

Reconstruction of Past Vegetation Dynamics in Temperate Regions by Environmental DNA

Chae Eun LIM*, Jung A KIM, Yoonjee HONG, Hye Sook JEON

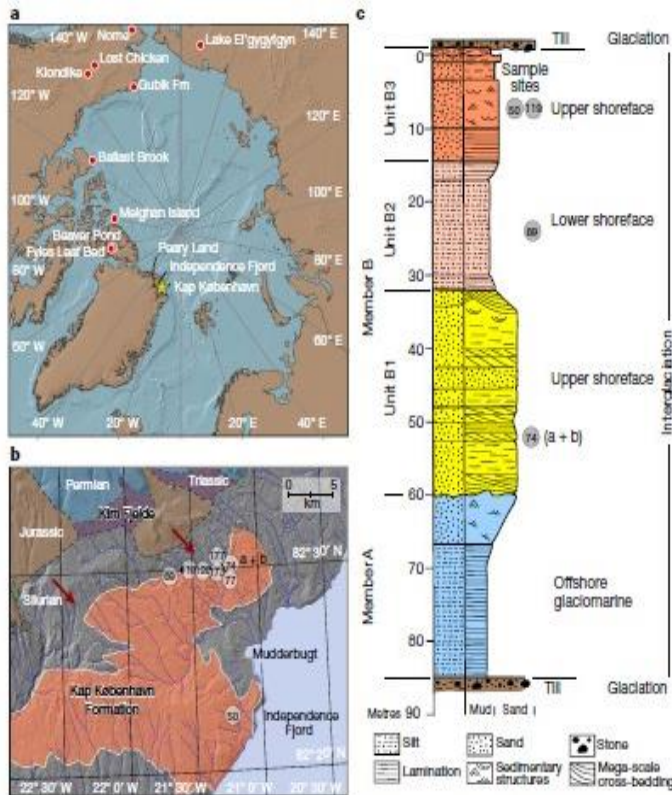
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국립생물자원관
National Institute of Biological Resources

Background

1. Comparison of eDNA, pollen, and microfossils in Greenland
2. Using ancient eDNA, tracking ecosystems from 2 million years ago
3. eDNA provides biota information previously undetected in pollen and macrofossils.



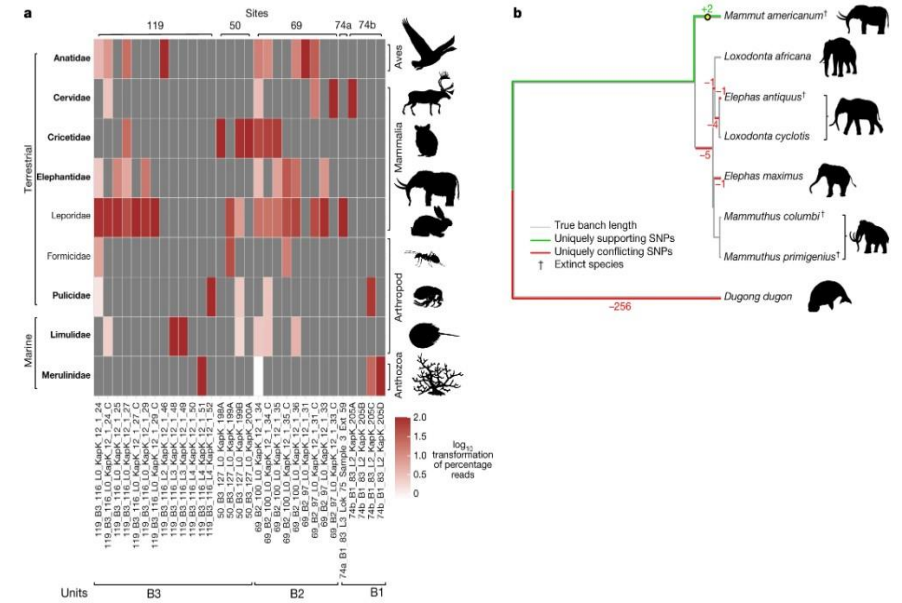
Extended Data Fig. 1 | Seeing A. Type locality 50 indicating units in formation b. Overview of locality 74a-b with a complete sediment sequence. C. Overview of locality 77. D. Detail of organic-rich sediment in unit B3 before excavation and



cleaning for ancient eDNA samples. E. Sampling in the permafrost within unit B3 at locality 50. F. Organic-rich sediment at the base of mega-scale cross-bedding within unit B2 at locality 74a-b. White circles mark persons for scale.

Fig. 4: Early Pleistocene animals of northern Greenland.

From: A 2-million-year-old ecosystem in Greenland uncovered by environmental DNA



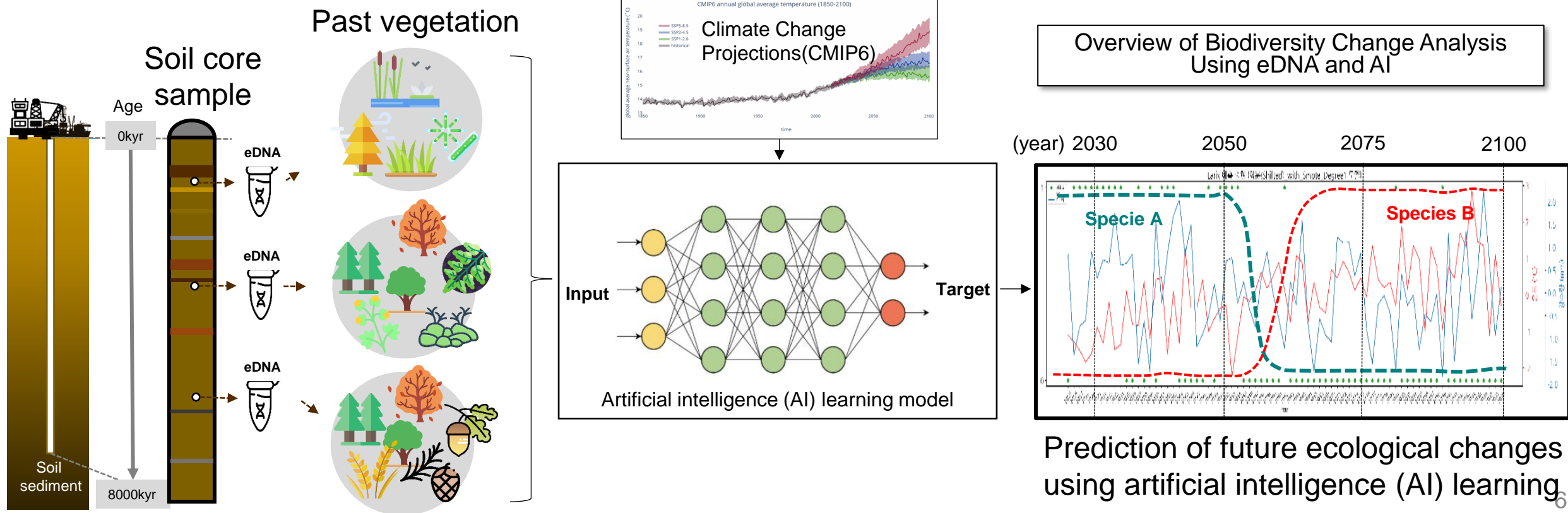
a. Taxonomic profiles of the animal assemblage from units B1, B2 and B3. Taxa in bold are genera only found as DNA. b. Phylogenetic placement and pathPhynder⁵² results of mitochondrial reads uniquely classified to Elephantidae or lower (Source Data 1). Extinct species as identified by either macrofossils or phylogenetic placements are marked with a dagger.

