Random Walk Simulator as an EIA Tool

Ji Young Kim mythe@kei.re.kr
Tae Ho Ro thro@kei.re.kr
Korea Environment Institute

Contents

1. Impacts of Development Projects on Animal Movements

■ By Expert Judgments

Abrupt morphological changes and ecological breakages are induced by project implementation. However, it is hard to achieve satisfactory estimation on the impacts of development project on animal movements. Judgements are usually relied on previous studies and general charaeteristics of behaviors with evidences collected from field traces by expert judgments.

■ Need to Prepare Evaluation Methods

Field mapping, Satellite image and Airborne photos give basic concept of obstacles that block animal movements.

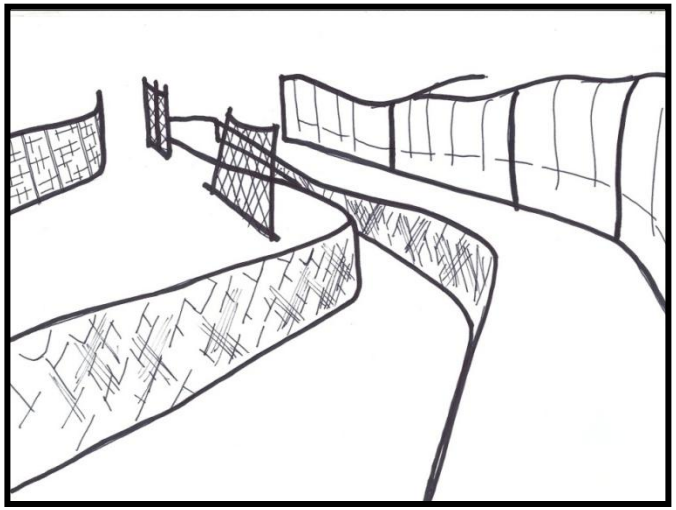
Distribution of the obstacles affects travelling possibilities of animals.

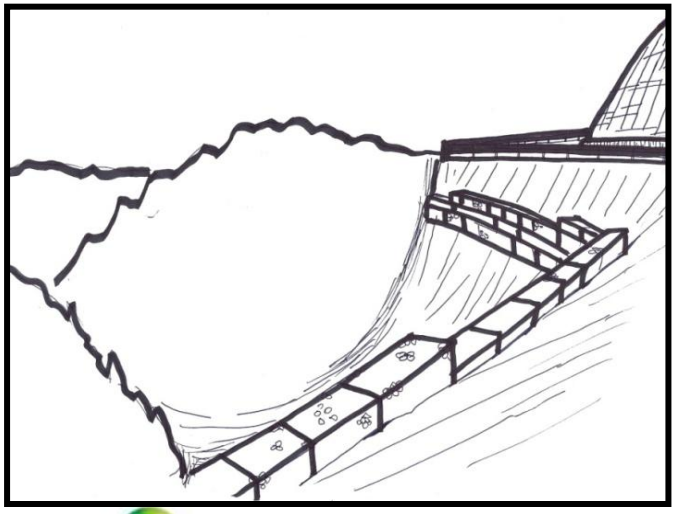
Due to lack of integrating device, comprehensive conclusion is hard to be inferred.

Random Walker Simulator may draw reasonable conclusions about changes in animal movement with hypothetical predicting simulation methods by combining these data.

2. Geographic Barriers (Topographic Obstacles) and Changes in Travelling Probabilities of Animals

Types of Geographic Barriers(Topographic Obstacles, Physical Barriers)





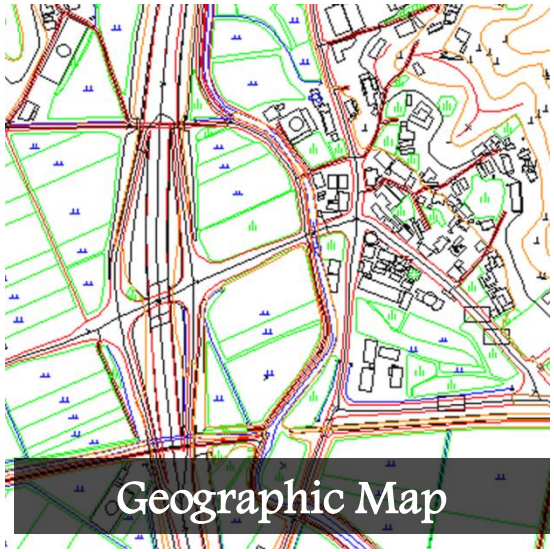
Steep stone work
Stone embankment
Wiremesh wall
Steep slope face
Retaining wall
Combination of guardrail and steep slope
Median strip(crash barrier) in the middle of expressway
Greenhouse
Densely populated residential area
Urban zone
Etc.

2. Geographic Barriers (Topographic Obstacles) and Changes in Travelling Probabilities of Animals

Mapping of Geographical Barriers


Satelline Image

+


Geographic Map

+


Field Mapping


Road view
Provided by portal sites
in Korea

Geographic Barrier can be defined as any physical objects that block animal movement

Geographic Barriers are easily recognizable by anyone without errors of recognition

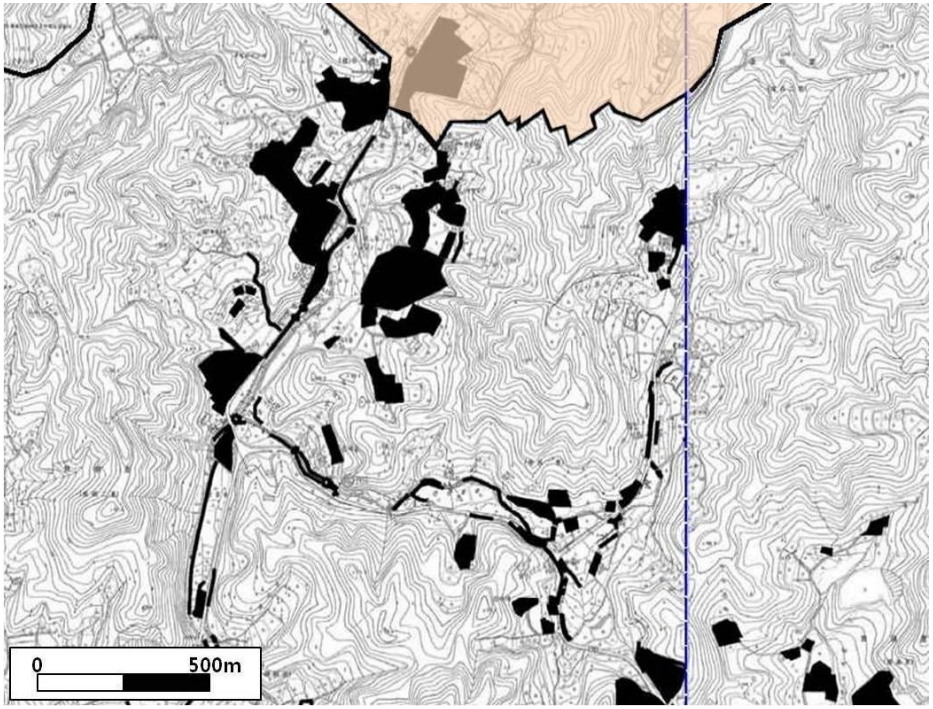
Confirmed conditions by satellite, road view, geographical map and field mapping.

