EGU General Assembly 2022

The impact of land-use change on multi-species using incidence function model

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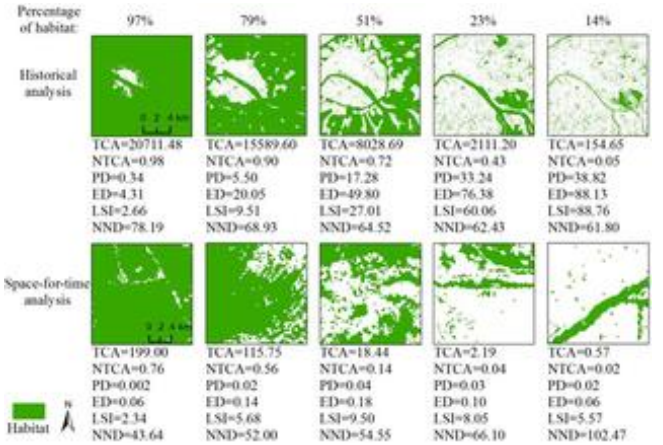
Background

- **Urbanization tends to decrease habitat amount and increase habitat fragmentation simultaneously over time**
- **Specifically, as habitat loss continues, mean patch size, total core area, and cohesion of habitats decrease, while patch density, edge density, as well as shape complexity, all increase.**

