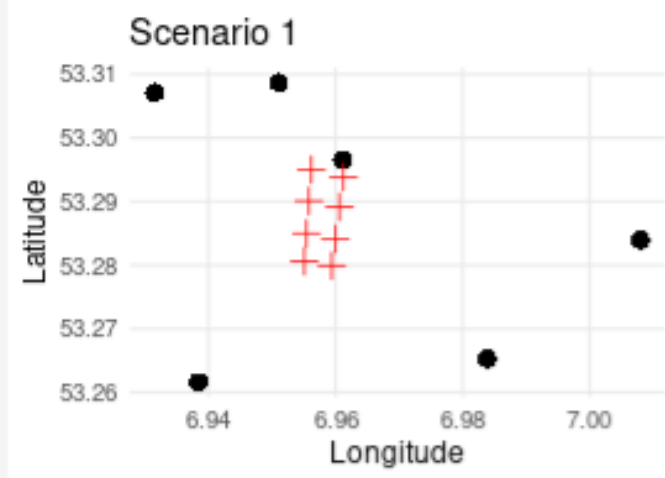


Wind4Birds Module 2

Eolrap - Wind Turbine Location



Results



Scenarios

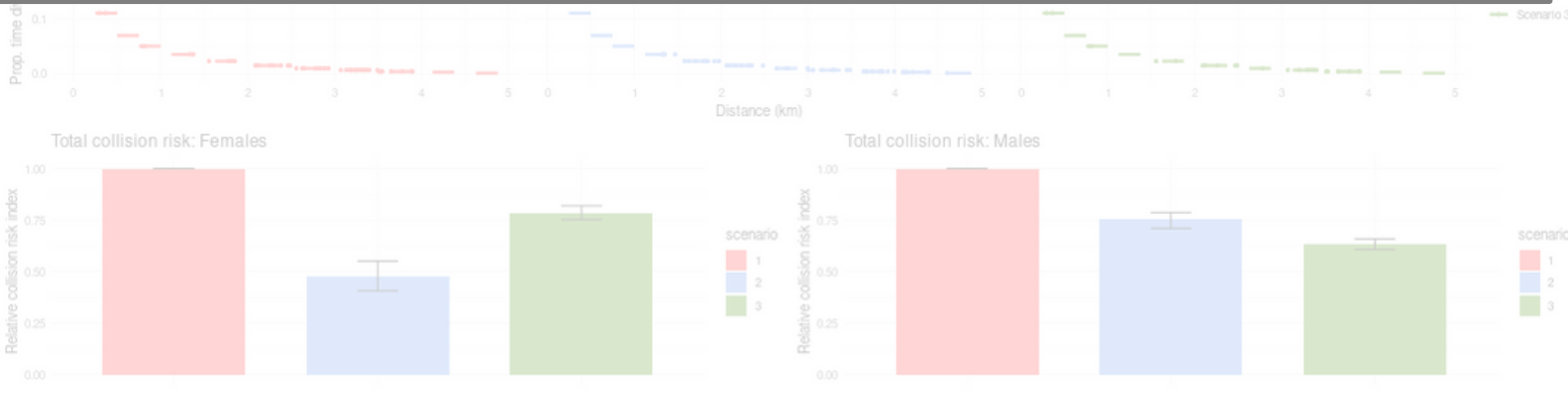
Delete Scenario Add Scenario

scenario_1 scenario_2 scenario_3

Wind turbines location

Browse...

Location	Longitude , Latitude
Location 1	6.956211 , 53.295010
Location 2	6.961249 , 53.293840
Location 3	6.955829 , 53.290087
Location 4	6.960627 , 53.289163



Wind4Birds Module 2

Eolrap - Wind Turbine Location

Select Species:

Red Kite

Bird Data

Time / distance matrix for female

Browse...

No file selected

Time / distance matrix for male

Browse...

No file selected

Nest locations

Browse...

Location

Longitude , Latitude

Location 1

6.931543 , 53.307126

Location 2

6.961100 , 53.296491

Location 3

6.983840 , 53.265292

Location 4

6.938467 , 53.261620

Location 5

7.007951 , 53.283989

Location 6

6.951100 , 53.308673

Scenarios

scenario_1

scenario_2

scenario_3

Wind turbines location

Browse...