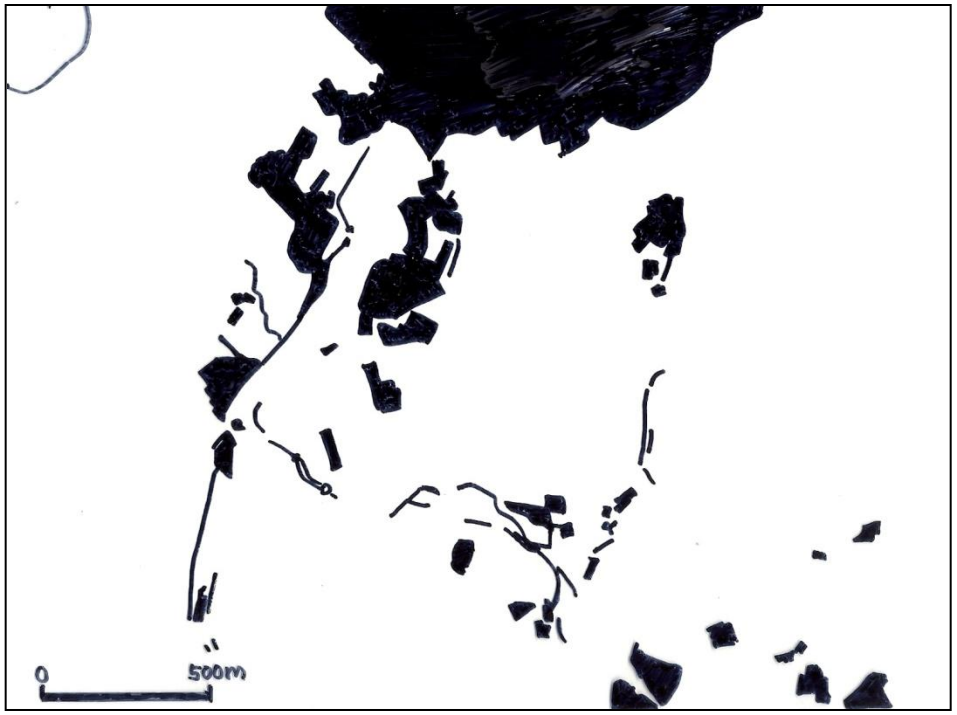
Linear barriers such as wire-mesh wall, concrete retaining wall could not be easily recognized in airborne data, but in the field.

Source : 웹사이트 http://www.map.naver.com

2. Geographic Barriers (Topographic Obstacles) and Changes in Travelling Probabilities of Animals

Geographical Barrier Map

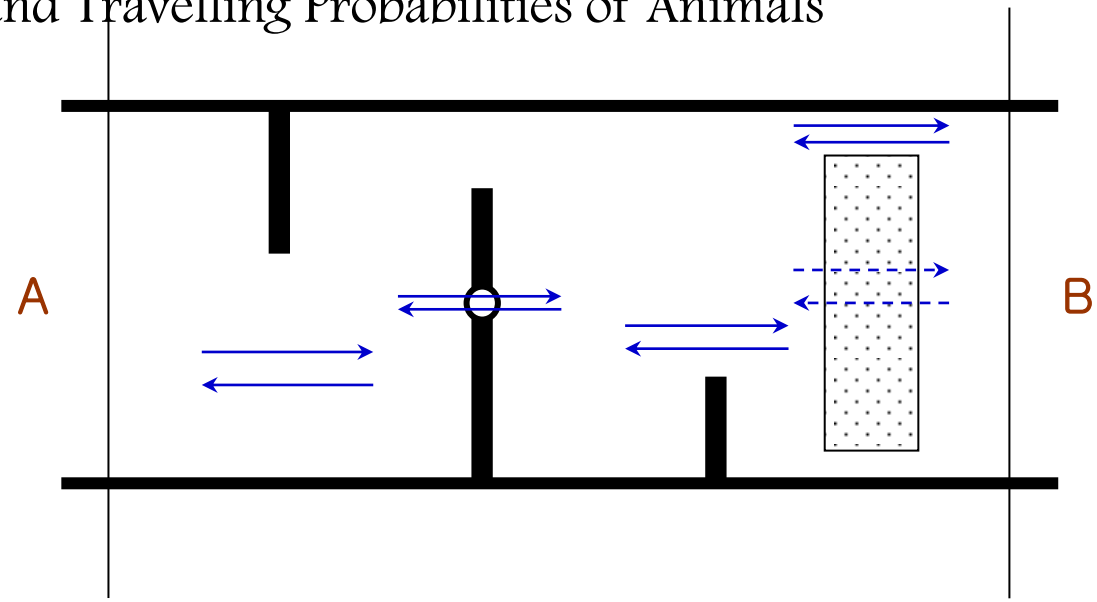




Source : 김지영 외(2014) 육상풍력 개발사업 지형변화지수 연구.

2. Geographic Barriers (Topographic Obstacles) and Changes in Travelling Probabilities of Animals

Permeability and Travelling Probabilities of Animals



Permeability can be defined as property of a material (media) to allow fluids to pass through it.

Permeability (in spatial and transport planning) is define as 'Extent to which urban-forms (e.g.. City) permit (or restrict) movement of people or vehicles in different directions

Permeability in ecology refer to 'Travelling Probability'

Travelling Probability is related to surface condition, slope, presence of obstacles, water body, etc.