Questions

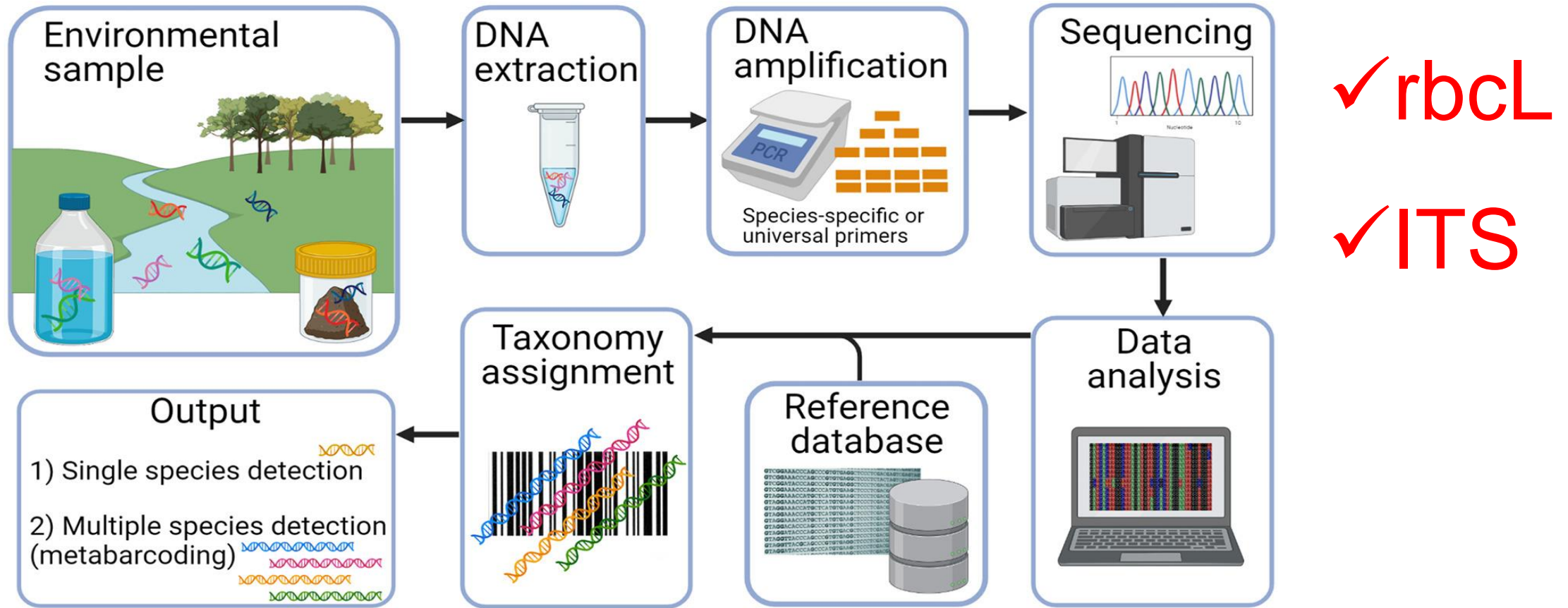
- Can we identify past ecological changes caused by climate change through sedimentary eDNA analysis?
- Is it possible to predict future ecological changes using artificial intelligence (AI) learning?
- Can ancient DNA from past organisms be preserved in temperate region soil sediments?

In this study

- We utilized Artificial Intelligence (AI) to model the interactions between past climate conditions and past ecological changes
 - Through the AI model, we aimed to predict how biodiversity would respond to future climate change



Methods: field sampling to species detection

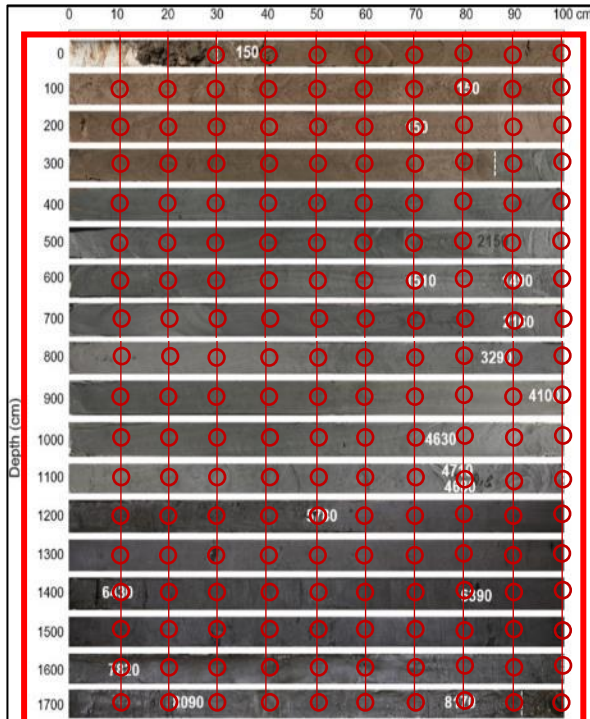


Sengupta et al., 2022

Results of soil cores: Site 1

• Topyeong stream

- ✓ Core depth : 0.3~18m
- ✓ Vascular Plants : 61 Genera in 40 Families
- ✓ Bryophyte : 2 Genera in 2 Families