Location

Longitude , Latitude

Location 1

6.956211 , 53.295010

Location 2

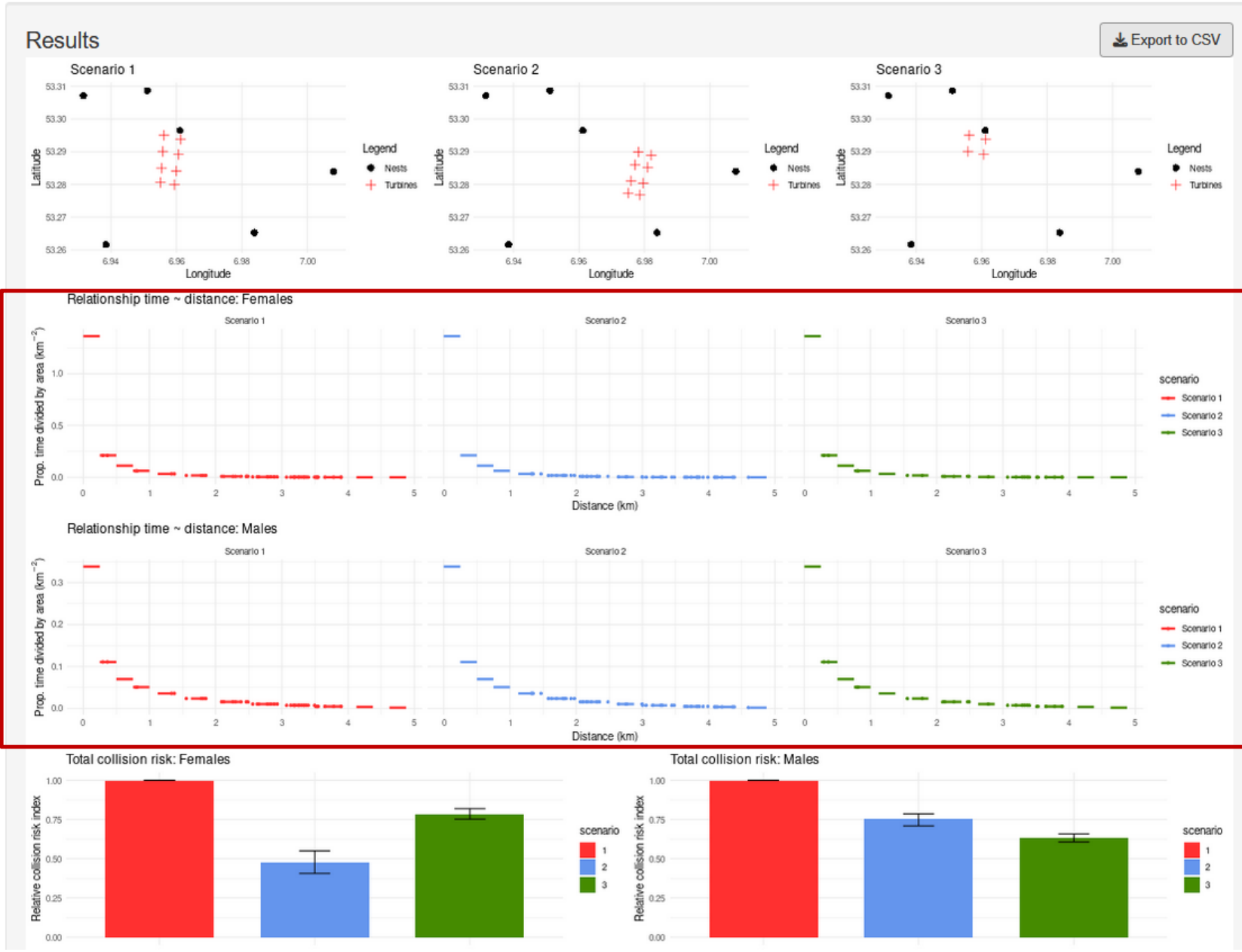
6.961249 , 53.293840

Location 3

6.955829 , 53.290087

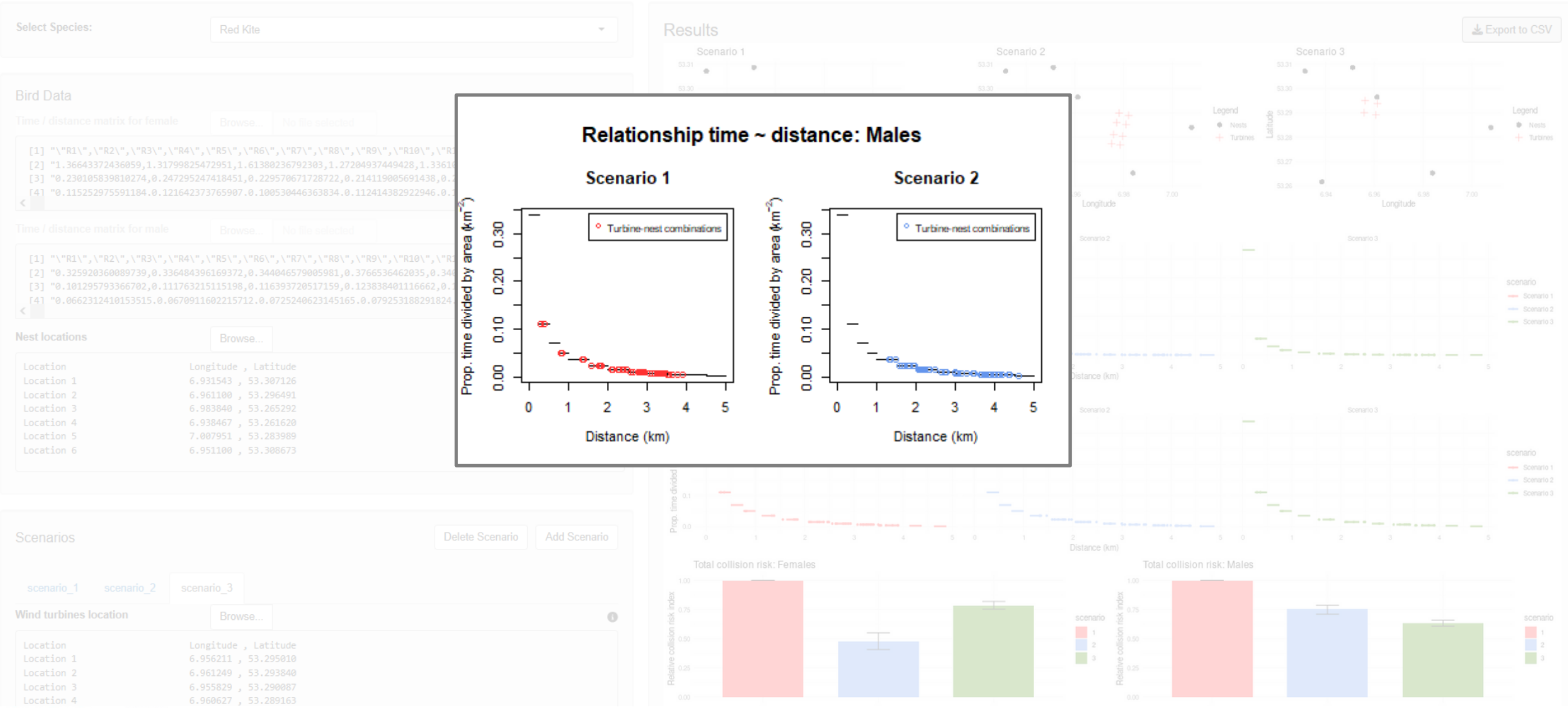
Location 4

6.960627 , 53.289163



Wind4Birds Module 2

Eolrap - Wind Turbine Location



Wind4Birds Module 2

Eolrap - Wind Turbine Location

Select Species:

Red Kite

Bird Data

Time / distance matrix for female

Browse...

No file selected

Time / distance matrix for male

Browse...

No file selected

Nest locations

Browse...

Location	Longitude	Latitude
Location 1	6.931543	53.307126
Location 2	6.961100	53.296491
Location 3	6.983840	53.265292
Location 4	6.938467	53.261620
Location 5	7.007951	53.283989
Location 6	6.951100	53.308673