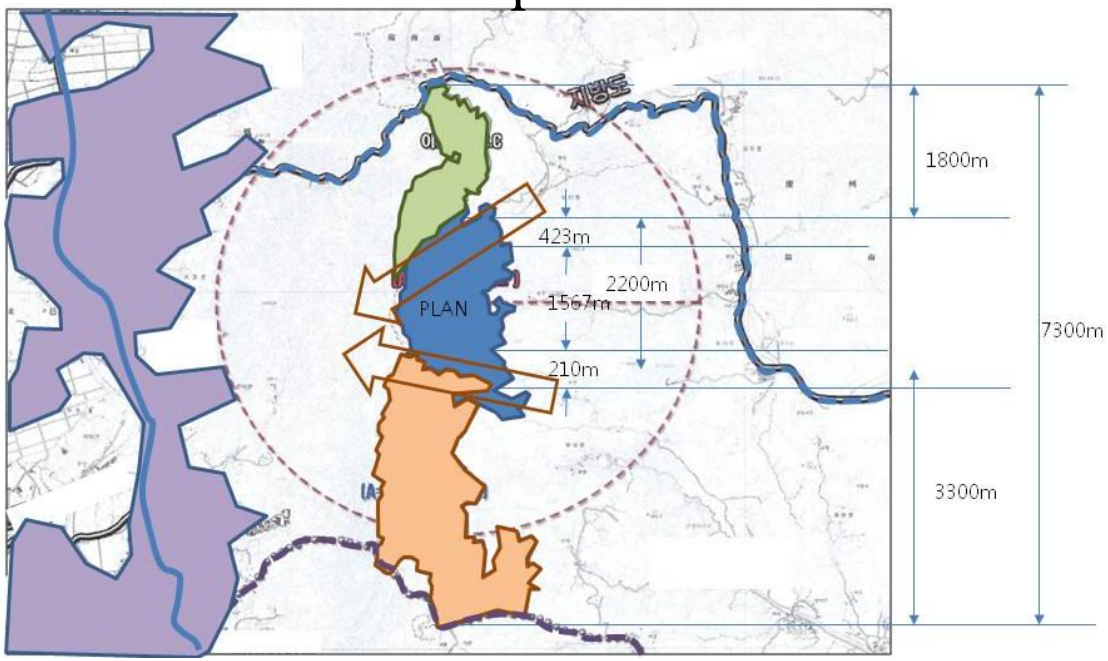
Source : Kim et al.(2013), Wikipedia

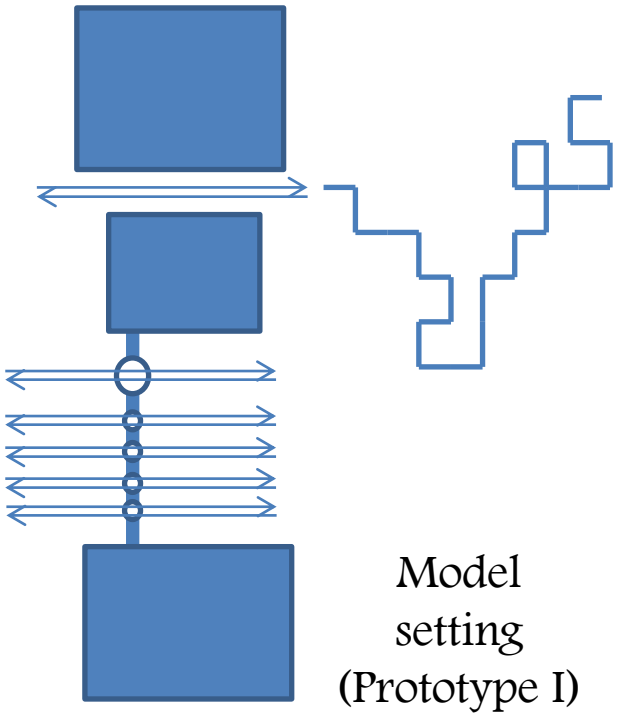
2. Geographic Barriers (Topographic Obstacles) and Changes in Travelling Probabilities of Animals

Ecological fragmentation (Central part of South Korea)
Travelling probabilities of animal movement has reduced by expressways, major roads and developed area.

Geographical Barriers
Dotted area :
Urban area,
Golf courses,
Reservoirs
Lines :
Expressways
Major roads

3. Case Ⅰ : E-W disconnection of topographic corridor (path) and its impacts





Model setting (Prototype I)

Additional planning (center, blue) will bring complete blockage of E-W topographic corridor

<Mitigation>

- Securing corridors to mitigate blockage impacts (shown as two arrows in left map)
- Construction of several ecological corridors across road (circle in the right diagram)

<Effectiveness of the mitigation>

- Simulation result suggests travelling probability will be **reduced to 22%** compared to present state

Source : Kim et al.(2013)

3. Case Ⅰ : E-W disconnection of topographic corridor (path) and its impacts

Changes in Permability
Random Walker Simulation Results

- Present state before project implementation : 30.1% (Permability)
- First planning in SEIA(maximize planning resulting in total blockage of corridor) : 0% (Permability)
- Reduced to 0% compared to present state
- Revised planning : 8.7% (Permability)

Reduced to 29% compared to present state

- Cumulative impacts of area planning and road construction :

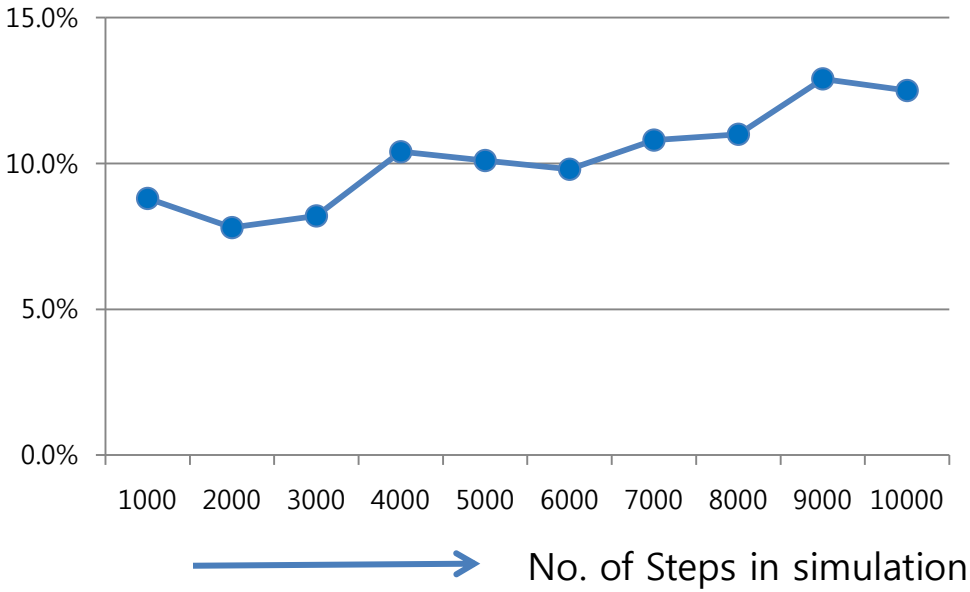
6.5% (Permability)

Reduced to **22%** compared to present state

Source : Kim et al.(2013)

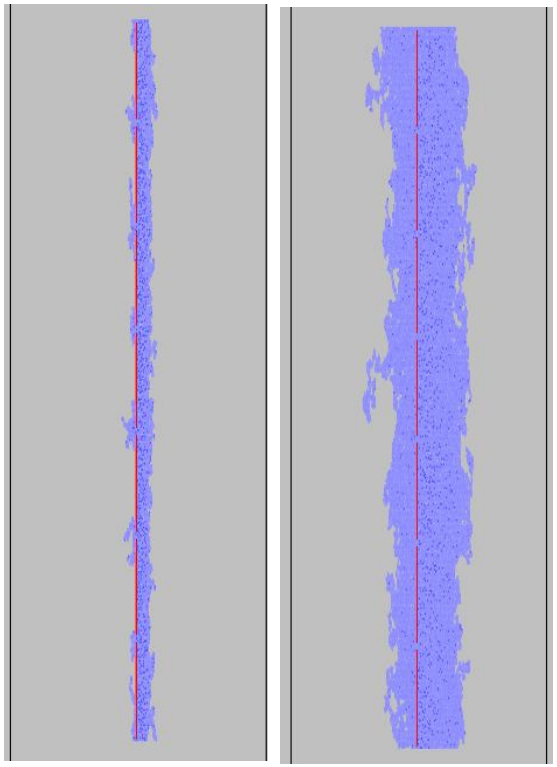
4. Case Ⅱ : Travelling probabilities across road through corridors

Relation between Travelling probability and Intervals of ecological corridor across expressway



Steps	Travelling probability
1,000	8.8%
2,000	7.8%
3,000	8.2%
4,000	10.4%
5,000	10.1%
6,000	9.8%
7,000	10.8%
8,000	11.0%
9,000	12.9%
10,000	12.5%

Prototype I



1,000 steps　　10,000 steps

Corridor interval :100m , Width of each corridor : 4m

Number of corridors : 8 , Width of road : 10m

Geometrical openness : 4.3%

Travelling prabability :

9~13%

Source : Kim et al.(2013)

5. Case Ⅲ : Locating strategy of inland windfarm complex

Interval length between naighbouring windfarm complexes

Dimension of access & management road is oversized than expected.