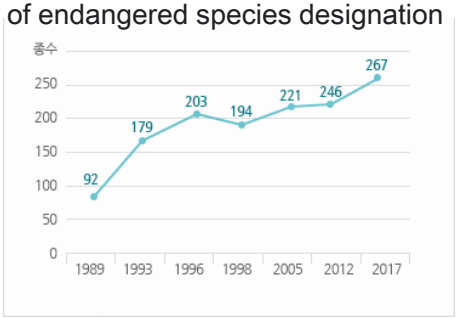


Liu et al., 2016

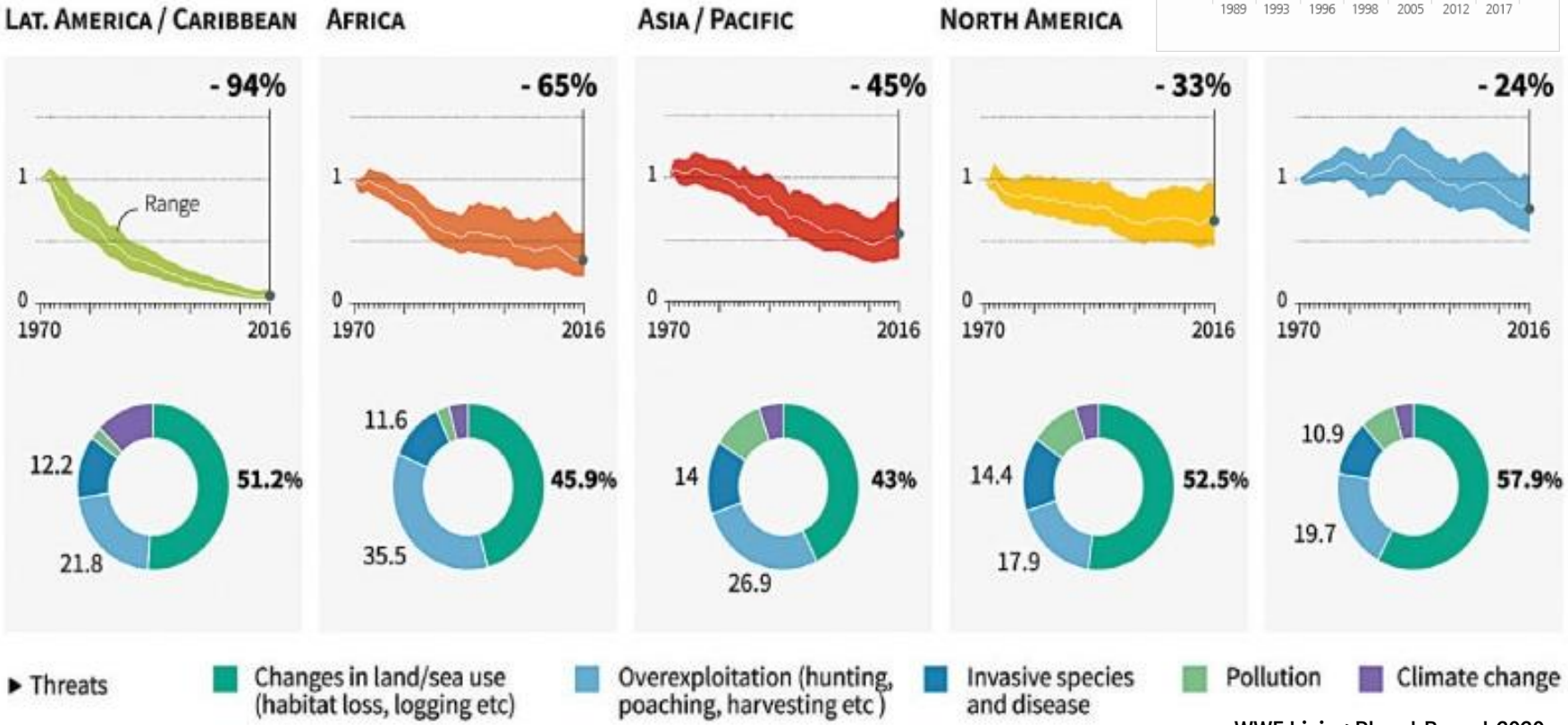
Background

- Increasing number of endangered species designation
- Declining biodiversity in suitability habitat

Number of endangered species designation



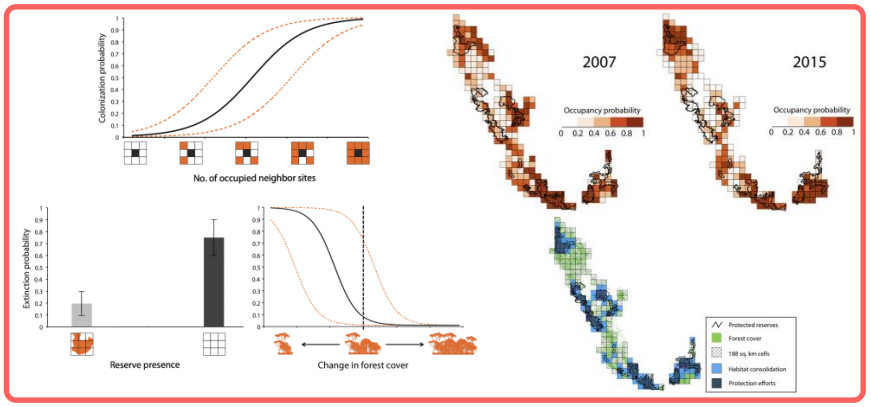
Declining state of biodiversity



WWF Living Planet Report 2020

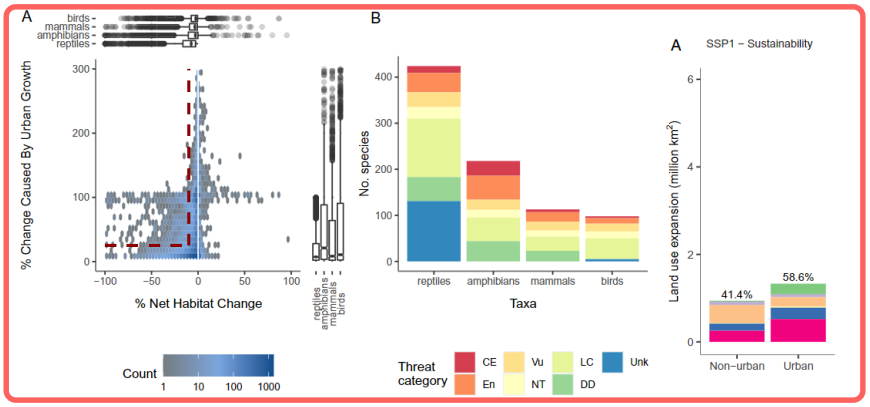
Previous Studies

- Analysis of the impact of human activities and urban development on biodiversity and species population



