Potential Distribution of Amphibians with Different Habitat Characteristic in Response to Climate Change in South Korea

생태빅데이터 활용사례

국립생태원 김현우, 이은서

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Introduction

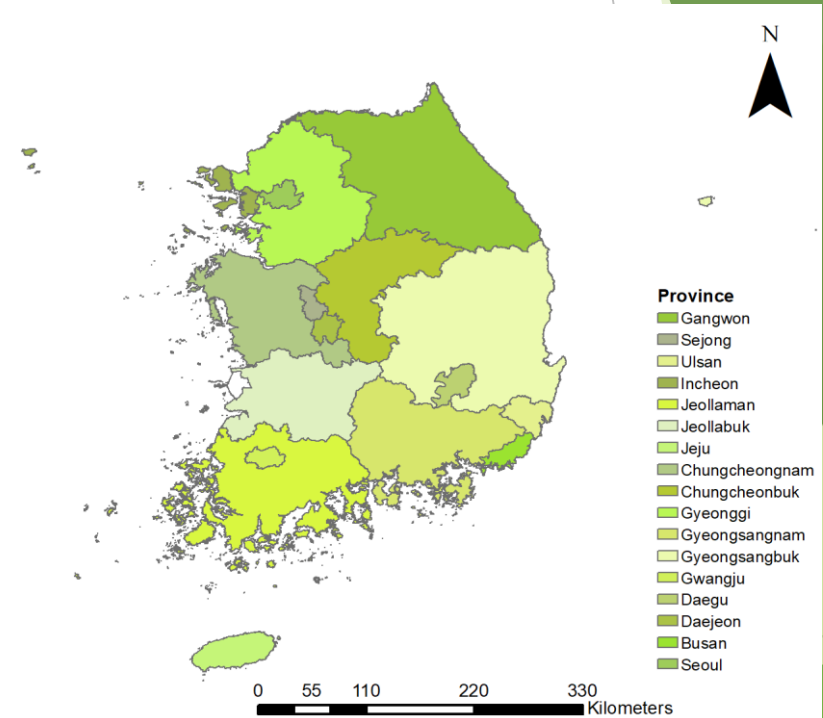- Amphibians
  - Excellent indicators of environmental change
    - Unique biphasic life cycle
    - Highly permeable skin
    - Unshelled eggs
  - Play an important role in various food web
    - Predators for some, and preys for others!
  - One of the most threatened animal groups on Earth.
    - Approximately 50% are threatened with extinction.
  - Reasons for amphibian decline → very complicated.
    - Major reasons: overexploitations and wildlife trade, habitat destruction and fragmentation caused by land cover change, diseases, introduction of alien species, etc.

Introduction

- Climate change: another important factor influencing amphibian decline & extinction, directly and indirectly.
    - Interactions with chytridiomycosis, a fatal fungal disease
    - Ultraviolet-B irradiation due to anthropogenic ozone depletion
    - Spread of invasive species.
- Many Korean researchers have studied on the distribution of amphibian species
    - But almost of them were fragmental, and limited to one or several species.
- Objective
    - To figure out the impacts of climate change on the potential distributions of amphibian species in Korea.

Methodology

▶ Site description

  ▶ The whole South Korean region

▶ Species occurrence data

  ▶ 16 amphibian species in South Korea.

  ▶ Datasets: NES-herptiles, mounted on Environmental Bigdata Platform.

Province
- Gangwon
- Sejong
- Ulsan
- Incheon
- Jeollaman
- Jeollabuk
- Jeju
- Chungcheongnam
- Chungcheonbuk
- Gyeonggi
- Gyeongsangnam
- Gyeongsangbuk
- Gwangju
- Daegu
- Daejeon
- Busan
- Seoul

0   55   110   220   330
Kilometers

Methodology

- Habitat characteristics related to breeding behavior

Groups	Habitat characteristics	Species
Group 1 (Wetland amphibians)	Living wetlands.	*D. japonicus*
		K. borealis
		G. rugosa
		L. catesbeianus
		P. chosenicus
		P. nigromaculata
		R. coreana
Group 2 (Migrating amphibians)	Living upland, but moving to near waterbodies when they are spawning.	*B. orientalis*
		B. gargarizans
		H. leechii
		H. quelpaertensis
		R. uenoi
Group 3 (Forest-dweling amphibians)	Living uplands.	*B. stejnegeri*
		K. koreana
		O. koreanus
		R. huanrenensis