Length and width of carrying vehicle : 40~50m, 6m

Management road and windturbine sites produce lengthy obstacles within well-preserved zone at the center of mountain region

Assume :

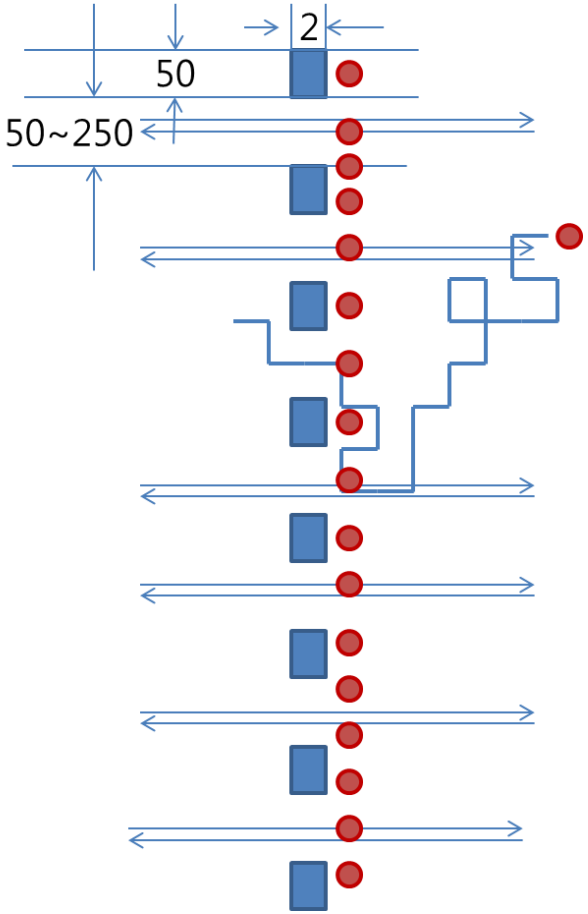
Total length of road and turbine units : 5km (Unit L)

Total capacity of of each windfarm complex : 50MW (2MW x 25 trubines)

Credit capacity : 25% (e.g. total electricity produced by 50MW windfarm complex can be regarded as conventional electricity capacity of 12.5MW)

Total length of mountain ridges :; 100km

Model setting :
Inland windfarm complexes
Prototype I



Source : Kim et al.(2014)

5. Case Ⅲ : Locating strategy of inland windfarm complex

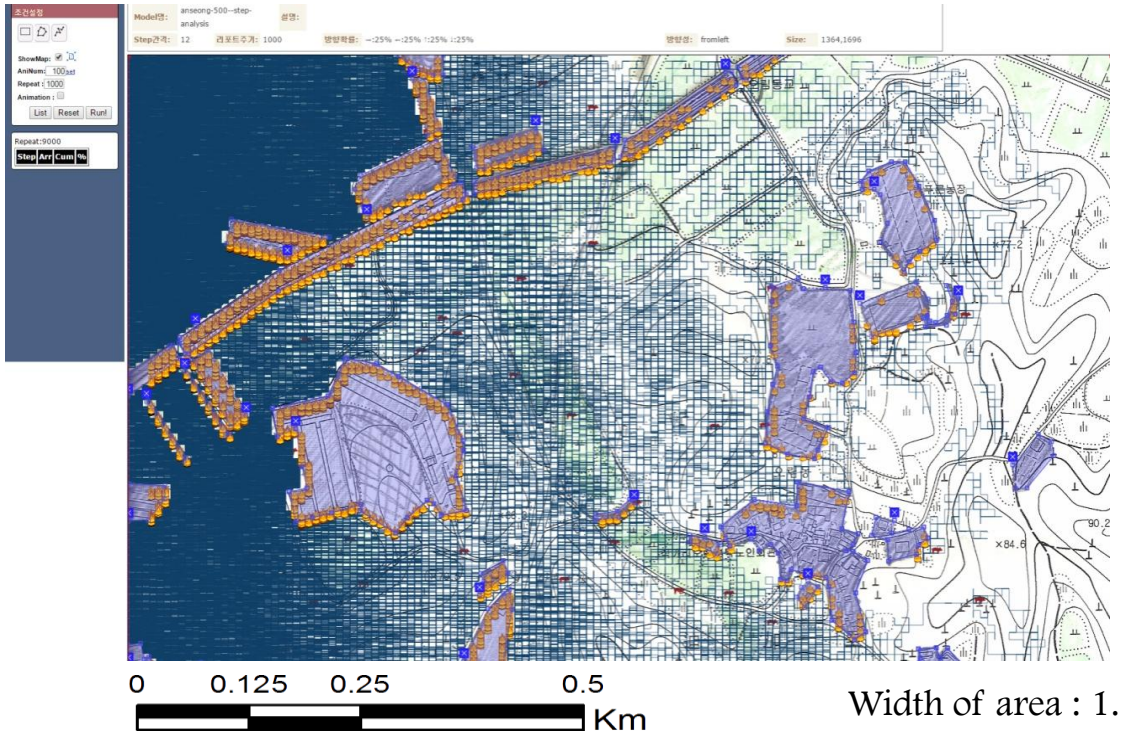
Open space (interval length) and real production of electricity (Prototype I)

Interval length beween neighbouring windfarm complexes (L : Unit length of complexes)		Maximul installed capacity	Real production capacity (credit capacity 25%)	Relative electricity production (%)	Estimated travelling probability (%)
1L	5km	538MW	134.6MW	285%	64%
	6km	493MW	123.2MW	260%	68%
	9km	393MW	98.3MW	208%	72%
2L	10km	368MW	92.1MW	195%	76%
3L	15km	280MW	70.0MW	148%	79%
5L	25km	189MW	47.3MW	100%	87%

L : Unit length of 1 windfarm complexe, includes of management road and 25 wind turbines.

Source : Kim et al.(2014)

6. Case Ⅳ : Simulation of animal movement(Prototype Ⅱ)



Width of area : 1.1km

Able to adopt complex shaped objects.

Flexible setting of starting point or line line, ending point or line.

Use of image map such as airborne photo as a reference map.

Easy setting of obstacles by clicking mouse on monitor screen.