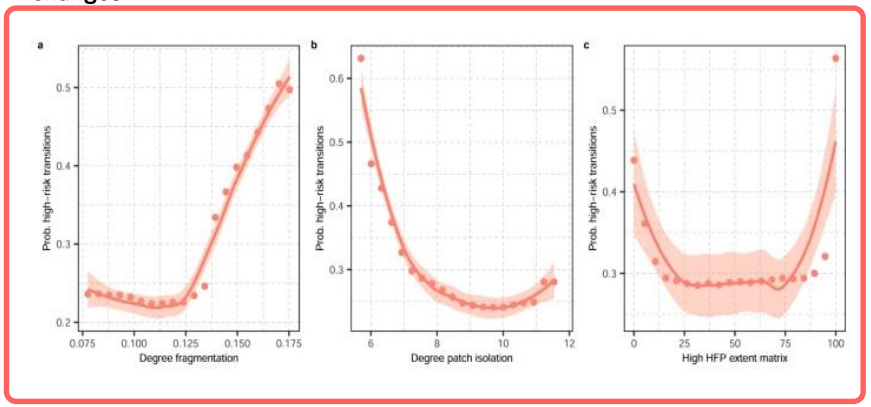
A.Srivathsa et al., 2019. nature

Analysis of occupied patch and colonization according to forest cover changes



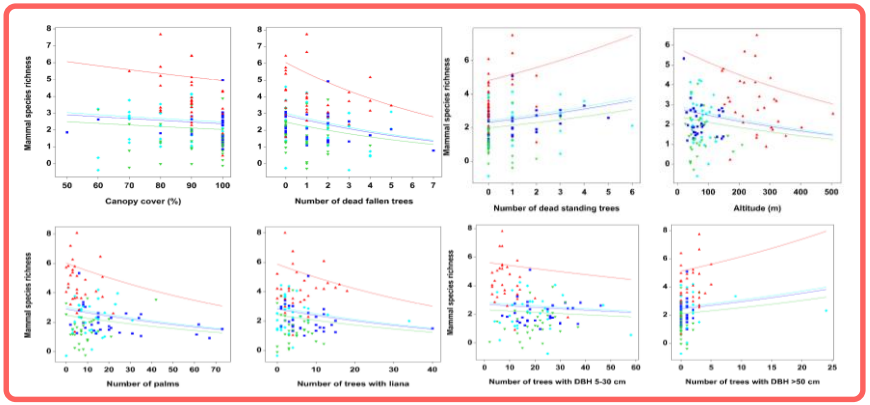
R.Simkin et al., 2022, PNAS

Analysis of impact on endangered species according to Urban, Non–urban area



J. Delgado et al.,2022. nature

Valiability of species' s extinction on Habitat fragmentation, isolation

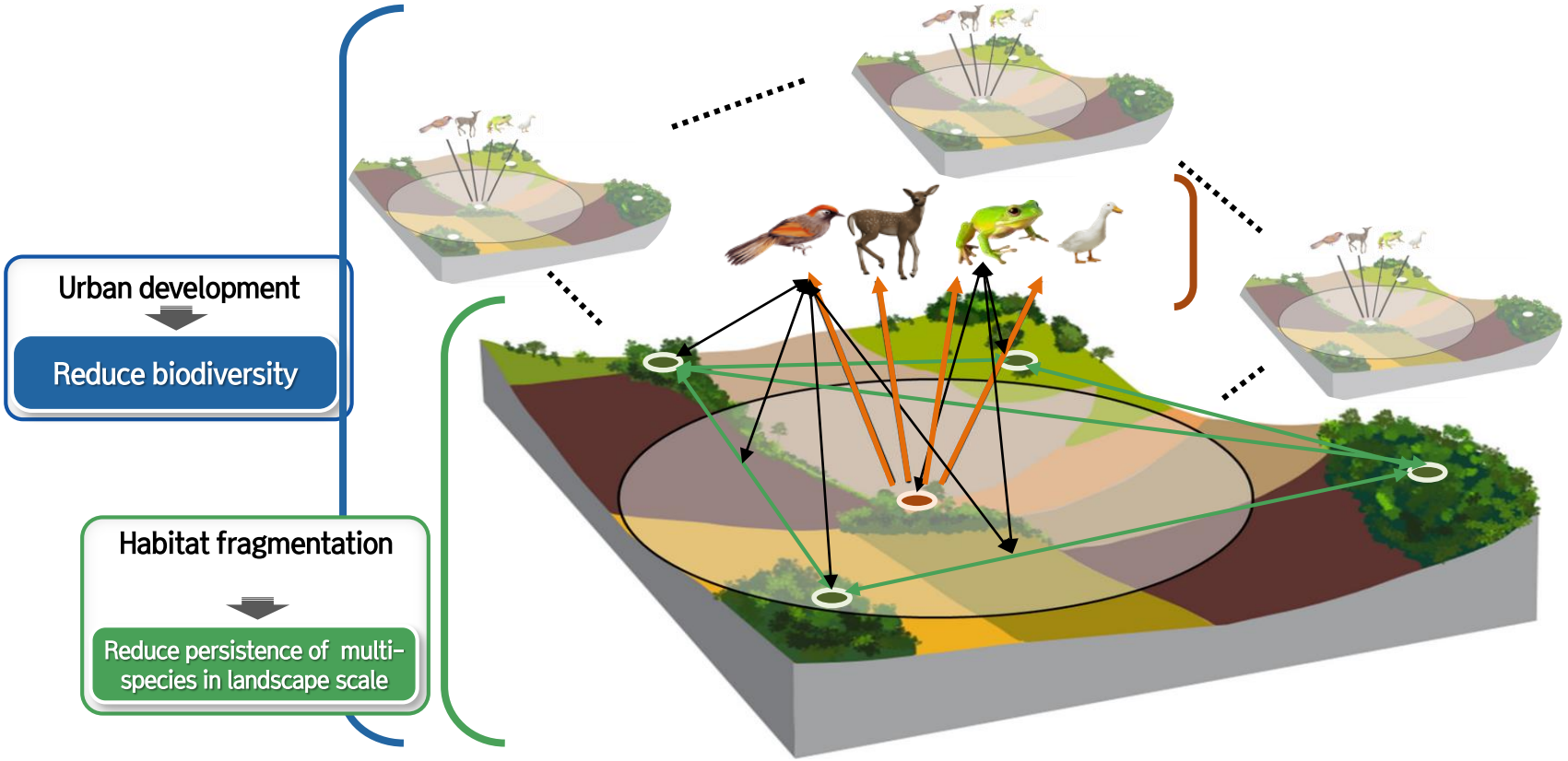


S.Liza et al.,2018. Ecology and Evolution

Forest factor(canopy cover, dead fallen trees, DBH) affected species richness

Background

- Reduction of biodiversity and leads to fragmentation of ecological land due to development projects
- Increasingly it is recognised that an understanding of landscape pattern and process is necessary to identify the impacts of land-use change on species
- A site-based approach to EcIA is argued to be insufficient (Mörtberg et al., 2007).



Research Aim

Research aim