Scenarios

scenario_1

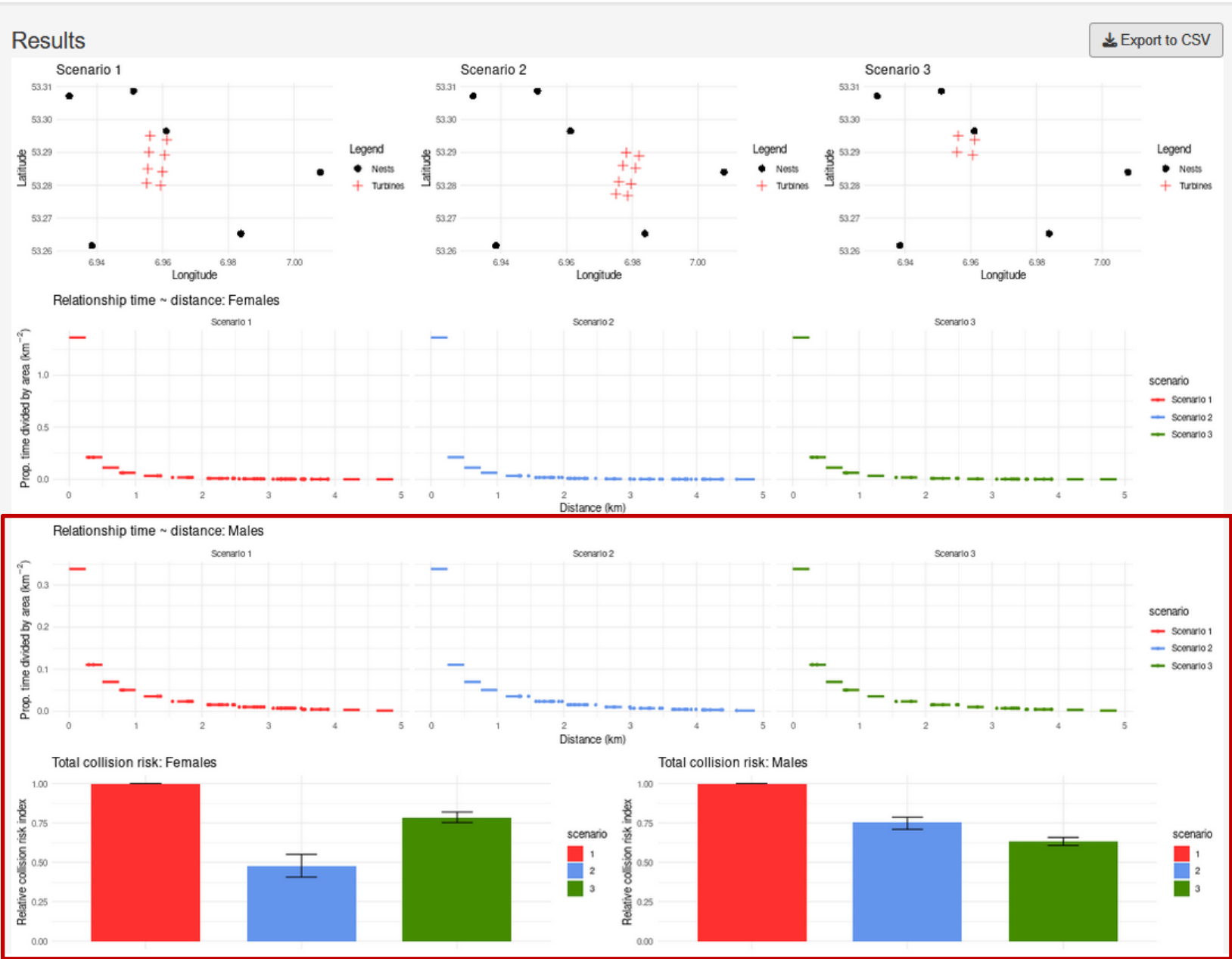
scenario_2

scenario_3

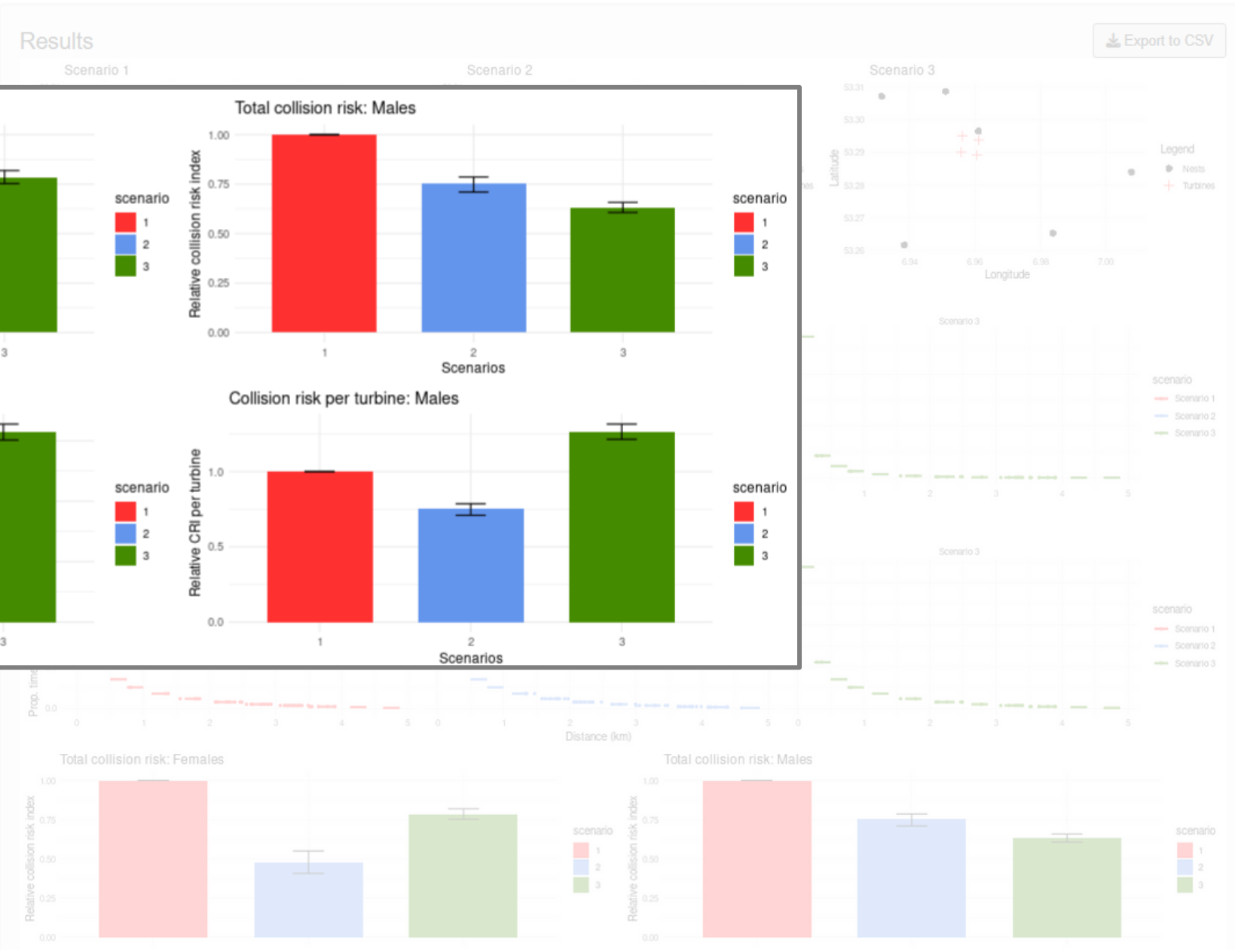
Wind turbines location

Browse...

Location	Longitude	Latitude
Location 1	6.956211	53.295010
Location 2	6.961249	53.293840
Location 3	6.955829	53.290087
Location 4	6.960627	53.289163



Eolrap - Wind Turbine Location



Eolrap - Wind Turbine Location

Figure 10 consists of six bar charts arranged in a 2x3 grid. The top row shows 'Collision risk per individual turbine: Females' and the bottom row shows 'Collision risk per individual turbine: Males'. The columns represent 'Scenario 1' (red bars), 'Scenario 2' (blue bars), and 'Scenario 3' (green bars). The x-axis for all charts is 'Wind Turbines' (1 to 8). The y-axis is 'Collision risk index'.