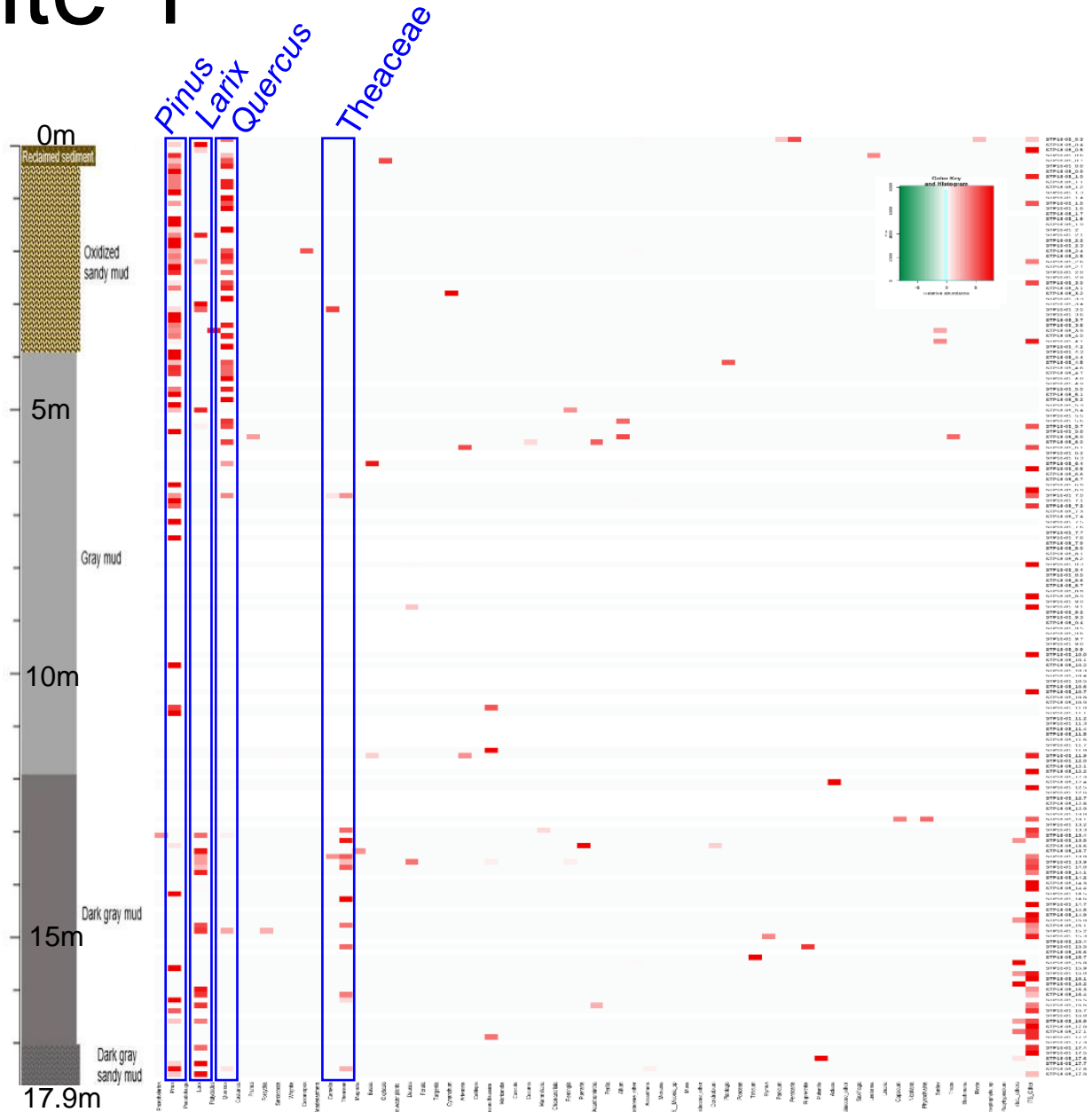
* ○ indicates soil subsampling sites

Sample No.	Depth (cm)	Cal yr BP	eDNA(Family/Genus)
STP18-05_0.3	35	150	<i>Quercus, Persicaria, Riccia</i>
STP18-05_0.4	40	150	<i>Pinus, Larix</i>
STP18-05_0.5	50	150	<i>Larix</i>
STP18-05_0.6	60	150	<i>Pinus, Quercus, Larix</i>
STP18-05_0.7	70	150	<i>Pinus, Quercus, Poaceae</i>
STP18-05_0.8	80	150	<i>Pinus, Quercus</i>
STP18-05_0.9	90	150	<i>Pinus</i>
STP18-05_1.0	100	150	<i>Pinus</i>
STP18-05_1.1	110	150	<i>Pinus, Quercus</i>
STP18-05_1.2	120	150	<i>Pinus, Quercus</i>
STP18-05_1.3	130	150	<i>Pinus</i>
STP18-05_1.4	140	150	<i>Quercus</i>
STP18-05_1.5	150	155	
STP18-05_1.6	160	174	<i>Quercus</i>
STP18-05_1.7	170	193	
STP18-05_1.8	180	212	<i>Pinus</i>
STP18-05_1.9	190	232	<i>Pinus</i>
STP18-05_2	200	252	<i>Pinus, Quercus, Smilax</i>
STP18-05_2.1	210	272	<i>Pinus, Larix</i>
STP18-05_2.2	220	292	<i>Pinus</i>
STP18-05_2.3	230	312	<i>Pinus</i>
STP18-05_2.4	240	332	<i>Pinus, Quercus, Castanea, Castanopsis</i>
STP18-05_2.5	250	351	<i>Pinus, Quercus</i>
STP18-05_2.6	260	370	<i>Pinus, Quercus</i>
STP18-05_2.7	270	391	<i>Pinus</i>
STP18-05_2.8	280	416	<i>Pinus</i>
STP18-05_2.9	290	444	
STP18-05_3.0	300	471	

Sample No.	Depth (cm)	Cal yr BP	eDNA(Family/Genus)
STP18-05_14.4	1440	6533	<i>Larix</i>
STP18-05_14.5	1450	6572	<i>Pinus, Linaria</i>
STP18-05_14.6	1460	6611	<i>Theaceae, Araceae</i>
STP18-05_15.1	1510	6914	<i>Larix, Theaceae, Araceae</i>
STP18-05_15.2	1520	6991	<i>Larix, Quercus, Forsythia</i>
STP18-05_15.3	1530	7070	<i>Larix, Elymus, Smilacaceae, Apocynaceae, Fabaceae</i>
STP18-05_15.5	1550	7226	<i>Theaceae, Polygonaceae</i>
STP18-05_15.7	1570	7383	<i>Triticum</i>
STP18-05_15.8	1580	7462	
STP18-05_15.9	1590	7541	<i>Pinaceae</i>
STP18-05_16.2	1620	7729	<i>Perilla</i>
STP18-05_16.3	1630	7765	<i>Larix</i>
STP18-05_16.4	1640	7799	<i>Larix, Theaceae, Araceae</i>
STP18-05_16.5	1650	7834	<i>Pinus, Theaceae</i>
STP18-05_16.6	1660	7868	<i>Pinus, Larix, Orchidaceae, Lamiaceae</i>
STP18-05_16.7	1670	7902	<i>Pinus, Linaria</i>
STP18-05_16.8	1680	7936	
STP18-05_16.9	1690	7970	<i>Pinus, Larix</i>
STP18-05_17.2	1720	8073	<i>Brassicaceae</i>
STP18-05_17.3	1730	8107	
STP18-05_17.4	1740	8140	<i>Larix</i>
STP18-05_17.5	1750	8173	
STP18-05_17.6	1760	8207	<i>Pulsatilla</i>
STP18-05_17.7	1770	8240	<i>Pinus, Larix</i>
STP18-05_17.8	1778	8270	<i>Pinus, Quercus, Theaceae, Araceae</i>
STP18-05_17.9	1790	8300	<i>Pinus, Larix</i>