- we aim to develop method of estimating persistence of multi-species using species distribution model in landscape scale which are comparable between landscapes.

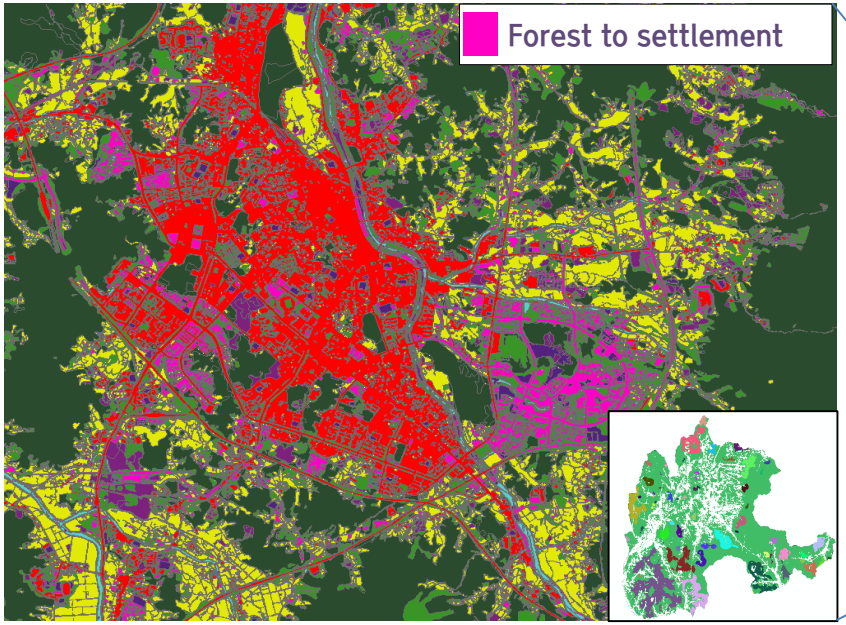
Research question ?

- Are the multi-speices impacts of urban development different?
- which species need additional protection except for the endangered species reported by IUCN?

Study site

- Location : wonju, republic of korea
- Area : 872.56 km²

- Recently, Wonju was selected as an innovative city and urban development is being actively carried out.



Class	2013	2021	change rate
Settlement	4667.33	5223.069	-11.906998(%)
Agriculture	14288.83	9447.704	33.8805023
Forest	61494	58621.53	4.67115287
Grass	2426.854	8799.178	-262.575481
Bare	693.6041	1496.913	-115.816691
Wetland	1798.153	3108.062	-72.8475043
Water	1337.278	0.291122	99.9782303

Research flow

Species occurrence data

Environmental data

2013, 2014 year data

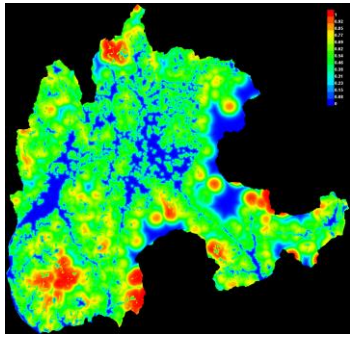
GBIF
VerNet
BISON
Naturing
Ebird
Bird traking