Collision risk per individual turbine: Females

Scenario	Turbine 1	Turbine 2	Turbine 3	Turbine 4	Turbine 5	Turbine 6	Turbine 7	Turbine 8
Scenario 1	0.24	0.24	0.08	0.08	0.05	0.05	0.03	0.04
Scenario 2	0.05	0.04	0.04	0.05	0.05	0.05	0.06	0.05
Scenario 3	0.24	0.24	0.08	0.08	0.00	0.00	0.00	0.00

Collision risk per individual turbine: Males

Scenario	Turbine 1	Turbine 2	Turbine 3	Turbine 4	Turbine 5	Turbine 6	Turbine 7	Turbine 8
Scenario 1	0.16	0.16	0.10	0.10	0.08	0.08	0.07	0.07
Scenario 2	0.08	0.07	0.07	0.08	0.08	0.08	0.08	0.08
Scenario 3	0.16	0.16	0.10	0.10	0.00	0.00	0.00	0.00

RAPPEL



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Effects of wind turbine dimensions on the collision risk of raptors: A simulation approach based on flight height distributions

Tonio Schaub^{a,b,c,d,*}, Raymond H.G. Klaassen^{c,d}, Caroline De Zutter^b, Pascal Albert^e, Olivier Bedotti^f, Jean-Luc Bourrioux^e, Ralph Buij^g, Joël Chadœuf^e, Celia Grande^h, Hubertus Illnerⁱ, Jérôme Isambert^j, Kjell Janssens^{d,k}, Eike Julius^l, Simon Lee^{m,n}, Aymeric Mionnet^o, Gerard Müskens^b, Rainer Raab^l, Stef van Rijn^q, Judy Shamoun-Baranes^r, Geert Spanoghe^k, Benoît Van Hecke^e, Jonas Waldenström^s, Alexandre Millon^{a,e}

Effects of wind turbine dimensions on the collision risk of raptors: a simulation approach based on flight height distributions

Tonio Schaub^{1,2,3,4}, Raymond H. G. Klaassen^{3,4}, Caroline De Zutter², Pascal Albert⁵, Olivier Bedotti⁶, Jean-Luc Bourrioux⁵, Ralph Buij⁷, Joël Chadœuf⁵, Celia Grande⁸, Hubertus Illner⁹, Jérôme Isambert¹⁰, Kjell Janssens^{4,11}, Eike Julius¹², Simon Lee^{13,14}, Aymeric Mionnet¹⁵, Gerard Müskens¹⁶, Rainer Raab¹², Stef van Rijn¹⁷, Judy Shamoun-Baranes¹⁸, Geert Spanoghe¹¹, Benoît Van Hecke⁵, Jonas Waldenström¹⁹ & Alexandre Millon^{1,5}

BACKGROUND

Informed selection of wind turbine dimensions could mitigate the collision risk of birds.

But: Effects of turbine dimensions still unknown for many species!

Methodological problem: Fatality data associated with strong biases

→ Alternative approach: Simulations based on flight height data allowing to keep confounding factors constant (e.g. bird abundance and behaviour)

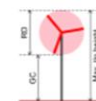


Figure 1: Illustration of the considered size parameters of wind turbines. OC = ground clearance; RD = rotor diameter.



275 GPS-tagged individuals of six raptor species in 15 study areas in FR, BE, LU, NL, DE and SE

High-frequency GPS tracking to obtain accurate flight height data (6,126 h of HF flight tracks +)



Figure 2: Example of high-frequency flight track (GPS interval of 3 s).

METHODS

Stochastic Band Collision Risk Model (sCRM) applied to range of wind turbine models using:

- Species-specific flight height distributions
- Rotation speed as a function of rotor diameter

RESULTS (1): Flight height distributions

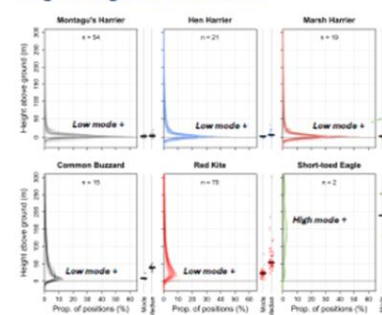


Figure 3: Flight height distributions per species in height bins of 5 m. Every line represents one individual bird; the mode and median per individual are indicated right of the panels (thick horizontal line: median across individuals). Prop. = proportion.

RESULTS (2): Effects of turbine dimensions

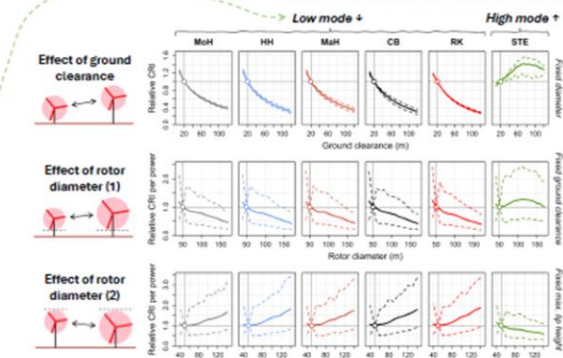


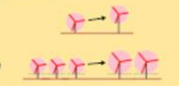
Figure 4: Effect of ground clearance and rotor diameter of wind turbines on collision risk relative to a reference level (thick vertical line). Panels show either collision risk index (CRI) per turbine (first row) or per rated power (second and third row). Thin lines: means; dashed lines: 95% confidence intervals.

CONCLUSIONS:

Opposite effects of wind turbine dimensions on collision risk for different raptor species depending on the flight height distribution (low mode vs. high mode)

For species with low mode: Collision risk reduced when using

- turbines with higher ground clearance
- less turbines with larger diameter instead of more turbines with smaller diameter to achieve given total power (at fixed ground clearance)



FURTHER READING:



UP NEXT:

Development of publicly available online tool allowing to apply approach to real-world wind energy projects

If you want to keep updated, feel free to send an email! +



university of
 groningen



Grauwe Kiekkendief
 Kenniscentrum Akkervogels

tonio.schaub@imbe.fr



Merci de votre attention



Wind4Birds Module 1

Eolrap - Wind Turbine Dimensions

Select Species:

Red Kite

Bird Data

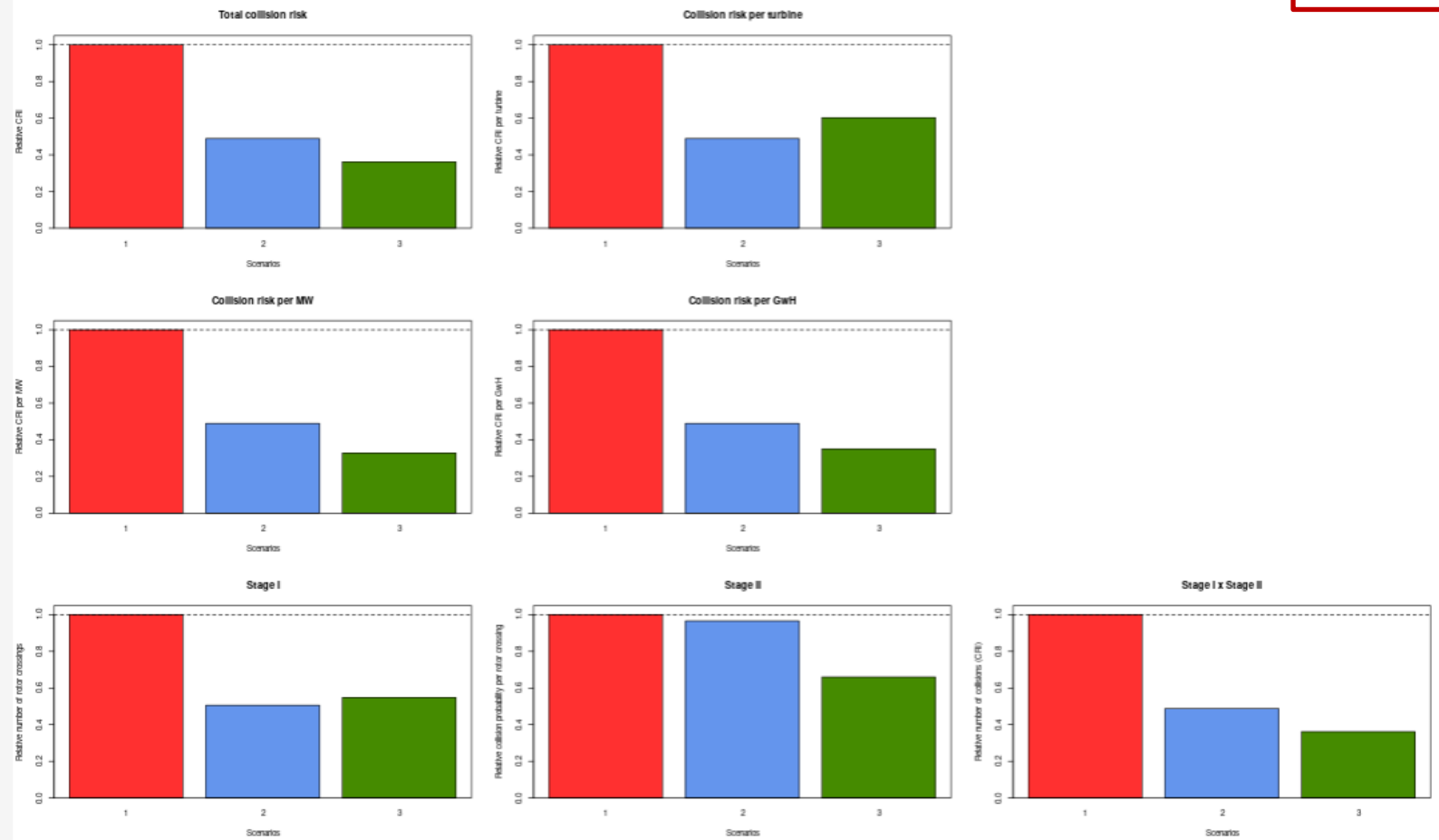
Flight Height Distribution

Browse...