Results of soil cores: Site 1

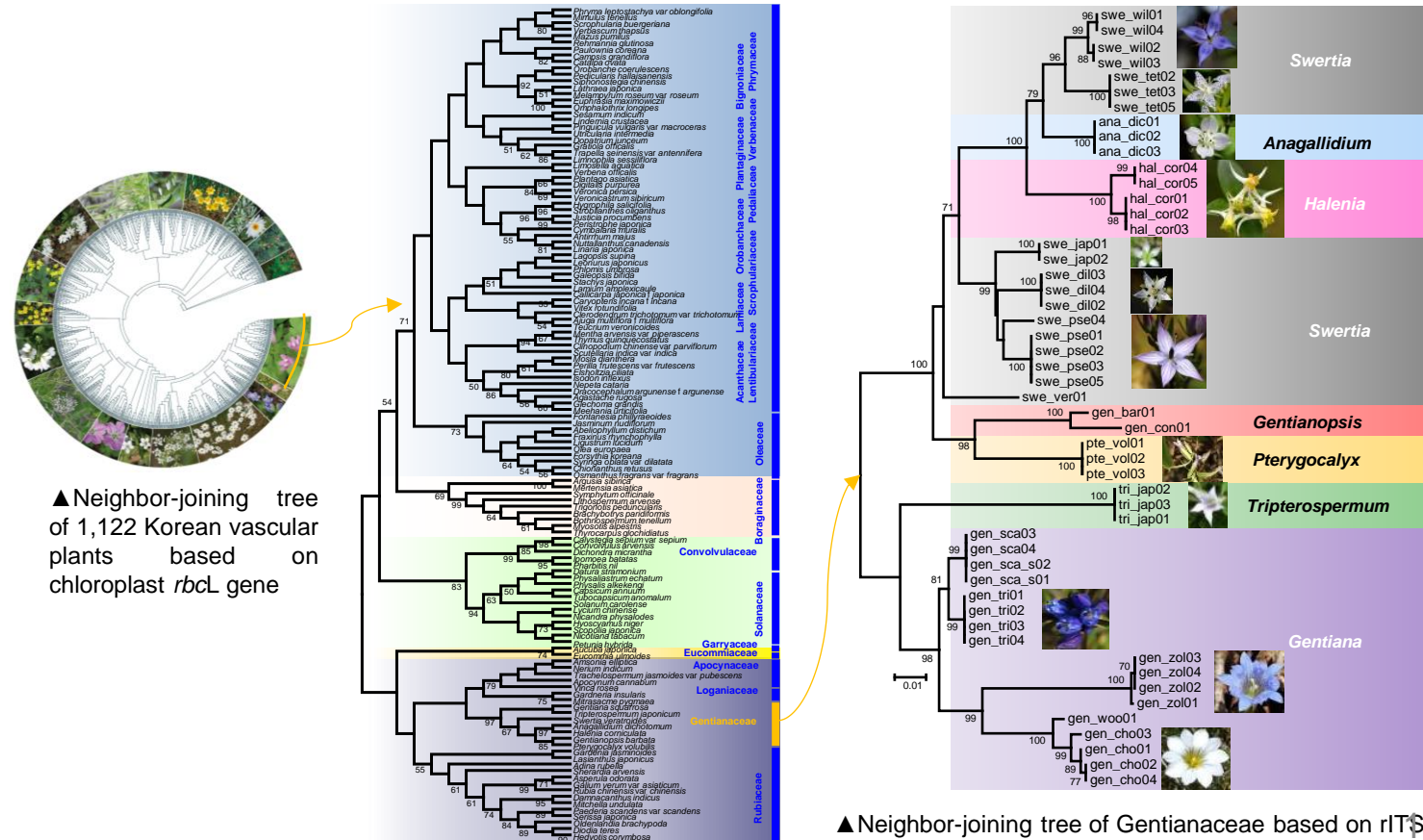
- Heat map of eDNA
- ✓ ***Pinus, Quercus, Larix, Theaceae***
- ✓ **Vascular Plants: 61 Genera in 40 Families**
 - Tree: 18 Genera (Gymnosperms (5), Angiosperm (13))
 - Evergreen broadleaf tree: *Camillia*, Theaceae
 - Deciduous coniferous tree: *Larix, Metasequaia*
 - Herbs: 49 Genera (Graminaceae 4 genera)
- ✓ **Aquatic plants: *Trapa*, Nymphaeaceae**
- ✓ **Bryophytes : 2 Genera in 2 Families**



Reference Database: DNA Barcode database of Vascular Plants in Korea (NIBR)

❖ Genus-level reference library of Korean vascular plants

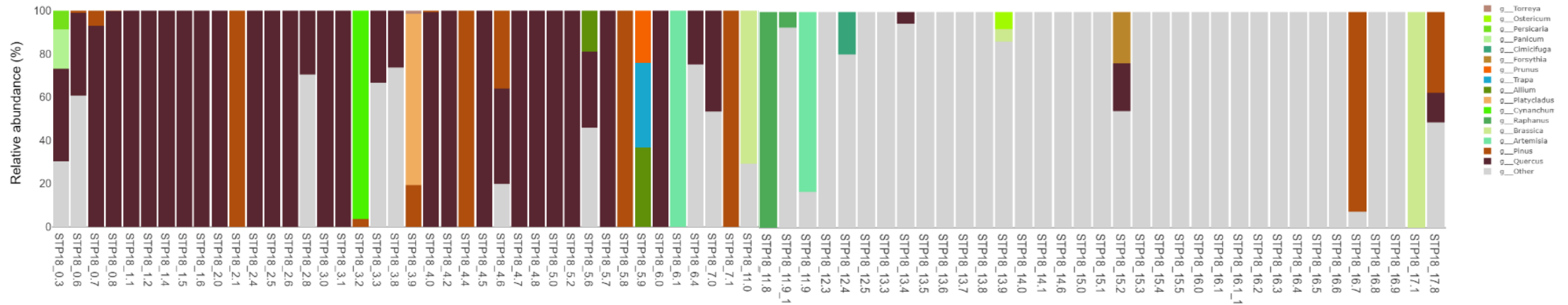
- ✓ 4,518 vascular plant species and 1,122 genera are listed in Korea.
- ✓ the *rbcL* sequences of all plant genera in Korea (1,122 genera)
- ✓ high resolution of genus-level taxonomic relationship (>95%) on the *rbcL* library
- ✓ Three more markers, *matK*, *psbA-trnH*, and ITS for 2,795 (62% of total vascular plants in Korea).