Methodology

- Environmental variables
  - Six dominant bioclimatic variables and altitude.
    - Bio1
    - Bio2
    - Bio3
    - Bio12
    - Bio13
    - Bio14
    - Altitude

Methodology

- Model
  - Maximum Entrophy (MaxEnt) machine learning tool
- Model validation
  - Area under curve (AUC)
  - True skill statistic (TSS)
- Representative Concentration Pathways (RCP)
  - RCP 4.5
  - RCP 8.5

Results and Discussions– model validation

| Family Name	Scientific Name	Common Name	Presence	AUC	TSS
Bufonidae	*Bufo gargarizans*	Asian toad	1233	0.79	0.59
Bufonidae	*Bufo stejnegeri*	Water toad	233	0.92	0.72
Discoglossidae	*Bombina orientalis*	Oriental fire-bellied toad	3302	0.73	0.54
Hylidae	*Dryophytes japonicus*	Japanes tree frog	4976	0.66	0.53
Hynobiidae	*Hynobius leechii*	Korean salamander	3401	0.77	0.65
Hynobiidae	*Hynobius quelpaertensis*	Jeju salamander	74	0.99	0.98
Hynobiidae	*Onychodactylus koreanus*	Korean clawed salamander	240	0.89	0.66
Microhylidae	*Kaloula borealis*	Narrow-mouthed toad	64	0.87	0.65
Plethodontidae	*Karsenia koreana*	Korean crevice salamander	13	0.82	0.69
Ranidae	*Glandirana rugosa*	Wrinkled frog	1683	0.71	0.61
Ranidae	*Lithobates catesbeianus*	American bullfrog	2527	0.87	0.59
Ranidae	*Pelophylax chosenicus*	Korean golden frog	31	0.97	0.89
Ranidae	*Pelophylax nigromaculatus*	black-spotted pond frog	6314	0.78	0.65
Ranidae	*Rana coreana*	Korean brown frog	1562	0.76	0.57
Ranidae	*Rana uenoi*	Korean large brown frog	3708	0.68	0.55
Ranidae	*Rana huanrenensis*	Huanren brown frog	930	0.86	0.54
Hylidae	*Dryophytes suweonensis* *	Suweon tree frog	Presenc epoints < 10		
Hynobiidae	*Hynobius yangi* *	Kori salamander	Presenc epoints < 10		
Hylidae	*Dryophytes flaviventris* [a]	Yellow-bellied tree frog	www.krsh.co.kr (accessed on 20 July 2021)		
Hynobiidae	*Hynobius geojeensis* [a]	Geoje salamander	Borzée and Min, 2021		
Hynobiidae	*Hynobius notialis* [a]	Southern Korean salamander	Borzée and Min, 2021		
Hynobiidae	*Hynobius perplicatus* [a]	Cryptic Uiryeong salamander	Borzée and Min, 2021		
Hynobiidae	*Hynobius unisacculus* [a]	Korean small salamander	www.krsh.co.kr (accessed on 20 July 2021)		

Variable contributions

Groups	Species	Altitude	Bio01	Bio02	Bio03	Bio12	Bio13	Bio14
Group 1	D. japonicus	81.4	4.4	3.5	3.7	0.4	6.2	0.3
	K. borealis	48.5	7.1	0.3	6.9	16.9	10.6	9.7
	G. rugosa	60.1	2.6	6.9	12.7	11.6	1.9	4.3
	L. catesbeianus	31.2	46.1	0.8	2.3	2.6	16.4	0.6
	P. chosenicus	78.6	10.4	1.4	8.1	0.4	0.3	0.8
	P. nigromaculatus	77.4	9.0	3.6	7.3	1.6	0.8	0.2
	R. coreana	43.5	25.5	4.1	2.7	13.5	5.3	5.3
Group 2	B. orientalis	34.9	8.4	1.6	4.5	2.7	34.1	13.9
	B. gargarizans	56.0	9.4	2.0	6.7	10.1	15.5	0.3
	H. leechii	44.4	4.6	3.9	1.9	15.3	27.4	2.4
	H. quelpaertensis	0.0	6.7	0.3	0.3	60.1	0.3	32.3
	R. uenoi	74.6	2.9	4.8	3.2	1.5	7.8	5.2
Group 3	B. stejnegeri	16.0	59.2	2.7	7.9	1.1	4.1	8.9
	K. koreana	22.2	0.0	18.6	29.4	0.0	29.6	0.2
	O. koreanus	42.8	41.0	4.1	0.9	0.9	2.3	8.0
	R. huanrenensis	57.2	21.9	3.3	2.1	3.4	7.2	5.0