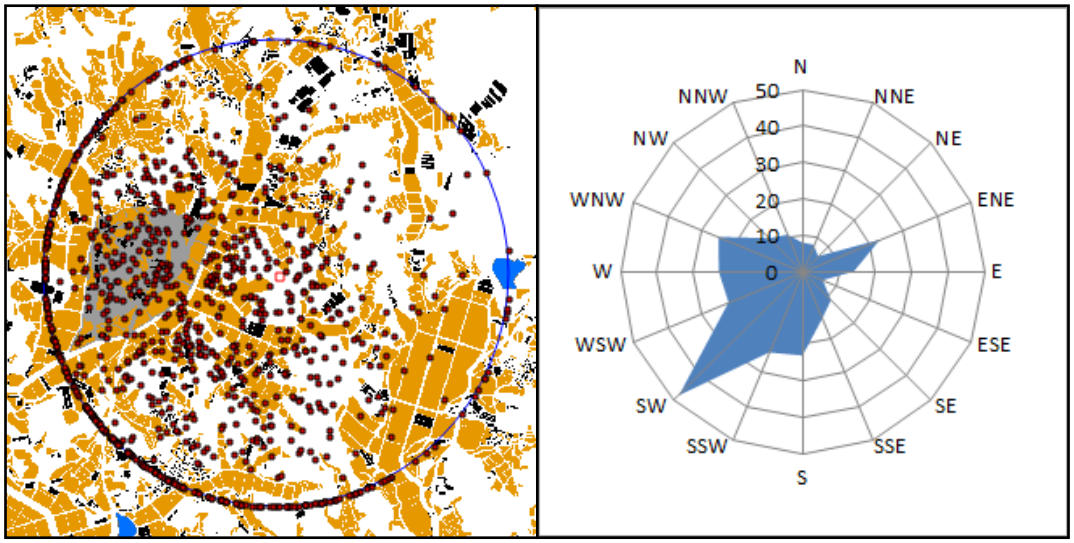
Step size adjustable and data results exportable to spreadsheet.

Web-based operation brought remarkable slowdown.

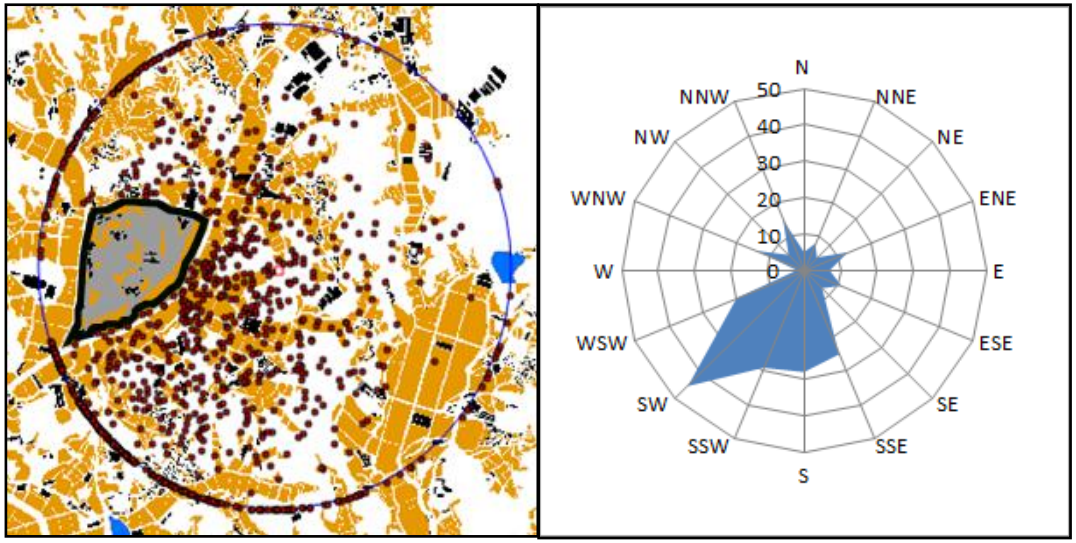
Source : Kim et al, (2014)

7. EN (Ecological Network) Simulator

Present state
Before
project implementation

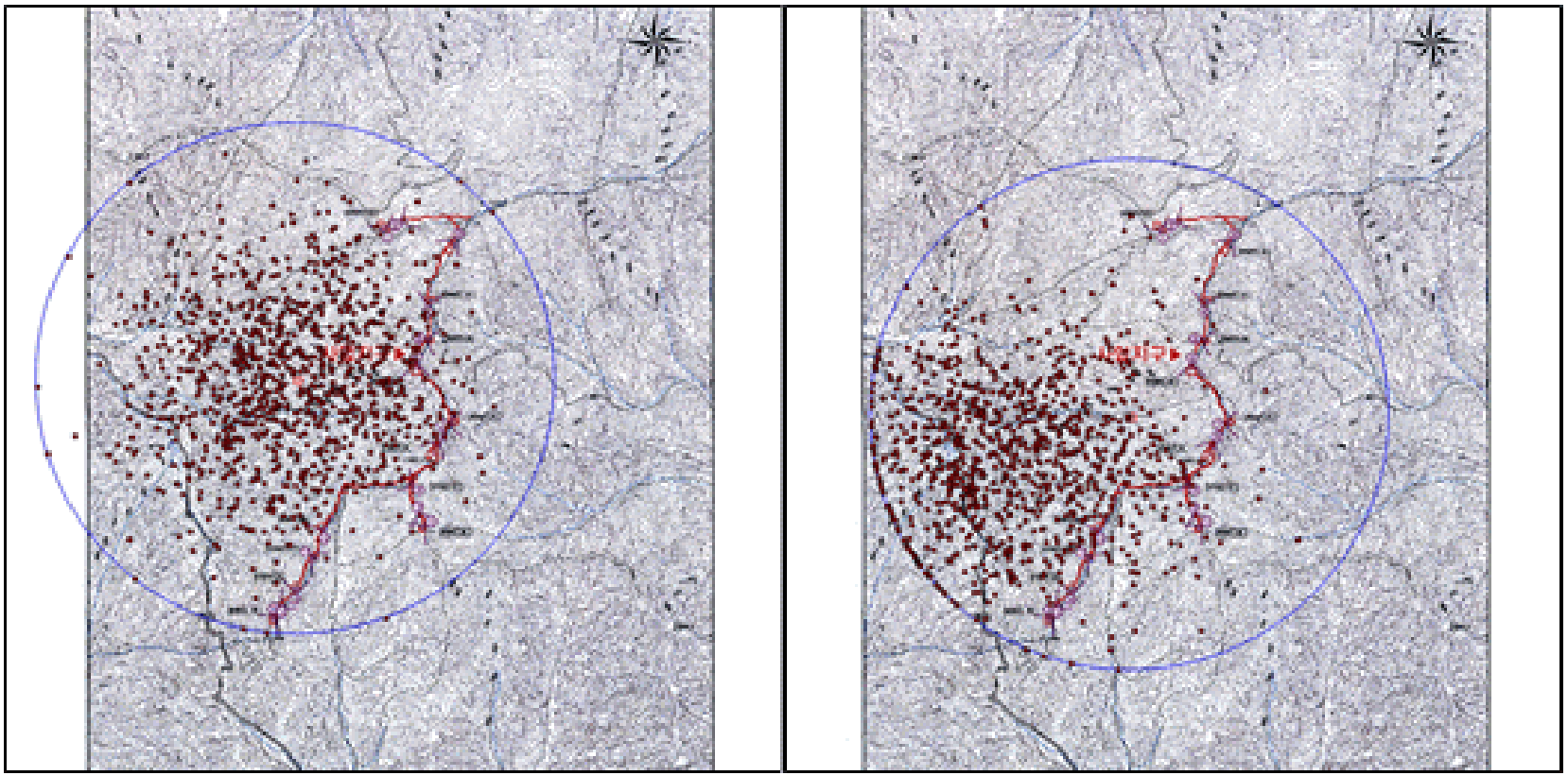


Simulated state
After
project implementation



Source : Kim et al.(2015)