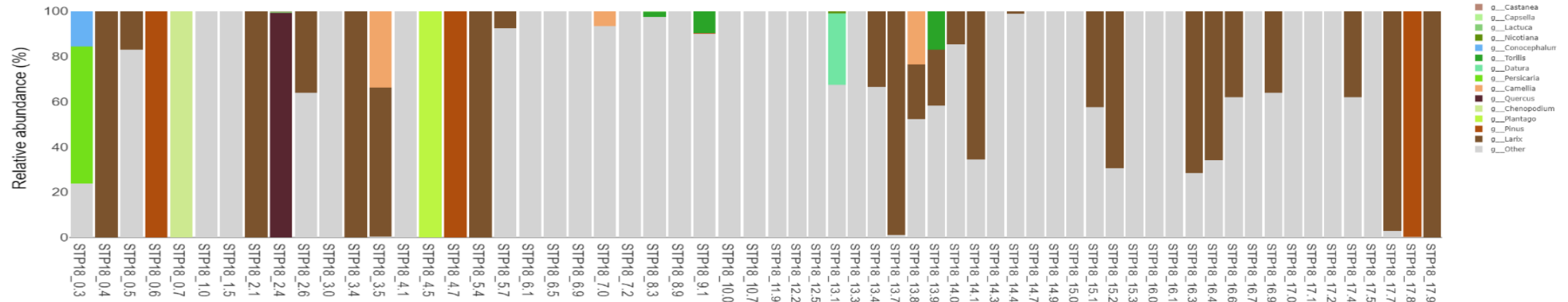
Results of soil cores: Site 1

- Bar-plot graph (Reference: [NIBR](#))

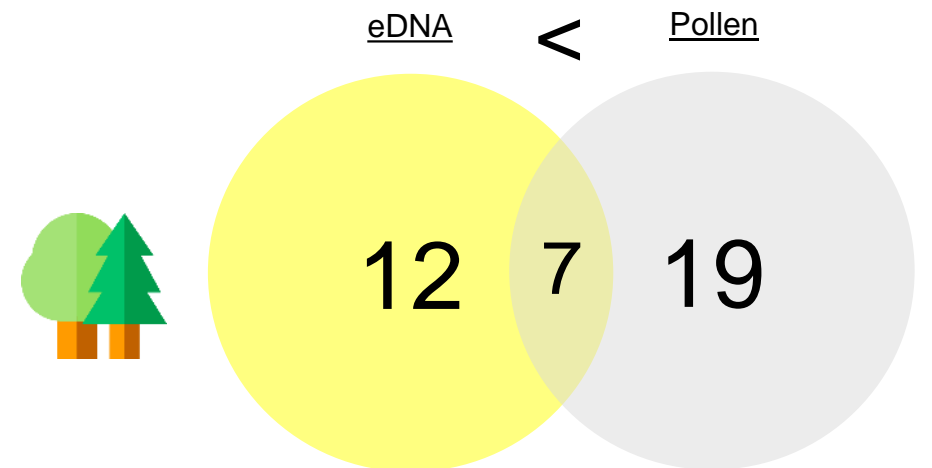
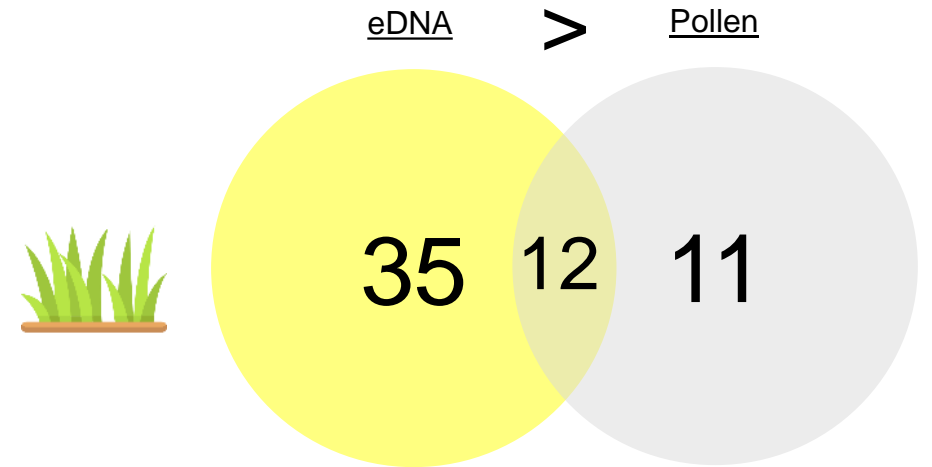
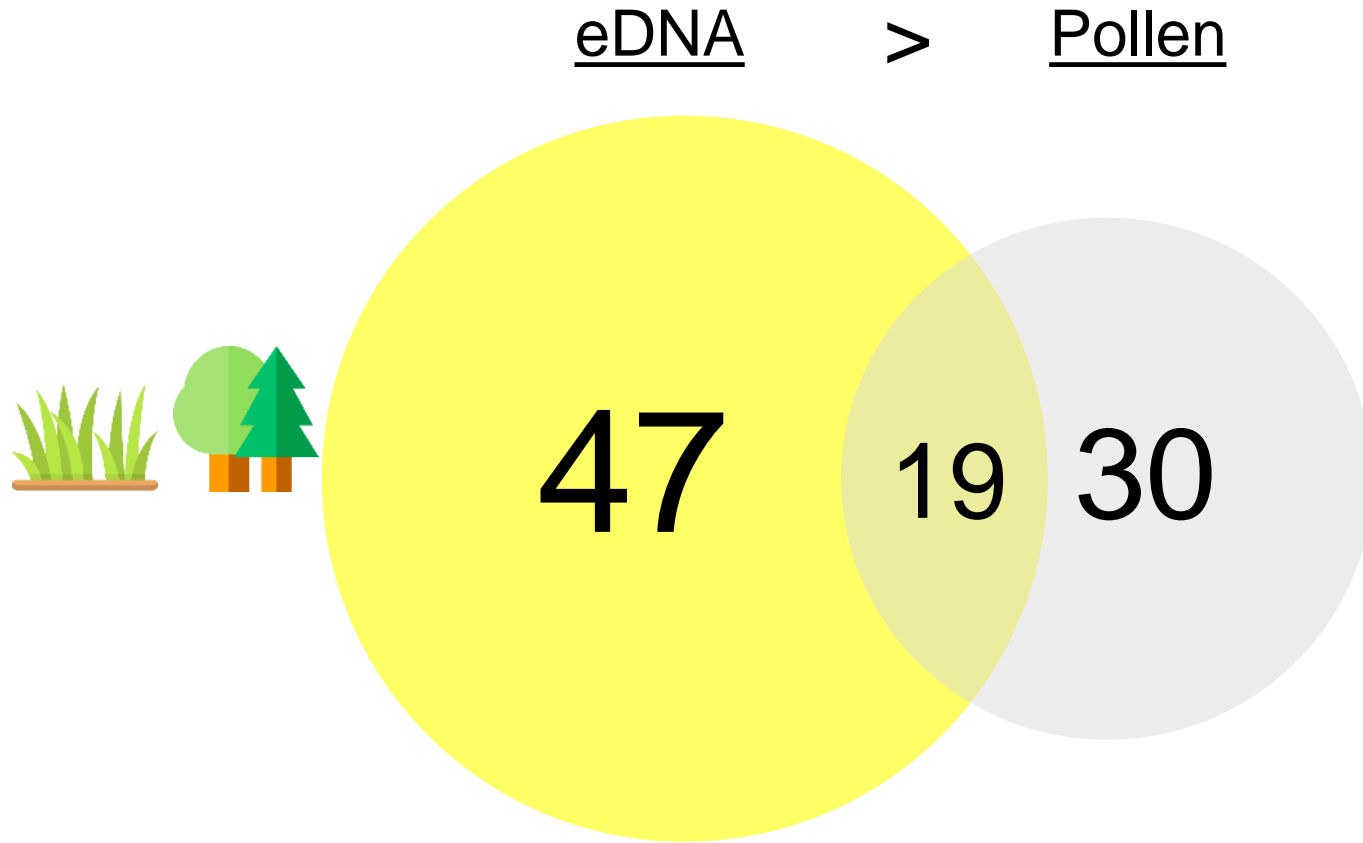
ITS