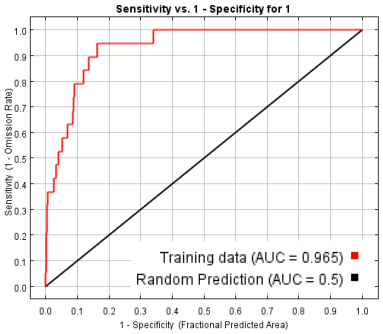
1	2	3	4	5	6	7	8	9	10
Land	Plant				terrain				
Land cover	Forest class	Age class	DBH	Density of forest	Aspect	Dem	Hillshade	Slope	TWI
11	12	13	14	15	16	17			
Distance						Bioclimatic			
distance to forest edge	distance to water	distance to agriculture	distance to grass	distance to road	distacne to urban	bio1~bio19			

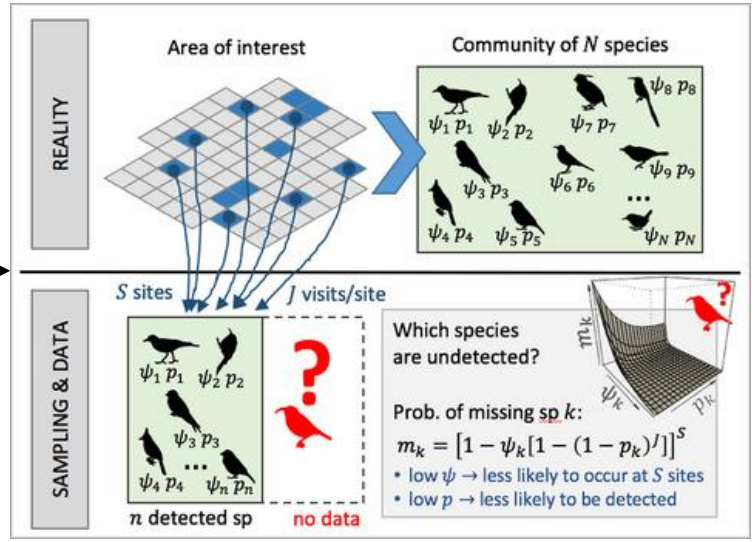
Species Distribution Model

Thersold

Suitability of Habitat







Hanski, 1996

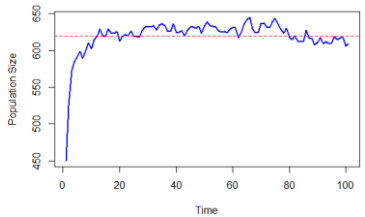
$$J_i = \frac{C_i}{C_i + E_i - C_i E_i}$$

$$E_i = \frac{e}{A_i^x}, \quad \text{for } A \geq e^{1/x}$$

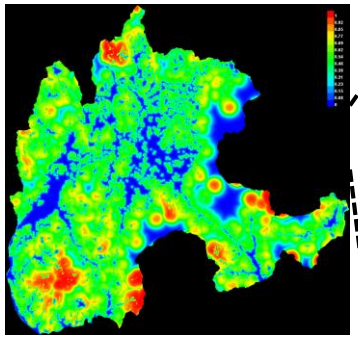
$$M_i = \beta S = \beta \sum_{j \neq i}^{R} \exp(-\alpha d_{ij}) p_j A_j$$

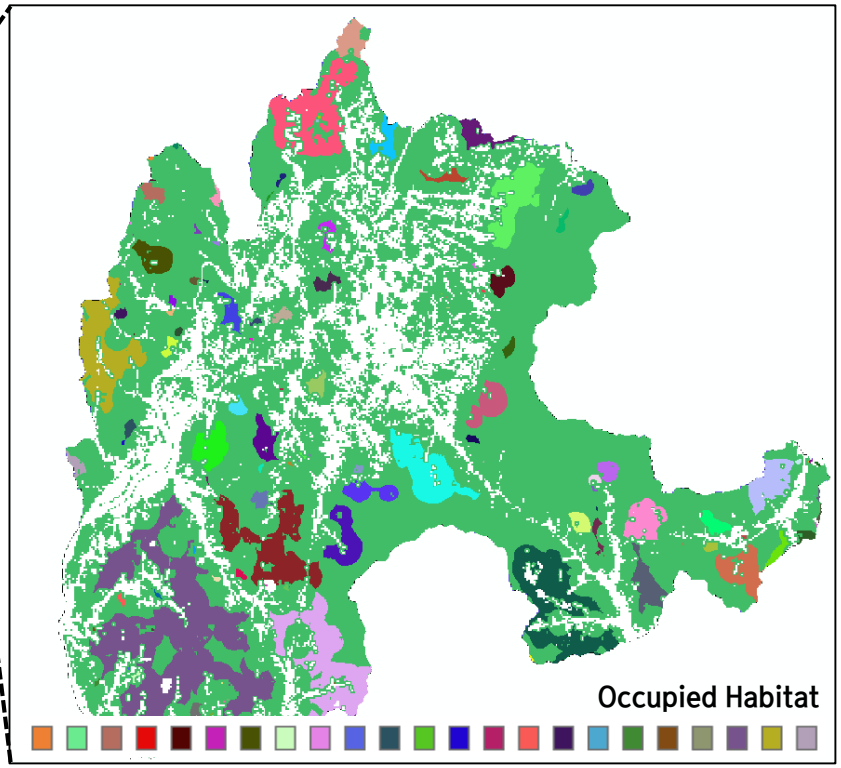
$$C_i = \frac{M_i^2}{M_i^2 + y^2} = \frac{S_i^2}{S_i^2 + y}, \quad \text{where } y \text{ absorps } \beta$$