No fit

[1] "\\height\\",\\"R1\\",\\"R2\\",\\"R3\\",\\"R4\\",\\"R5\\",\\"R6\\",\\"R7\\",\\"R8\\",\\"R9\\",\\"R10\\",\\"R11\\",\\"R12\\",\\"R13\\",\\"R14\\",\\"R15\\",\\"R16\\",\\"R17\\",\\"R18\\",\\"R19\\",\\"R20\\",\\"R21\\",\\"R22\\",\\"R23\\",\\"R24\\",\\"R25\\",\\"R26\\",\\"R27\\",\\"R28\\",\\"R29\\",\\"R30\\",\\"R31\\",\\"R32\\",\\"R33\\",\\"R34\\",\\"R35\\",\\"R36\\",\\"R37\\",\\"R38\\",\\"R39\\",\\"R40\\",\\"R41\\",\\"R42\\",\\"R43\\",\\"R44\\",\\"R45\\",\\"R46\\",\\"R47\\",\\"R48\\",\\"R49\\",\\"R50\\",\\"R51\\",\\"R52\\",\\"R53\\",\\"R54\\",\\"R55\\",\\"R56\\",\\"R57\\",\\"R58\\",\\"R59\\",\\"R60\\",\\"R61\\",\\"R62\\",\\"R63\\",\\"R64\\",\\"R65\\",\\"R66\\",\\"R67\\",\\"R68\\",\\"R69\\",\\"R70\\",\\"R71\\",\\"R72\\",\\"R73\\",\\"R74\\",\\"R75\\",\\"R76\\",\\"R77\\",\\"R78\\",\\"R79\\",\\"R80\\",\\"R81\\",\\"R82\\",\\"R83\\",\\"R84\\",\\"R85\\",\\"R86\\",\\"R87\\",\\"R88\\",\\"R89\\",\\"R90\\",\\"R91\\",\\"R92\\",\\"R93\\",\\"R94\\",\\"R95\\",\\"R96\\",\\"R97\\",\\"R98\\",\\"R99\\",\\"R100\\",\\"R101\\",\\"R102\\",\\"R103\\",\\"R104\\",\\"R105\\",\\"R106\\",\\"R107\\",\\"R108\\",\\"R109\\",\\"R110\\",\\"R111\\",\\"R112\\",\\"R113\\",\\"R114\\",\\"R115\\",\\"R116\\",\\"R117\\",\\"R118\\",\\"R119\\",\\"R120\\",\\"R121\\",\\"R122\\",\\"R123\\",\\"R124\\",\\"R125\\",\\"R126\\",\\"R127\\",\\"R128\\",\\"R129\\",\\"R130\\",\\"R131\\",\\"R132\\",\\"R133\\",\\"R134\\",\\"R135\\",\\"R136\\",\\"R137\\",\\"R138\\",\\"R139\\",\\"R140\\",\\"R141\\",\\"R142\\",\\"R143\\",\\"R144\\",\\"R145\\",\\"R146\\",\\"R147\\",\\"R148\\",\\"R149\\",\\"R150\\",\\"R151\\",\\"R152\\",\\"R153\\",\\"R154\\",\\"R155\\",\\"R156\\",\\"R157\\",\\"R158\\",\\"R159\\",\\"R160\\",\\"R161\\",\\"R162\\",\\"R163\\",\\"R164\\",\\"R165\\",\\"R166\\",\\"R167\\",\\"R168\\",\\"R169\\",\\"R170\\",\\"R171\\",\\"R172\\",\\"R173\\",\\"R174\\",\\"R175\\",\\"R176\\",\\"R177\\",\\"R178\\",\\"R179\\",\\"R180\\",\\"R181\\",\\"R182\\",\\"R183\\",\\"R184\\",\\"R185\\",\\"R186\\",\\"R187\\",\\"R188\\",\\"R189\\",\\"R190\\",\\"R191\\",\\"R192\\",\\"R193\\",\\"R194\\",\\"R195\\",\\"R196\\",\\"R197\\",\\"R198\\",\\"R199\\",\\"R200\\",\\"R201\\",\\"R202\\",\\"R203\\",\\"R204\\",\\"R205\\",\\"R206\\",\\"R207\\",\\"R208\\",\\"R209\\",\\"R210\\",\\"R211\\",\\"R212\\",\\"R213\\",\\"R214\\",\\"R215\\",\\"R216\\",\\"R217\\",\\"R218\\",\\"R219\\",\\"R220\\",\\"R221\\",\\"R222\\",\\"R223\\",\\"R224\\",\\"R225\\",\\"R226\\",\\"R227\\",\\"R228\\",\\"R229\\",\\"R230\\",\\"R231\\",\\"R232\\",\\"R233\\",\\"R234\\",\\"R235\\",\\"R236\\",\\"R237\\",\\"R238\\",\\"R239\\",\\"R240\\",\\"R241\\",\\"R242\\",\\"R243\\",\\"R244\\",\\"R245\\",\\"R246\\",\\"R247\\",\\"R248\\",\\"R249\\",\\"R250\\",\\"R251\\",\\"R252\\",\\"R253\\",\\"R254\\",\\"R255\\",\\"R256\\",\\"R257\\",\\"R258\\",\\"R259\\",\\"R260\\",\\"R261\\",\\"R262\\",\\"R263\\",\\"R264\\",\\"R265\\",\\"R266\\",\\"R267\\",\\"R268\\",\\"R269\\",\\"R270\\",\\"R271\\",\\"R272\\",\\"R273\\",\\"R274\\",\\"R275\\",\\"R276\\",\\"R277\\",\\"R278\\",\\"R279\\",\\"R280\\",\\"R281\\",\\"R282\\",\\"R283\\",\\"R284\\",\\"R285\\",\\"R286\\",\\"R287\\",\\"R288\\",\\"R289\\",\\"R290\\",\\"R291\\",\\"R292\\",\\"R293\\",\\"R294\\",\\"R295\\",\\"R296\\",\\"R297\\",\\"R298\\",\\"R299\\",\\"R300\\",\\"R301\\",\\"R302\\",\\"R303\\",\\"R304\\",\\"R305\\",\\"R306\\",\\"R307\\",\\"R308\\",\\"R309\\",\\"R310\\",\\"R311\\",\\"R312\\",\\"R313\\",\\"R314\\",\\"R315\\",\\"R316\\",\\"R317\\",\\"R318\\",\\"R319\\",\\"R320\\",\\"R321\\",\\"R322\\",\\"R323\\",\\"R324\\",\\"R325\\",\\"R326\\",\\"R327\\",\\"R328\\",\\"R329\\",\\"R330\\",\\"R331\\",\\"R332\\",\\"R333\\",\\"R334\\",\\"R335\\",\\"R336\\",\\"R337\\",\\"R338\\",\\"R339\\",\\"R340\\",\\"R341\\",\\"R342\\",\\"R343\\",\\"R344\\",\\"R345\\",\\"R346\\",\\"R347\\",\\"R348\\",\\"R349\\",\\"R350\\",\\"R351\\",\\"R352\\",\\"R353\\",\\"R354\\",\\"R355\\",\\"R356\\",\\"R357\\",\\"R358\\",\\"R359\\",\\"R360\\",\\"R361\\",\\"R362\\",\\"R363\\",\\"R364\\",\\"R365\\",\\"R366\\",\\"R367\\",\\"R368\\",\\"R369\\",\\"R370\\",\\"R371\\",\\"R372\\",\\"R373\\",\\"R374\\",\\"R375\\",\\"R376\\",\\"R377\\",\\"R378\\",\\"R379\\",\\"R380\\",\\"R381\\",\\"R382\\",\\"R383\\",\\"R384\\",\\"R385\\",\\"R386\\",\\"R387\\",\\"R388\\",\\"R389\\",\\"R390\\",\\"R391\\",\\"R392\\",\\"R393\\",\\"R394\\",\\"R395\\",\\"R396\\",\\"R397\\",\\"R398\\",\\"R399\\",\\"R400\\",\\"R401\\",\\"R402\\",\\"R403\\",\\"R404\\",\\"R405\\",\\"R406\\",\\"R407\\",\\"R408\\",\\"R409\\",\\"R410\\",\\"R411\\",\\"R412\\",\\"R413\\",\\"R414\\",\\"R415\\",\\"R416\\",\\"R417\\",\\"R418\\",\\"R419\\",\\"R420\\",\\"R421\\",\\"R422\\",\\"R423\\",\\"R424\\",\\"R425\\",\\"R426\\",\\"R427\\",\\"R428\\",\\"R429\\",\\"R430\\",\\"R431\\",\\"R432\\",\\"R433\\",\\"R434\\",\\"R435\\",\\"R436\\",\\"R437\\",\\"R438\\",\\"R439\\",\\"R440\\",\\"R441\\",\\"R442\\",\\"R443\\",\\"R444\\",\\"R445\\",\\"R446\\",\\"R447\\",\\"R448\\",\\"R449\\",\\"R450\\",\\"R451\\",\\"R452\\",\\"R453\\",\\"R454\\",\\"R455\\",\\"R456\\",\\"R457\\",\\"R458\\",\\"R459\\",\\"R460\\",\\"R461\\",\\"R462\\",\\"R463\\",\\"R464\\",\\"R465\\",\\"R466\\",\\"R467\\",\\"R468\\",\\"R469\\",\\"R470\\",\\"R471\\",\\"R472\\",\\"R473\\",\\"R474\\",\\"R475\\",\\"R476\\",\\"R477\\",\\"R478\\",\\"R479\\",\\"R480\\",\\"R481\\",\\"R482\\",\\"R483\\",\\"R484\\",\\"R485\\",\\"R486\\",\\"R487\\",\\"R488\\",\\"R489\\",\\"R490\\",\\"R491\\",\\"R492\\",\\"R493\\",\\"R494\\",\\"R495\\",\\"R496\\",\\"R497\\",\\"R498\\",\\"R499\\",\\"R500\\",\\"R501\\",\\"R502\\",\\"R503\\",\\"R504\\",\\"R505\\",\\"R506\\",\\"R507\\",\\"R508\\",\\"R509\\",\\"R510\\",\\"R511\\",\\"R512\\",\\"R513\\",\\"R514\\",\\"R515\\",\\"R516\\",\\"R517\\",\\"R518\\",\\"R519\\",\\"R520\\",\\"R521\\",\\"R522\\",\\"R523\\",\\"R524\\",\\"R525\\",\\"R526\\",\\"R527\\",\\"R528\\",\\"R529\\",\\"R530\\",\\"R531\\",\\"R532\\",\\"R533\\",\\"R534\\",\\"R535\\",\\"R536\\",\\"R537\\",\\"R538\\",\\"R539\\",\\"R540\\",\\"R541\\",\\"R542\\",\\"R543\\",\\"R544\\",\\"R545\\",\\"R546\\",\\"R547\\",\\"R548\\",\\"R549\\",\\"R550\\",\\"R551\\",\\"R552\\",\\"R553\\",\\"R554\\",\\"R555\\",\\"R556\\",\\"R557\\",\\"R558\\",\\"R559\\",\\"R560\\",\\"R561\\",\\"R562\\",\\"R563\\",\\"R564\\",\\"R565\\",\\"R566\\",\\"R567\\",\\"R568\\",\\"R569\\",\\"R570\\",\\"R571\\",\\"R572\\",\\"R573\\",\\"R574\\",\\"R575\\",\\"R576\\",\\"R577\\",\\"R578\\",\\"R579\\",\\"R580\\",\\"R581\\",\\"R582\\",\\"R583\\",\\"R584\\",\\"R585\\",\\"R58

Results



Wind4Birds Module 1

Eolrap - Wind Turbine Dimensions

Select Species:

Red Kite

Bird Data

Flight Height Distribution

Browse...No file

[1] "\\height\\","R1\\","R2\\","R3\\","R4\\","R5\\","R6\\","R7\\","R8\\",
[2] "0,0.00344837716370137,0.00364865279500655,0.00400521440337913,0.003
[3] "1,0.00406440708297611,0.00426669705749565,0.00466036106922995,0.003
[4] "1,0.00471305107004733,0.00490709570049065,0.005207077305732,0.00490

Relationship Flight Speed Height

Browse...No file

[1] "\\mean_ground_speed\\" "6.75519845482305" "7.26172184723346"
[4] "7.57343954083399" "7.77285876971577" "7.96048338052847"
[7] "8.15868280235877" "8.34431087672573" "8.46753195139934"
[10] "8.61877158583236" "8.7203683728929" "8.79871792758187"
[13] "8.88886070526696" "8.98817457766349" "9.04696263179823"

Body Length (m) *

0,66

Wingspan: *

1,57

Flight Mode *

Gliding

Scenarios

scenario_1scenario_2scenario_3

Ground clearance (m) *

80

Rotor diameter (m) *

150

Maximum tip height (m)

230

Number of turbines *

3

Rotation speed (RPM) *

7,7171397051204

Blade width (m) *

4,18154063826314

Rated power (MW) *

4,29454337386609

	A	B	C	D	E	F
1	Parameter,"scenario_1","scenario_2","scenario_3"					
2	Ground Clearance,30,80,80					
3	Rotor Diameter,100,100,150					
4	Maximum Tip Height,130,180,230					
5	Number of Turbines,5,5,3					
6	Rotation Speed,11.80096797525,11.80096797525,7.7171397051204					
7	Blade Width,3.7951186204209,3.7951186204209,4.18154063826314					
8	Rated Power,2.33100587475159,2.33100587475159,4.29454337386609					
9	Annual Energy Production,25,25,28					
10	Annual Operation Time,6000,6000,6500					
11	Flight Speed,8.29970767272446,8.93331705883078,9.02510033472741					
12	,NA,NA,NA					
13	CRI_lwr,1,0.471,0.344					
14	CRI_mean,1,0.489,0.362					
15	CRI_upr,1,0.513,0.386					
16	CRI_p.turbine_lwr,1,0.471,0.573					
17	CRI_p.turbine_mean,1,0.489,0.603					
18	CRI_p.turbine_upr,1,0.513,0.643					
19	CRI_p.MW_lwr,1,0.471,0.311					
20	CRI_p.MW_mean,1,0.489,0.327					
21	CRI_p.MW_upr,1,0.513,0.349					
22	CRI_p.GWh_lwr,1,0.471,0.332					
23	CRI_p.GWh_mean,1,0.489,0.35					
24	CRI_p.GWh_upr,1,0.513,0.373					
25	CRM_stage_I,1,0.506,0.548					
26	CRM_stage_II,1,0.966,0.66					



Wind4Birds Module 2

Eolrap - Wind Turbine Location

Select Species:

Red Kite

Bird Data

Time / distance matrix for female

Browse...

No file selected

[1] "\\R1\\",\\"R2\\",\\"R3\\",\\"R4\\",\\"R5\\",\\"R6\\",\\"R7\\",\\"R8\\",\\"R9\\",\\"R10\\",\\"R11\\",\\"R12\\",\\"R13\\",\\"R14\\",\

[2] "1.36643372436059,1.31799825472951,1.61380236792303,1.27204937449428,1.33610818585296,1.14682453654906,1.

[3] "0.230105839810274,0.247295247418451,0.229570671728722,0.214119005691438,0.232487824944099,0.214588498226

[4] "0.115252975591184,0.121642373765907,0.100530446363834,0.112414382922946,0.108474284693799,0.115198779804

Time / distance matrix for male

Browse...

No file selected

[1] "\\R1\\",\\"R2\\",\\"R3\\",\\"R4\\",\\"R5\\",\\"R6\\",\\"R7\\",\\"R8\\",\\"R9\\",\\"R10\\",\\"R11\\",\\"R12\\",\\"R13\\",\\"R14\\",\

[2] "0.325920360089739,0.336484396169372,0.344046579005981,0.3766536462035,0.340098214252789,0.34172017880201

[3] "0.101295793366702,0.111763215115198,0.116393720517159,0.123838401116662,0.107141555616659,0.117396032471

[4] "0.0662312410153515,0.0670911602215712,0.0725240623145165,0.079253188291824,0.0666838062853348,0.07725824

Nest locations

Browse...

Location	Longitude	Latitude
Location 1	6.931543	53.307126
Location 2	6.961100	53.296491
Location 3	6.983840	53.265292
Location 4	6.938467	53.261620
Location 5	7.007951	53.283989
Location 6	6.951100	53.308673