▶ Altitude

▶ Water related > temperature related

Habitat suitability

| Group	Scientific Name	Current	RCP 4.5			PHL * (%)	RCP 8.5			PHL * (%)
			2030	2050	2080		2030	2050	2080	
Group 1	H. japonica	69,191	74,273	50,748	23,119	66.6	52,626	41,463	22,798	67.1
	K. borealis	24,392	30,814	39,835	61,206	−150.9	48,429	33,656	41,009	−68.1
	G. rugosa	60,730	52,518	41,887	19,256	68.3	35,123	34,411	31,959	47.4
	L. catesbeianus	28,523	62,436	37,986	27,067	5.1	40,263	55,541	42,311	−48.3
	P. chosenicus	10,901	4298	298	2000	81.7	3255	412	168	98.5
	P. nigromaculatus	65,551	71,358	49,658	28,648	56.3	57,881	44,831	19,902	69.6
	R. coreana	47,791	33,675	17,128	15,420	67.7	28,215	25,815	16,617	65.2
Group 2	B. gargarizans	65,144	62,370	41,381	21,368	67.2	46,998	48,268	24,268	62.7
	B. orientalis	56,561	47,634	30,044	2529	95.5	25,427	30,774	3354	94.1
	H. leechii	68,673	38,858	22,711	11,747	82.9	24,299	31,160	15,452	77.5
	H. quelpaertensis	1585	1427	888	1510	4.7	1343	253	1220	23.0
	R. uenoi	66,419	13,369	9417	2261	96.6	13,130	7152	2356	96.5
Group 3	B. stejnegeri	17,160	16,158	4288	265	98.5	3916	1448	59	99.7
	O. koreanus	21,351	9675	5193	330	98.5	4920	2953	118	99.4
	K. koreana	45,627	76,576	84,130	87,674	−92.2	79,896	78,035	87,252	−91.2
	R. huanrenensis	31,061	13,481	6600	670	97.8	6466	3026	1228	96.0
Total area						100,411 [a]				