Consideration slope factors : steeper surface, harder to move

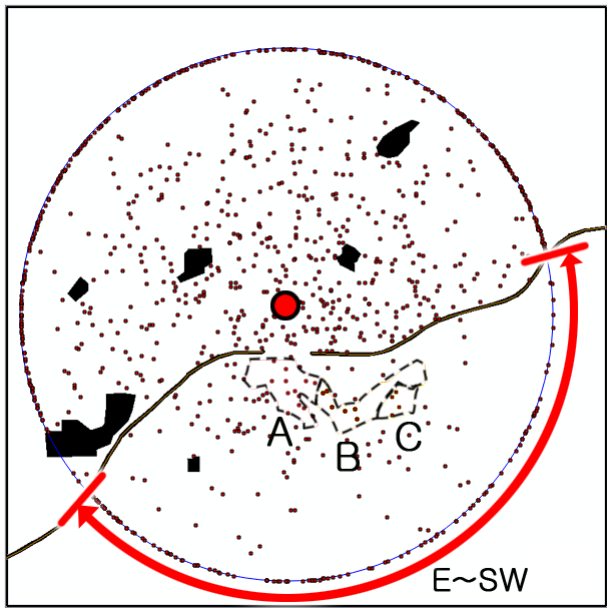


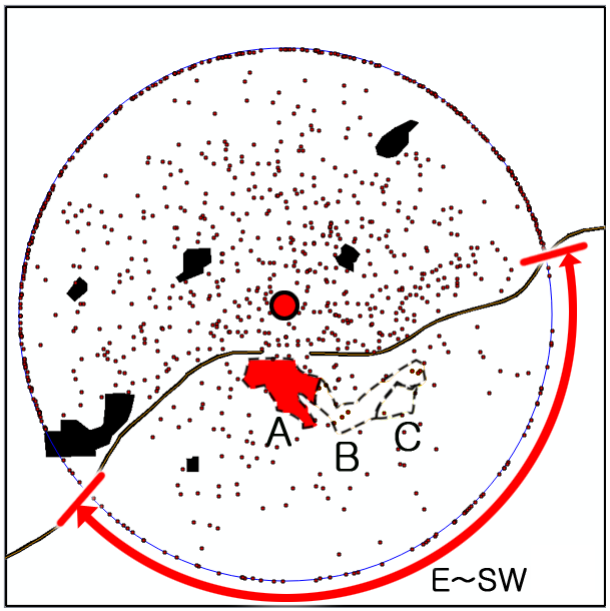
Slope factor excluded

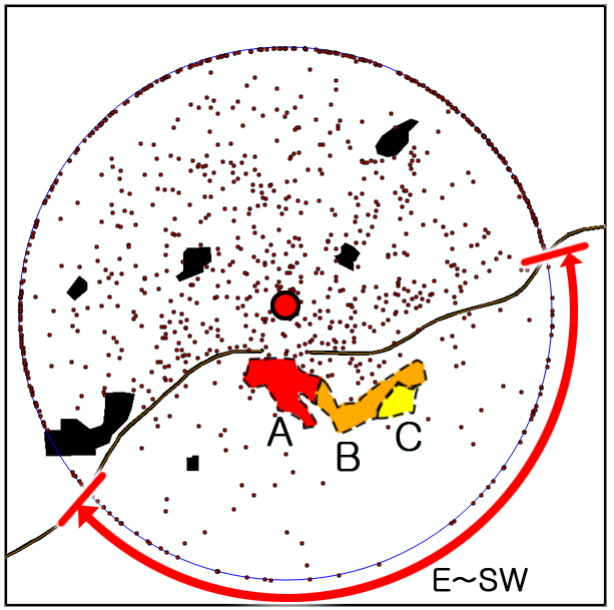
Slope factor involved

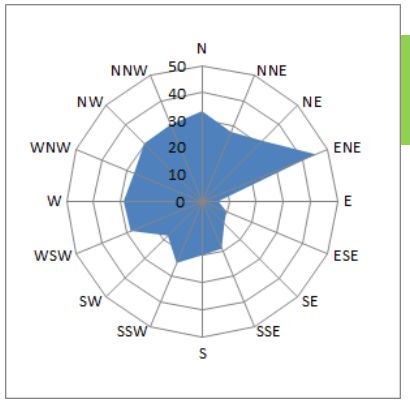
8. Case Ⅴ: Project that obstruct existing animal path