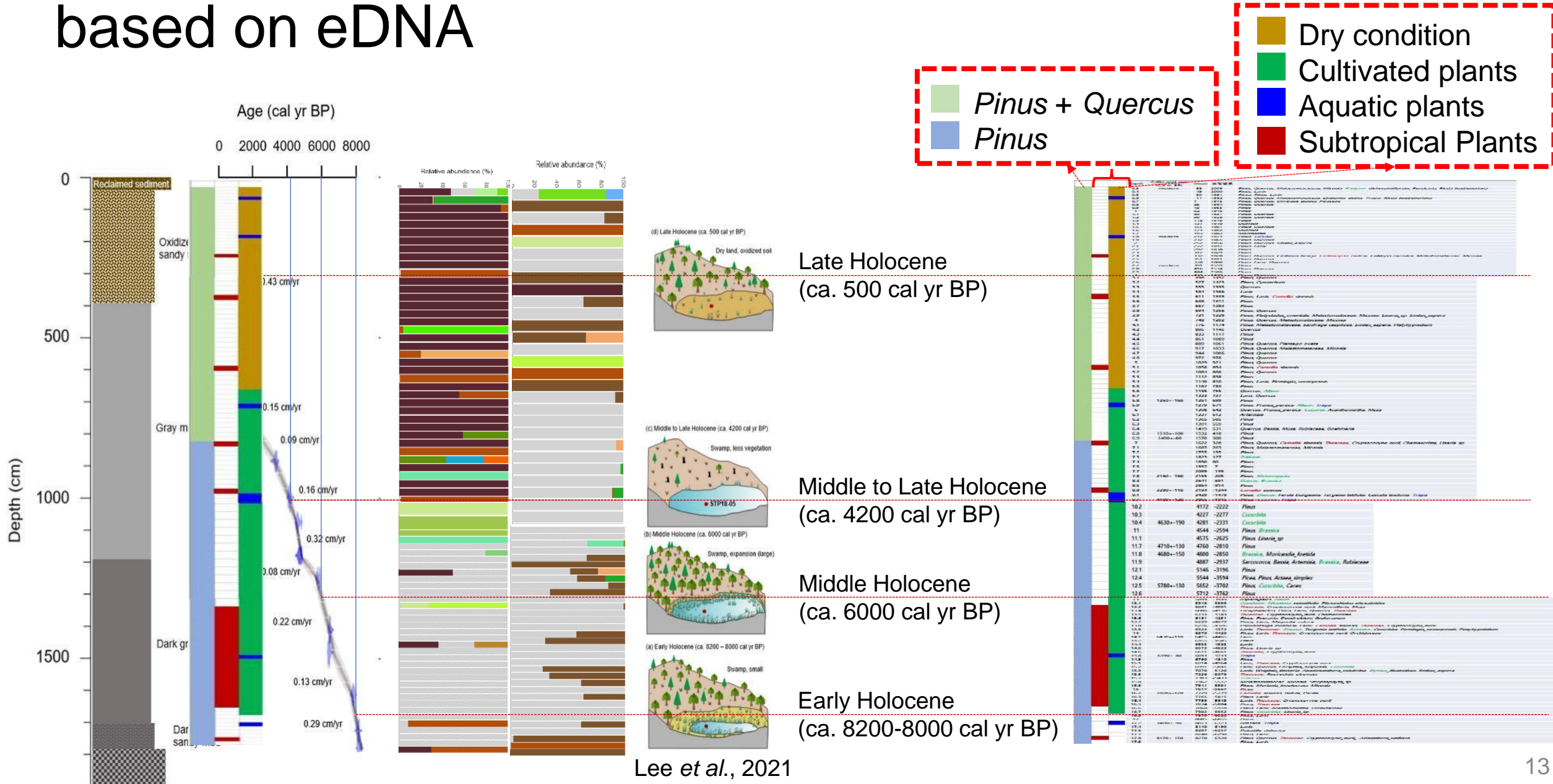
rbcl



eDNA vs. Pollen (Number of Genus): Site 1



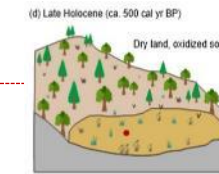
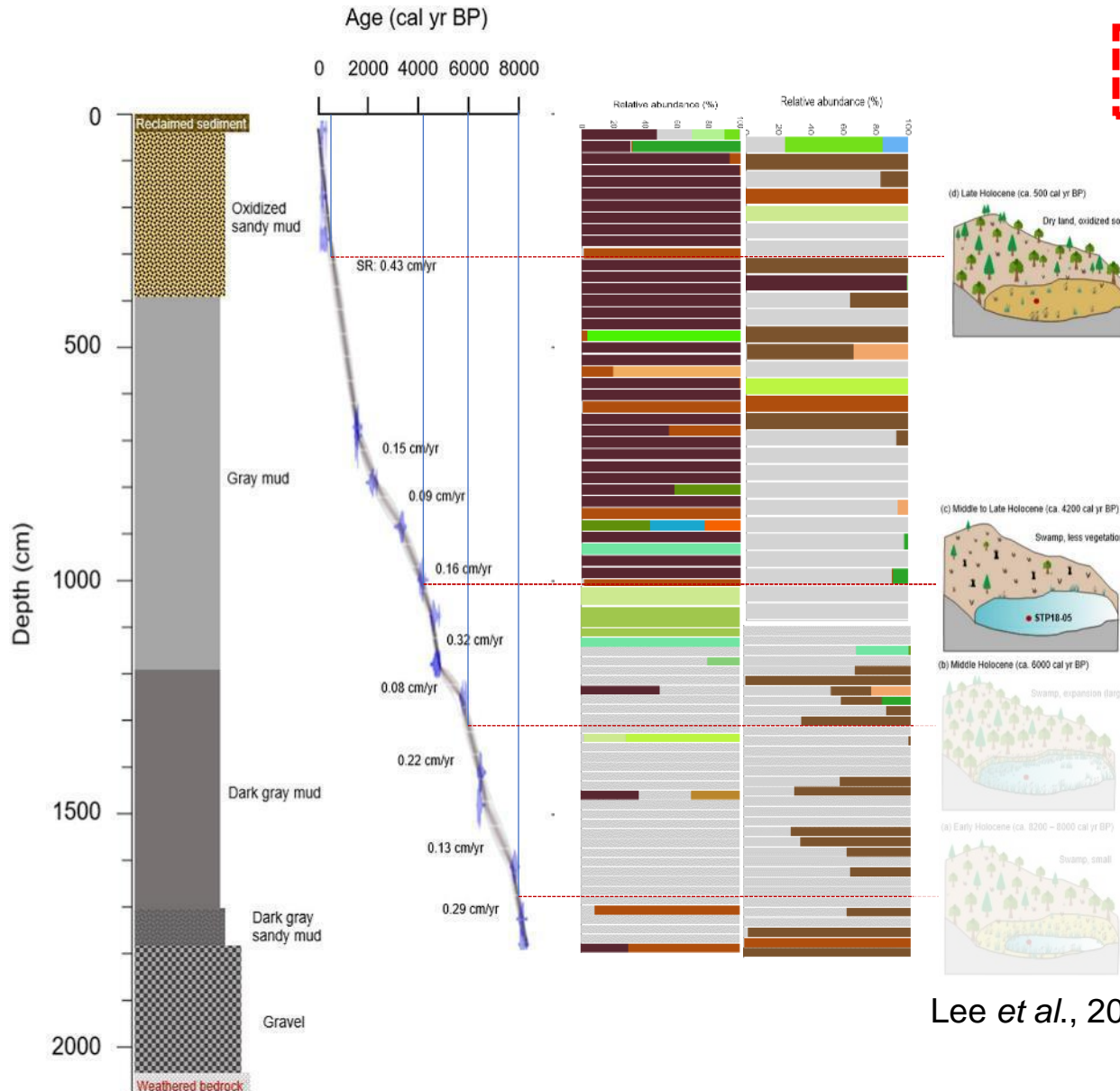
Vegetation changes in Site 1 (Topyeong Stream) based on eDNA