$$J_i = \frac{S_i^2 A_i^x}{S_i^2 A_i^x + ey} = \frac{1}{1 + \frac{ey}{S_i^2 A_i^x}} = \left[1 + \frac{ey}{S_i^2 A_i^x}\right]^{-1}$$

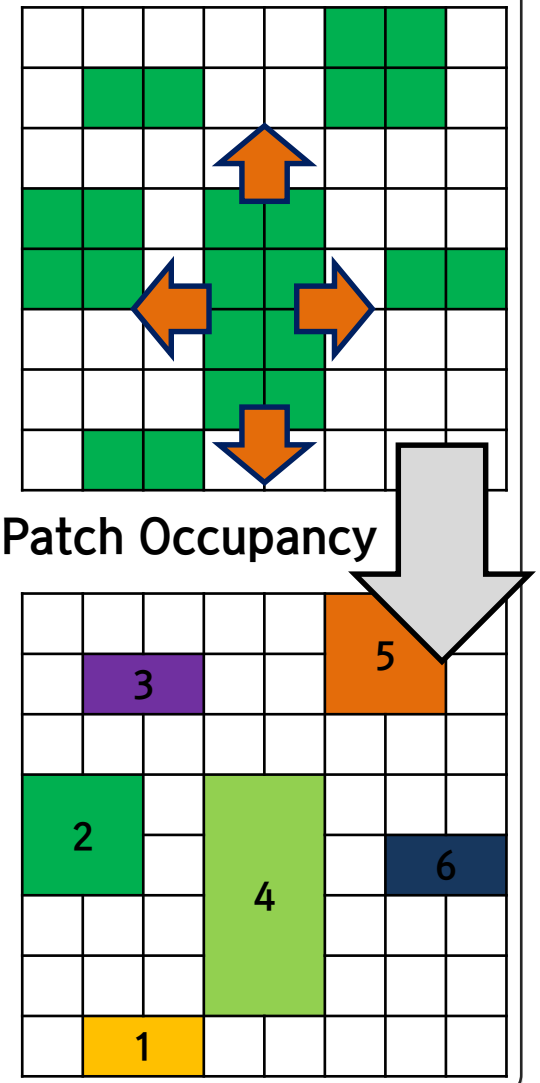


How to make occupied and empty habitat





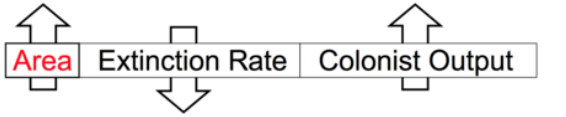
- Map of species distribution model
- Threshold 〉0.8
- Finding adjacent cell