EN (Ecological Network) Simulator

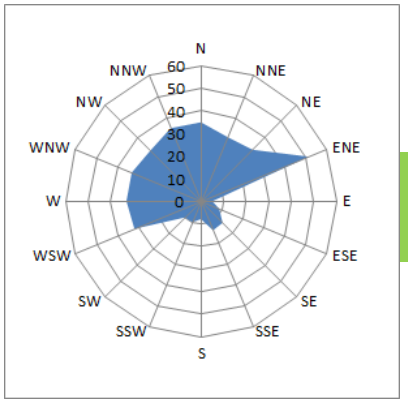




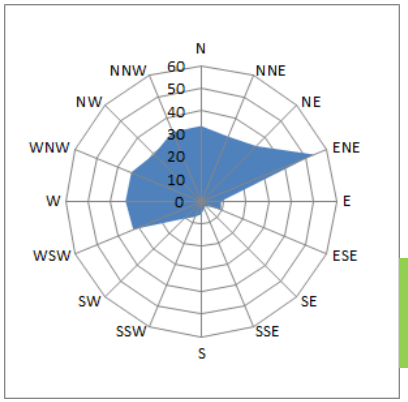




100%



64%



46%

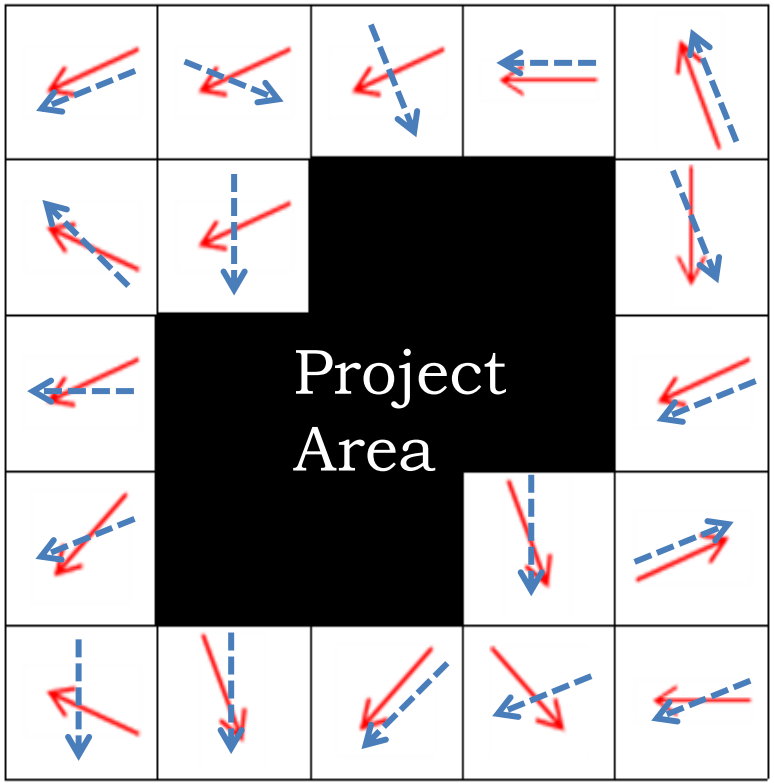
Present state 11%

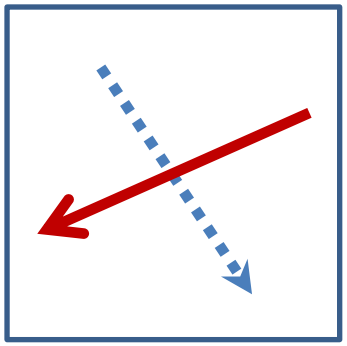
After A project 7%

After A, B, C project 5.1%

9. Case Ⅵ: EN (Ecological Network) Simulator

Path Direction Analysis





Change of
Movement direction

After project

Movement direction

Before project

9. Case Ⅵ: EN (Ecological Network) Simulator

Permeability Analysis

Analysis of permeability of each grid cell

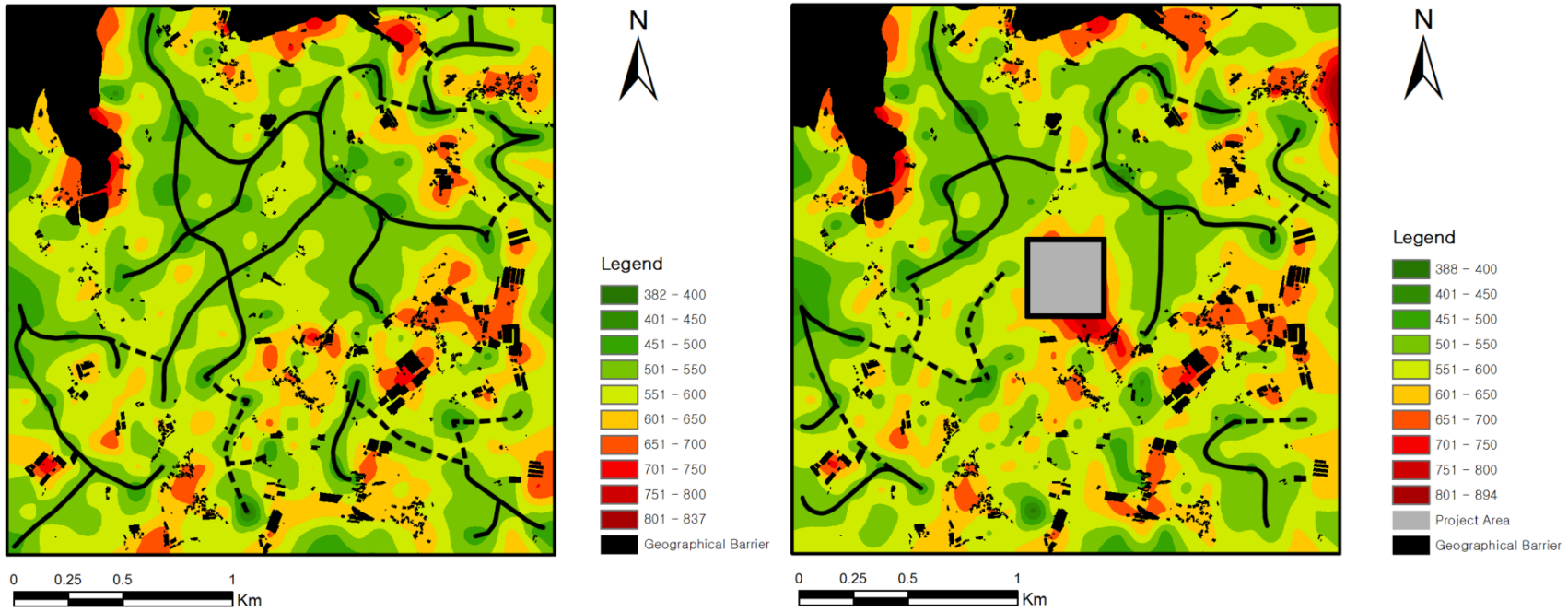
Count random walkers which remain within a given circle

Simulations of each grids before and after project implementation

Build equi-count curves.

Compose **moving path networks** before and after project implementation

The results suggests **broken paths** after project implementation by comparing



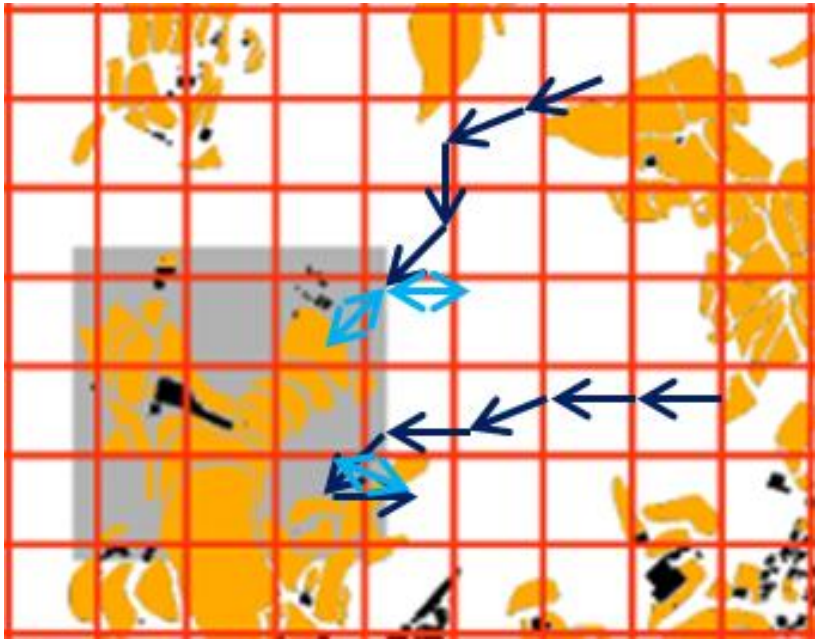
Source : Kim et al.(2015)

9. Case Ⅵ: EN (Ecological Network) Simulator

Path Tracing

Tracing most preferable moving direction and following the trends of each successive simulation results.