Lee et al., 2021

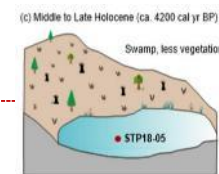
Vegetation changes in Site 1 (Topyeong Stream)

- Dry condition
- Cultivated plants
- Aquatic plants
- Subtropical Plants

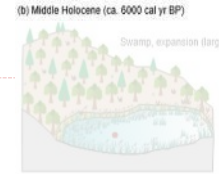


Pinus + Quercus

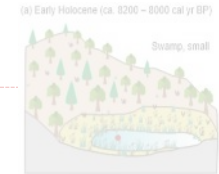
Late Holocene (ca. 500 cal yr BP)



Middle to Late Holocene (ca. 4200 cal yr BP)



Middle Holocene (ca. 6000 cal yr BP)



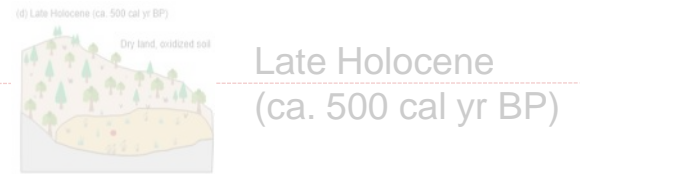
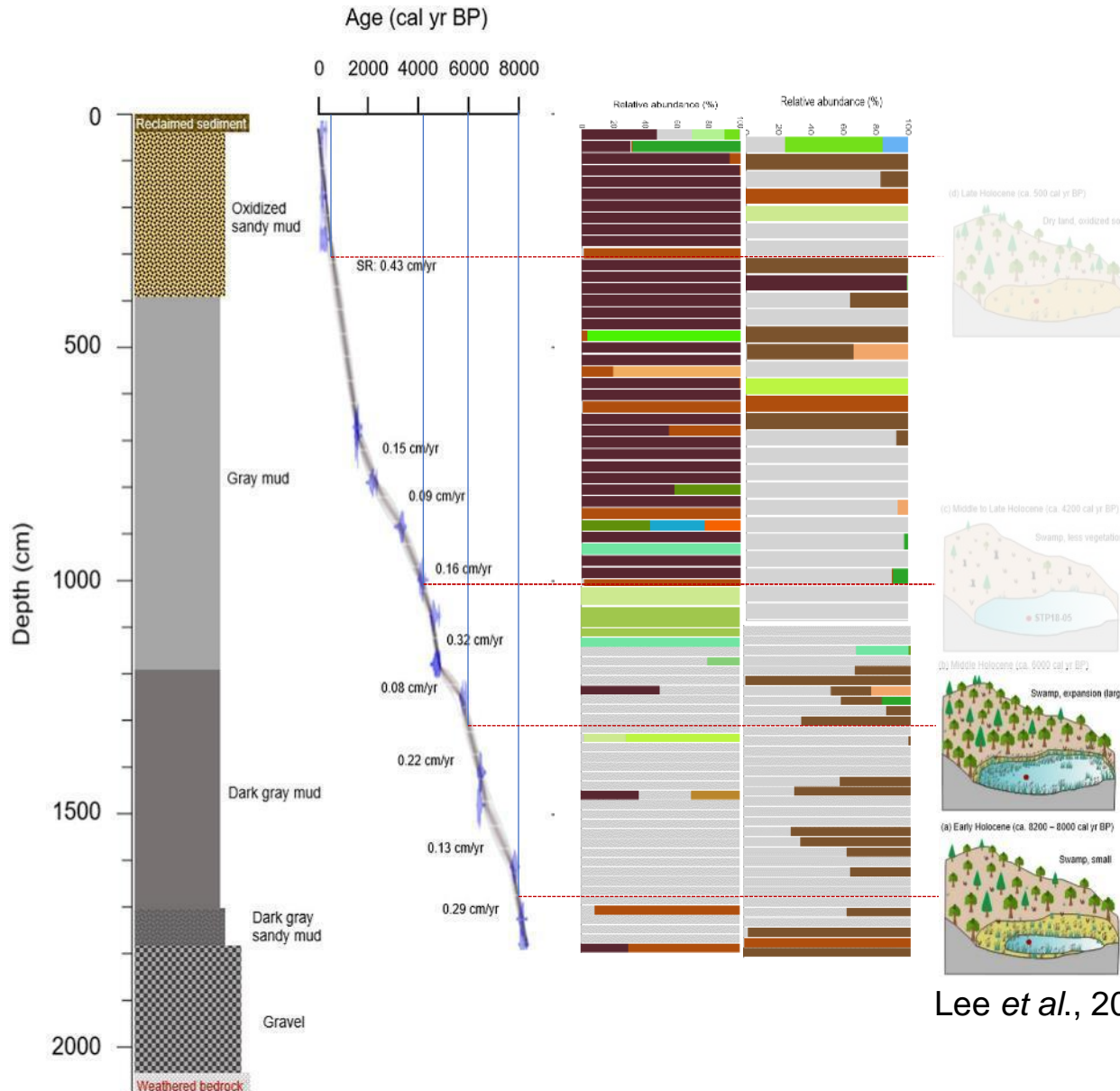
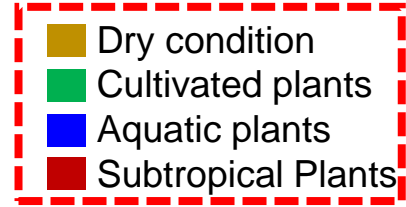
Early Holocene (ca. 8200-8000 cal yr BP)