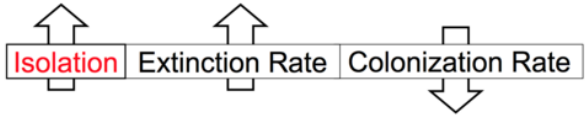


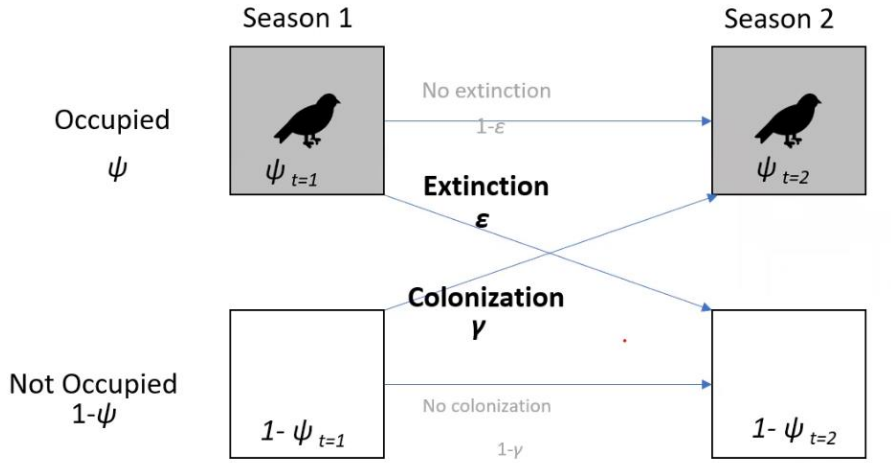
Incidence function model (IFM)

Incidence function model(IFM)

- Spatially realistic metapopulation model
- Low data requirements
- Urban landsacpes are fragmented







Model parameters

$\psi_{t=1}$:Initial occupancy (at season 1)

ε: Extinction probability(1→0)

γ: Colonization probability (0→1)

Derived parameters

- Second season occupancy(in season 2)

$\psi_{t=2} = \psi_{t=1} x(1- \varepsilon)+(1- \psi_{t=1})x\ \gamma$

- Trend(Rate of change in occupancy)

$\psi_{t=2} / \psi_{t=1}$

Results

- **Model simulation** (The mean and standard deviations for these parameters)

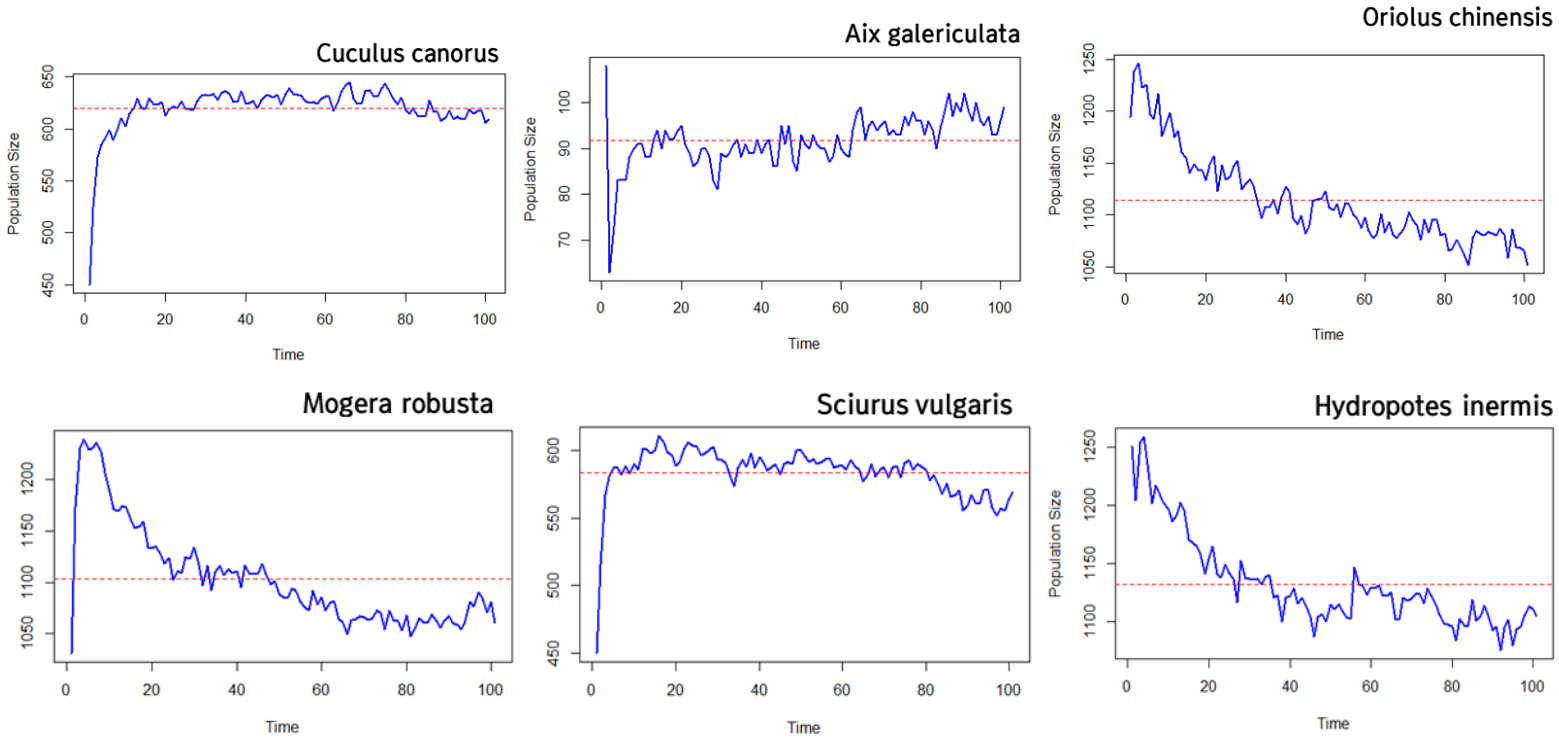
- Estimation of 100 sets of parameters *x*, *u* and *y* using logistic regression
- The model was well fitting for all species (pseudo-R^2 > 0.83) except for C. *micropterus* (pseudo-R^2 = 0.47).