Scenarios

scenario_1

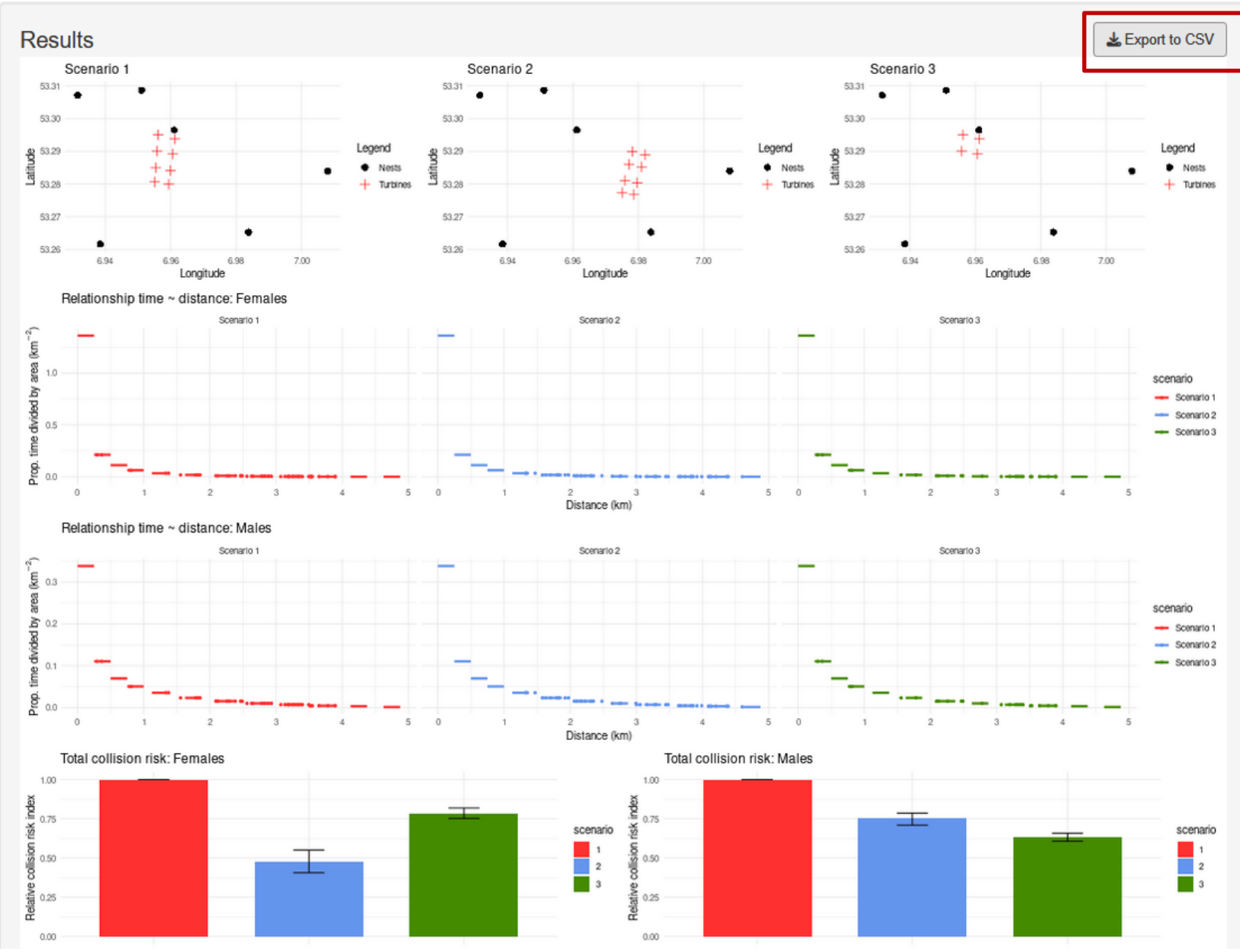
scenario_2

scenario_3

Wind turbines location

Browse...

Location	Longitude	Latitude
Location 1	6.956211	53.295010
Location 2	6.961249	53.293840
Location 3	6.955829	53.290087
Location 4	6.960627	53.289163



Wind4Birds Module 2

Eolrap - Wind Turbine Location

Select Species: Red Kite

Bird Data

Time / distance matrix for female Browse... No file selected

[1] "\R1\", \"R2\", \"R3\", \"R4\", \"R5\", \"R6\", \"R7\", \"R8\", \"R9\", \"R10\", \"R11\"

[2] "1.36643372436059,1.31799825472951,1.61380236792303,1.27204937449428,1.33610818

[3] "0.230105839810274,0.247295247418451,0.229570671728722,0.214119005691438,0.2324

[4] "0.115252975591184,0.121642373765907,0.100530446363834,0.112414382922946,0.1084

Time / distance matrix for male Browse... No file selected

[1] "\R1\", \"R2\", \"R3\", \"R4\", \"R5\", \"R6\", \"R7\", \"R8\", \"R9\", \"R10\", \"R11\"

[2] "0.325920360089739,0.336484396169372,0.344046579005981,0.3766536462035,0.340098

[3] "0.101295793366702,0.111763215115198,0.116393720517159,0.123838401116662,0.1071

[4] "0.0662312410153515,0.0670911602215712,0.0725240623145165,0.079253188291824,0.0

Nest locations Browse...

Location

Longitude , Latitude

Location 1

6.931543 , 53.307126

Location 2

6.961100 , 53.296491

Location 3

6.983840 , 53.265292

Location 4

6.938467 , 53.261620

Location 5

7.007951 , 53.283989

Location 6

6.951100 , 53.308673

Scenarios

scenario_1

scenario_2

scenario_3

Wind turbines location Browse...

Location

Longitude , Latitude

Location 1

6.956211 , 53.295010

Location 2

6.961249 , 53.293840

Location 3

6.955829 , 53.290087

Location 4

6.960627 , 53.289163

	A	B	C	D	E	F	G	H
1	Parameter,"scenario_1","scenario_2","scenario_3"							
2	Nest location 1,"6.931543 53.307126","6.931543 53.307126","6.931543 53.307126"							
3	Nest location 2,"6.961100 53.296491","6.961100 53.296491","6.961100 53.296491"							
4	Nest location 3,"6.983840 53.265292","6.983840 53.265292","6.983840 53.265292"							
5	Nest location 4,"6.938467 53.261620","6.938467 53.261620","6.938467 53.261620"							
6	Nest location 5,"7.007951 53.283989","7.007951 53.283989","7.007951 53.283989"							
7	Nest location 6,"6.951100 53.308673","6.951100 53.308673","6.951100 53.308673"							
8	Location 1,"6.956211 53.295010","6.978106 53.289920","6.956211 53.295010"							
9	Location 2,"6.961249 53.293840","6.982075 53.288988","6.961249 53.293840"							
10	Location 3,"6.955829 53.290087","6.977125 53.286000","6.955829 53.290087"							
11	Location 4,"6.960627 53.289163","6.981004 53.285256","6.960627 53.289163"							
12	Location 5,"6.955443 53.284981","6.975906 53.281111",""							
13	Location 6,"6.959953 53.284126","6.979645 53.280409",""							
14	Location 7,"6.955106 53.280607","6.974987 53.277392",""							
15	Location 8,"6.959403 53.279909","6.978632 53.276804",""							
16	Results,"",""							
17	n_turbines,"8","8","4"							
18	CRI_f_lwr,"1","0.406","0.753"							
19	CRI_f_mean,"1","0.479","0.784"							
20	CRI_f_upr,"1","0.55","0.819"							
21	CRI_m_lwr,"1","0.71","0.607"							
22	CRI_m_mean,"1","0.751","0.631"							
23	CRI_m_upr,"1","0.786","0.658"							
24	CRI_p.turbine_f_lwr,"1","0.406","1.506"							
25	CRI_p.turbine_f_mean,"1","0.479","1.569"							
26	CRI_p.turbine_f_upr,"1","0.55","1.638"							
27	CRI_p.turbine_m_lwr,"1","0.71","1.215"							
28	CRI_p.turbine_m_mean,"1","0.751","1.263"							
29	CRI_p.turbine_m_upr,"1","0.786","1.316"							
30	CRI_f.turbine_1,"0.242393057476808","0.0529906175818053","0.242393057476808"							
31	CRI_f.turbine_2,"0.24318832452907","0.0438415742127574","0.24318832452907"							
32	CRI_f.turbine_3,"0.0860536789912748","0.0404741408466456","0.0860536789912748"							
33	CRI_f.turbine_4,"0.0817665282719161","0.048923991984378","0.0817665282719161"							
34	CRI_f.turbine_5,"0.0521430506137945","0.04971925903664",NA							
35	CRI_f.turbine_6,"0.0497613918464501","0.048923991984378",NA							
36	CRI_f.turbine_7,"0.0361869901272869","0.058073035353426",NA							
37	CRI_f.turbine_8,"0.0412694078989076","0.0554845563418835",NA							
38	CRI_m.turbine_1,"0.164075036719972","0.080818670785197","0.164075036719972"							
39	CRI_m.turbine_2,"0.166626108002347","0.0732426841933954","0.166626108002347"							
40	CRI_m.turbine_3,"0.101387081028185","0.0715938926102241","0.101387081028185"							
41	CRI_m.turbine_4,"0.0987434705099906","0.0784373659939644","0.0987434705099906"							
42	CRI_m.turbine_5,"0.0848996553121921","0.0809884372763395",NA							