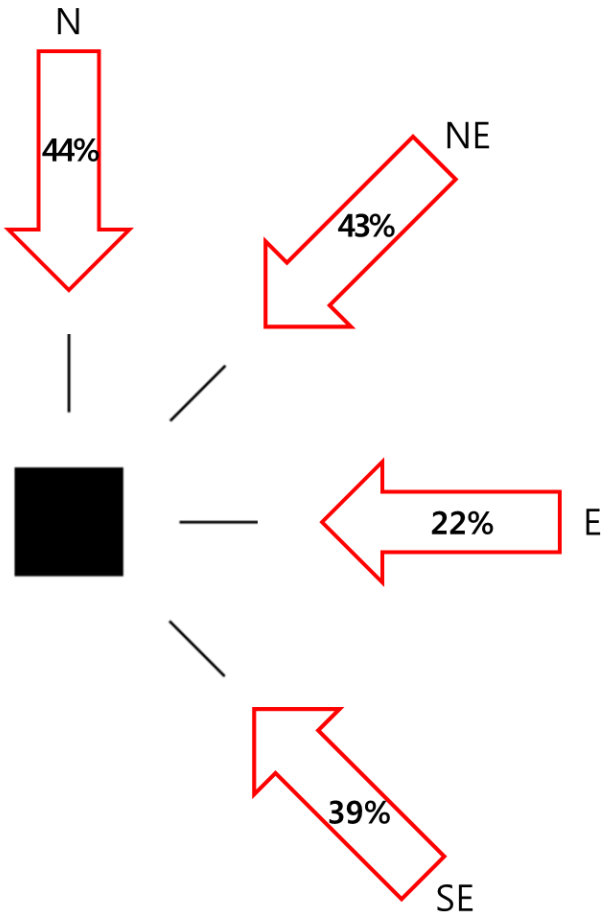
- Starting simulation from a point.
- Deciding major moving direction from simulation result.
- Moving to the direction and start again.
- Following the simulation results to move.



Source : Kim et al.(2015)

9. Case Ⅵ: EN (Ecological Network) Simulator

Permeability Analysis (Change in Permeability)



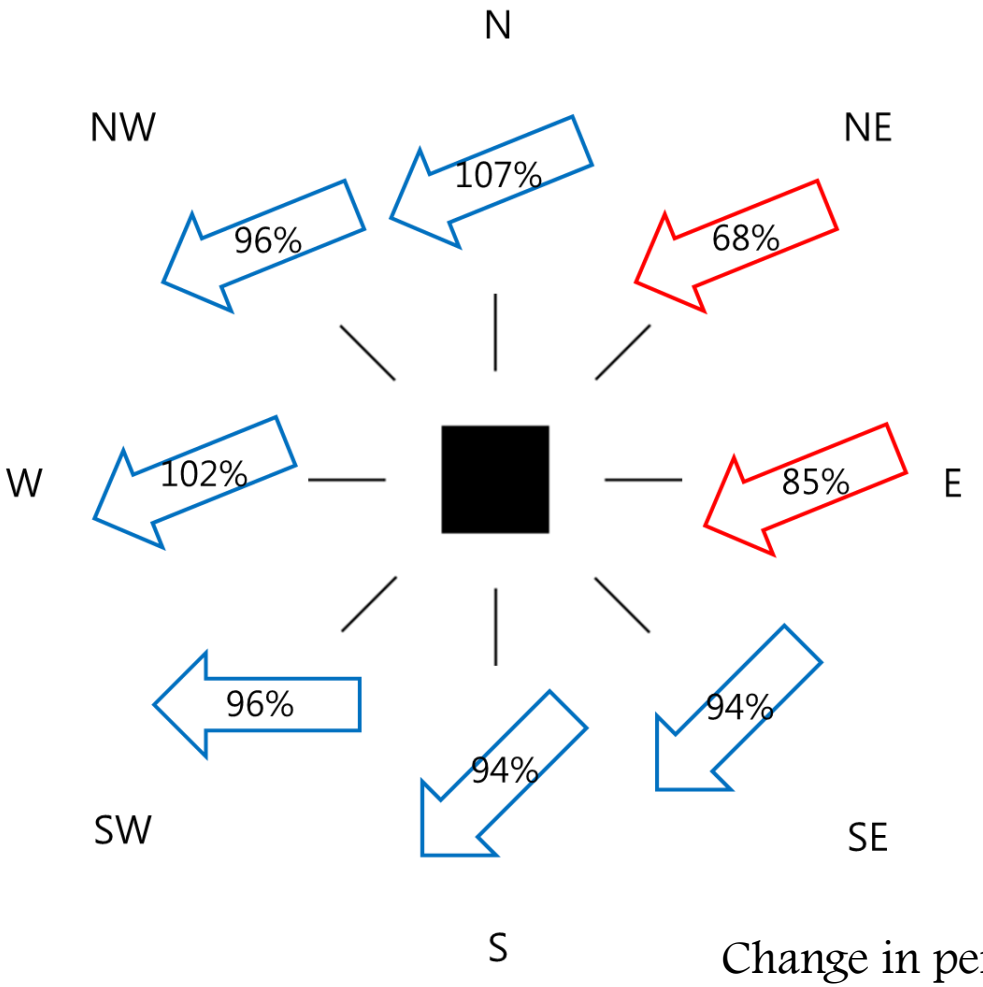
Change in permeability (travelling probability)
To the direction toward project site
(Percentage of After/Before)

- Permeability of movement toward project site reduced to 36% compared to present state.
- Where major moving direction was toward project site, their reducing rate **22~44%** compared to present state.

Source : Kmi et al.(20165

9. Case Ⅵ: EN (Ecological Network) Simulator

Permeability Analysis (Change in Permeability)



- Permeability toward major movement direction reduced to 91% at all the surrounding position
- Where major moving direction is similar to the direction toward project site (E, NE), permeability reduced to 85 and 68% compared to present state
- Where major moving direction is different to the direction toward project site, some results shows increase in permeability (102%, 107%).

Change in permeability(travelling probability)
and Major moving direction
At the major moving direction
(Percentage of After/Before)

Source : Kim et.al.(2015)

10. Conclusion

- **Random Walker** adopts an imaginary moving character for simulation
- Movement of water deer is considered as a reference to constitute simulation program in this study.
- Comparison between

  Recorded paths of animals

  and **Simulation results**

  will be accomplished to validate the EN Simulator

Source : Photo : Internet

10. Conclusion

- Useful tool for assessing magnitute of impacts on ecological breakage or connectivity due to project implementation by providing quantifiable figures.
- The results can be used as a tol for relative measures for various alternatives of project proposal
- The results are also applicable to locating strategy, SEA, measuring mitigation effectiveness
- Random Walker Simulator is able to provide hypothetical prediction methods and are useful for EIA purpose.

Source : Photo : Internet

THANK YOU

ご静聴、ありがとうございました

감사합니다

한국환경정책·평가연구원
Korea Environment Institute