Speices	Mean parameter values(SD)			Nagelkerke Pseudo-R^2(SD)
	x	u	y	
Cuculus canorus	1.76(0.005)	10.42(1.79)	206.1(31.1)	0.97(0.00)
Tamias sibiricus	1.31(0.008)	0.5(0.03)	4352.5(46.2)	0.96(0.01)
Cuculus micropterus	1.08(0.046)	0.54(0.18)	3754.1(586.9)	0.92(0.02)
Oriolus chinensis	0.95(0.068)	0.55(0.06)	2280.1(130.1)	0.41(0.03)
Hydropotes inermis	0.42(0.032)	0.14(0.01)	87.6(4.5)	0.84(0.00)
Mogera robusta	0.99(0.019)	0.09(0.02)	1733.1(104.2)	0.94(0.01)
Aix galericulata	0.23(0.035)	0.23(0.06)	33.3(2.0)	0.77(0.02)
Sciurus vulgaris	1.67(0.090)	8.50(0.83)	274.2(40.2)	0.92(0.00)

Results

- Impact of development on species

  - Persistence of specifications appeared differently according to urban development.
  - C. canorus, A. galericulata, and S.vulgaris were not significantly affected by urban development, but other species had dramatically reduced population rates.



Results

- Impact of development on species
  - Minimum occupancy means the total number of habitats in the year with the least occupied habitat after urban development.
  - In other words, this is an indicator that can confirm how much the area where species live decreases.
  - The Survival probability is also an indicator of the possibility of species inhabiting 500 years from now, confirming that all but C.canorus and S.vulgaris are declining.

FID	Species	Persistence measure	% change	
			Current	Post-development
1	Cuculus canorus	Minimum occupancy (ha)	60	2.30
		Survival probability (over 500 years)	0.28	0.80
2	Tamias sibiricus	Minimum occupancy (ha)	3152.22	-0.09
		Survival probability (over 500 years)	1.00	1.00
3	Cuculus micropterus	Minimum occupancy (ha)	3345.21	-0.23
		Survival probability (over 500 years)	1.00	1.00
4	Oriolus chinensis	Minimum occupancy (ha)	4862.21	-0.86
		Survival probability (over 500 years)	1.00	0.30
5	Hydropotes inermis	Minimum occupancy (ha)	5584.20	-1.12
		Survival probability (over 500 years)	1.00	0.64
6	Mogera robusta	Minimum occupancy (ha)	550	+0.12
		Survival probability (over 500 years)	0.30	0.29
7	Aix galericulata	Minimum occupancy (ha)	2286.12	-1.02
		Survival probability (over 500 years)	1.00	0.88
8	Sciurus vulgaris	Minimum occupancy (ha)	40	+1.81
		Survival probability (over 500 years)	0.25	0.66

Discussion & Conclusion

- The species of Tamias sibiricus, Cuculus Micropterus, Oriolus chinensis, Hydropotes inermis, and Aix galericulata decrease with urban development.
- In particular, since the reduction rate of Hydropotes inermis, which is a very rare species worldwide, is more influential than other species, we need to plan for conservation to Hydropotes inermis.

- As a result of a study using the Sdm results, it is necessary to confirm the reliability of the results through a survey.
- However, the framework proposed in this study was validated through the auc value, and it' ll be useful tool to analysis targeting a wide range area.

Conclusion

- We proposed new frame work for estimating the persistence of multi-species using incidence function model in landscape scale.
- Our method has potential to be used to for urban biodiversity and targeting species for conservation
- These method used useful tool to compare relative effects of varying urban development and management scenario
- Speices of Cuculus canorus, Mogera robusta and Sciurus vulgaris increased persistence rate by adapting urban development and move to other habitat with species of high dispersal distance
- But most species of least concerned decreased by developing urban (about11%)
- We also need to pay attention to common species except for endangered species.

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