Species richness: current
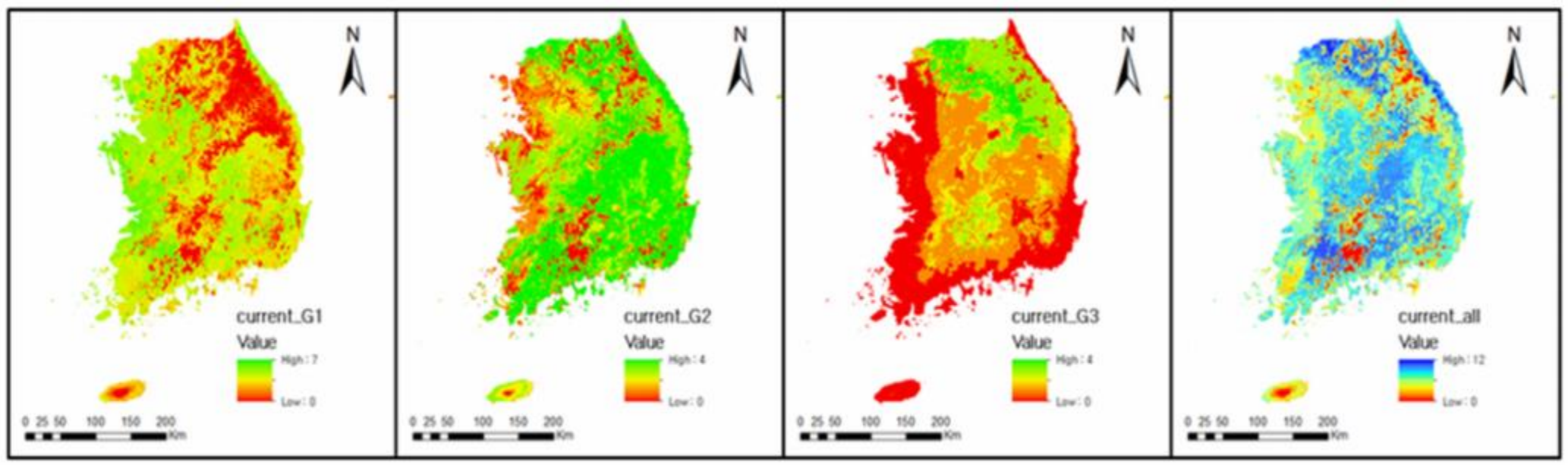
Results – Species richness under RCP 4.5
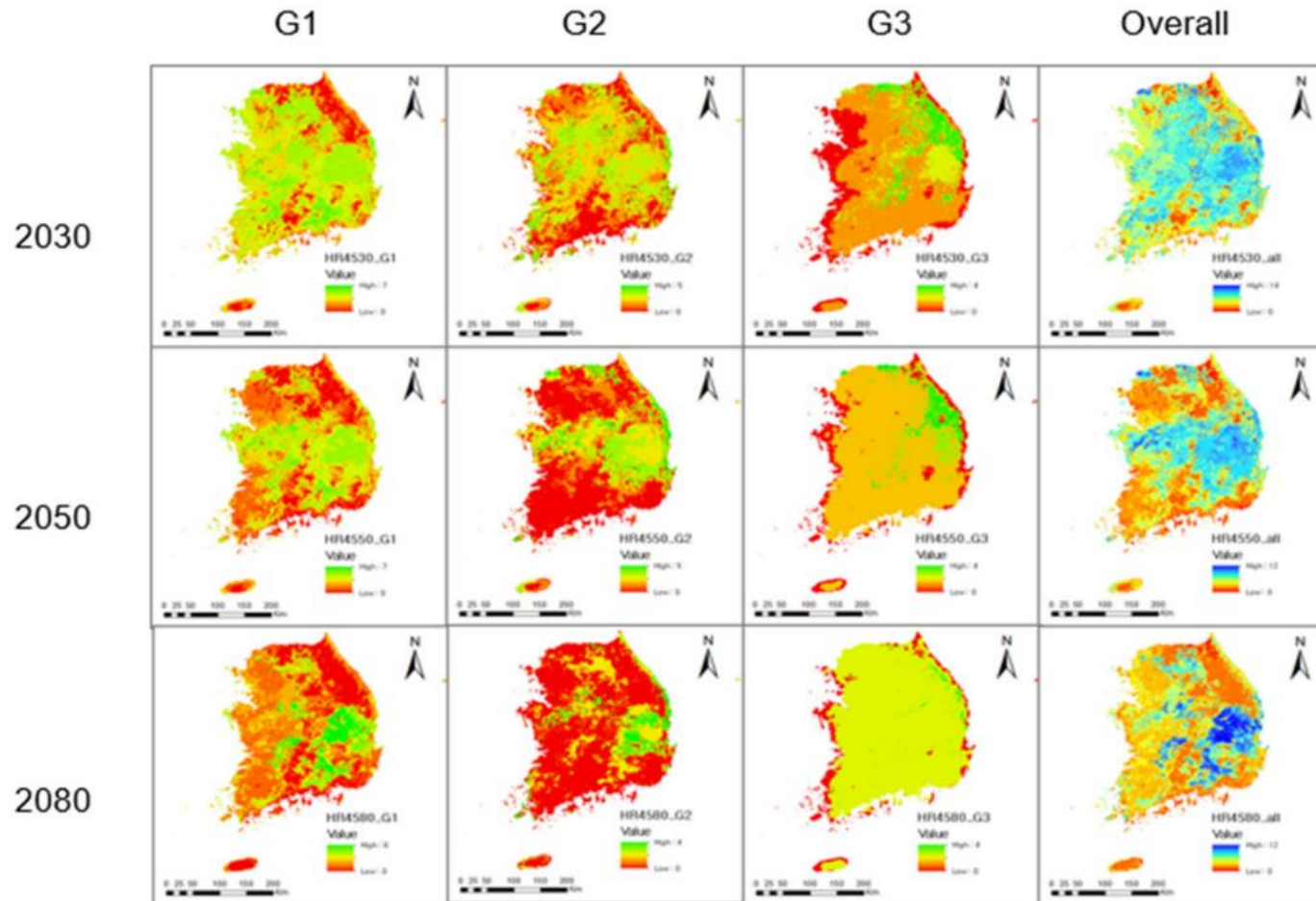
Results – Species richness under RCP 8.5
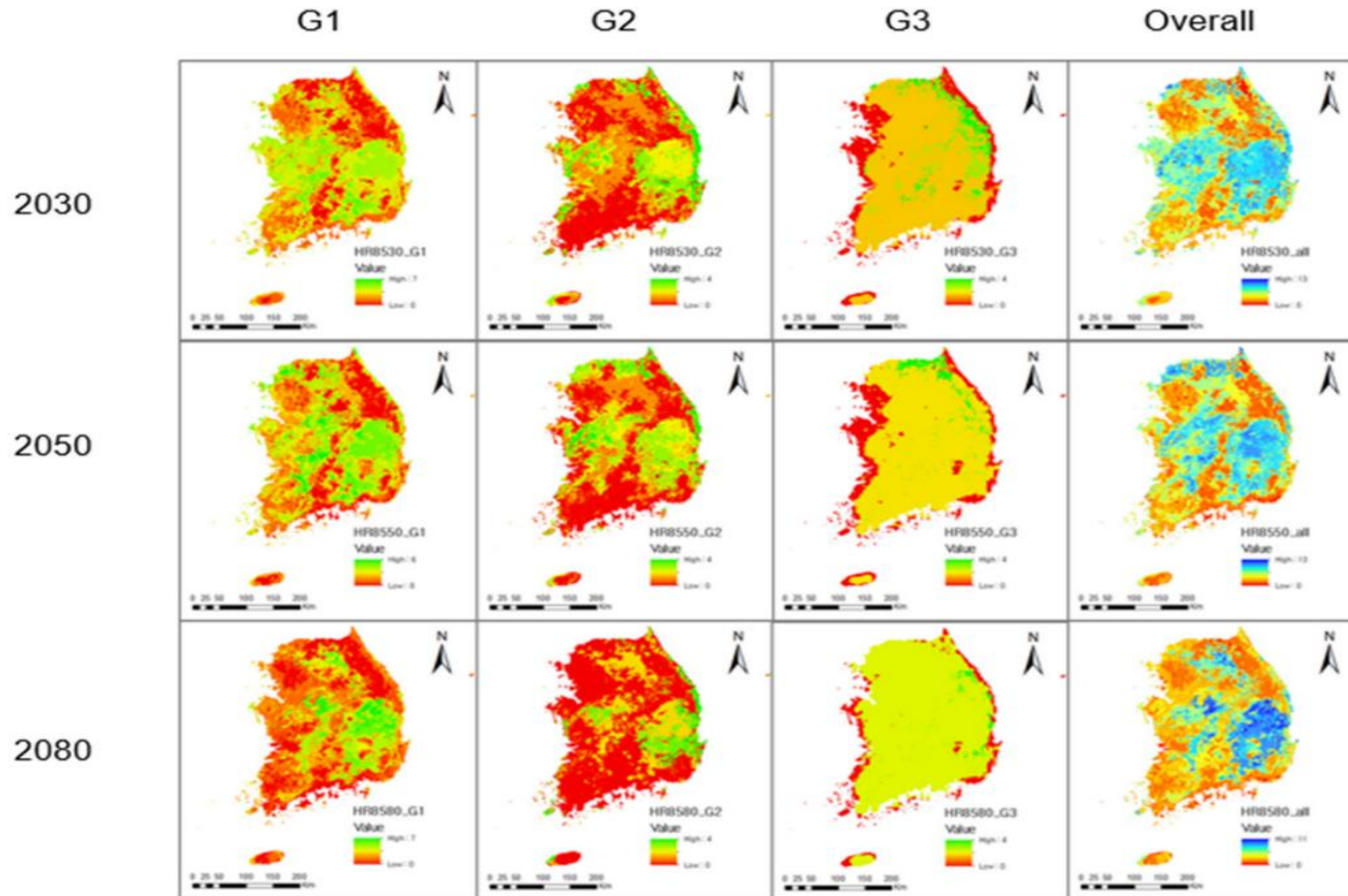
Conclusions

- We investigated the potential effects of climate change on the distribution of 16 amphibian species with different habitat characteristics in S. Korea.

- Suitable amphibian habitats will decrease until 2080.

  - Exceptions: *L. catesbeianus*, *K. borealis*, and *K. koreana*.

- Species richness of Group 1 and Group 2 would converge southeastward, around the Daegu basin.

- Forest-dwelling amphibians are the most vulnerable against climate change among 3 groups.

Thank you!