Lee et al., 2021

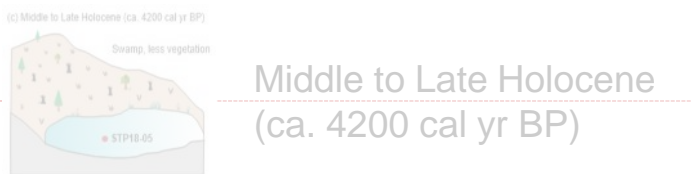
depth	Calibrated age (Cal yr BP)	mean	포함된 식물	
0.3			<i>Pinus, Quercus, Melastomataceae, Miconia, Pinus, Dichotomiflorum, Persea, Riccia huebeneriana</i>	
0.4			<i>Pinus, Larix</i>	
0.4	-49	2000	<i>Pinus, Pinus, Larix</i>	
0.5	-30	1991	<i>Pinus, Quercus, Melastomataceae, Lindernia, dubia, Trapa, Riccia huebeneriana</i>	
0.6	-11	1982	<i>Pinus, Quercus, Oryza sativa, Poaceae</i>	
0.7	-7	1973	<i>Pinus, Quercus</i>	
0.8	25	1964	<i>Pinus, Quercus</i>	
0.9	43	1955	<i>Pinus</i>	
1	62	1946	<i>Pinus</i>	
1.1	80	1937	<i>Pinus, Quercus</i>	
1.2	99	1928	<i>Pinus, Quercus</i>	
1.3	118	1919	<i>Pinus</i>	
1.4	137	1910	<i>Quercus</i>	
1.5	155	1901	<i>Pinus, Quercus</i>	
1.6	174	1892	<i>Quercus</i>	
1.7	193	1883	<i>Marchantia</i>	
1.8	212	1874	<i>Pinus, Euryale</i>	
1.9	232	1865	<i>Pinus, Quercus</i>	
2	252	1856	<i>Pinus, Quercus, Smilax, aspera</i>	
2.1	272	1847	<i>Pinus, Larix</i>	
2.2	292	1838	<i>Pinus</i>	
2.3	312	1829	<i>Pinus</i>	
2.4	332	1820	<i>Pinus, Quercus, Castanea henryi, Castanopsis carlesii, Callitris cauroina, Melastomataceae, Miconia</i>	
2.5	351	1811	<i>Pinus, Quercus</i>	
2.6	370	1800	<i>Pinus, Larix, Quercus</i>	
2.7	391	1791	<i>Pinus, Quercus</i>	
2.8	416	1784	<i>Pinus, Quercus</i>	
2.9	444	1766	<i>Pinus</i>	
3	471	1749	<i>Pinus, Quercus</i>	
3.1	498	1452	<i>Pinus, Quercus</i>	
3.2	527	1423	<i>Pinus, Cynanchum</i>	
3.3	555	1395	<i>Quercus</i>	
3.4	584	1366	<i>Larix</i>	
3.5	611	1339	<i>Pinus, Larix, Camellia sinensis</i>	
3.6	639	1311	<i>Pinus</i>	
3.7	667	1283	<i>Pinus</i>	
3.8	694	1256	<i>Pinus, Quercus</i>	
3.9	721	1229	<i>Pinus, Platycladus, orientalis, Melastomataceae, Miconia, Linaria, sp, Smilax, aspera</i>	
4	748	1202	<i>Pinus, Quercus, Melastomataceae, Miconia</i>	
4.1	776	1174	<i>Pinus, Melastomataceae, Saxifraga cespitosa, Smilax, aspera, Platypodium</i>	
4.2	805	1145	<i>Quercus</i>	
4.3	833	1117	<i>Pinus</i>	
4.4	861	1089	<i>Pinus</i>	
4.5	889	1061	<i>Pinus, Quercus, Plantago ovata</i>	
4.6	917	1033	<i>Pinus, Quercus, Melastomataceae, Miconia</i>	
4.7	944	1006	<i>Pinus, Quercus</i>	
4.8	972	978	<i>Pinus, Quercus</i>	
5	1029	921	<i>Pinus, Quercus</i>	
5.1	1055	894	<i>Pinus, Camellia sinensis</i>	
5.2	1084	866	<i>Pinus, Quercus</i>	
5.3	1112	838	<i>Pinus</i>	
5.4	1140	810	<i>Pinus, Larix, Flemingia, sootensis</i>	
5.5	1167	783	<i>Pinus</i>	
5.6	1195	755	<i>Quercus, Allium</i>	
5.7	1223	727	<i>Larix, Quercus</i>	
5.8	1250-160	1251	699	<i>Pinus</i>
5.9	1279	671	<i>Pinus, Prunus, persica, Allium, Trapa</i>	
6	1308	642	<i>Quercus, Prunus, persica, Cucumis, Acanthomintha, Musa</i>	
6.1	1337	613	<i>Artemisia</i>	
6.2	1365	585	<i>Pinus</i>	
6.3	1391	559	<i>Pinus</i>	
6.4	1419	531	<i>Quercus, Bassia, Musa, Rubiaceae, Boehmeria</i>	
6.8	1510-100	1532	418	<i>Pinus</i>
6.9	1490-80	1570	380	<i>Pinus</i>
7	1622	328	<i>Pinus, Quercus, Camellia sinensis, Theaceae, Cryptocarya</i>	
7.1	1687	263	<i>Pinus, Melastomataceae, Miconia</i>	
7.2	1755	195	<i>Pinus</i>	
7.3	1823	127	<i>Triticum</i>	
7.4	1890	60	<i>Pinus</i>	
7.5	1957	-7	<i>Pinus</i>	
7.7	2089	-139	<i>Pinus</i>	
7.8	2160-160	2155	-205	<i>Pinus, Metasequoia</i>
8.3	2641	-691	<i>Daucus, Brassica</i>	
8.5	2864	-914	<i>Pinus</i>	
8.8	3290-110	3194	-1244	<i>Camellia sinensis</i>
9.1	3429	-1479	<i>Pinus, Daucus, Ferula bungeana, Turgenia latifolia, Cuscuta tinctoria, Trapa</i>	
9.7	4100-120	3865	-1915	<i>Pinus, Cucumis, Trapa</i>



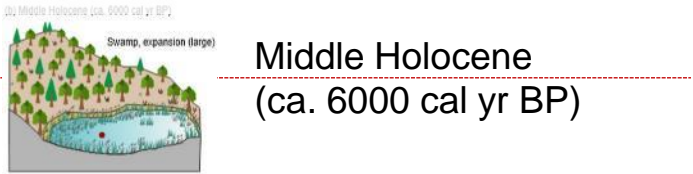
Vegetation changes in Site 1 (Topyeong Stream)



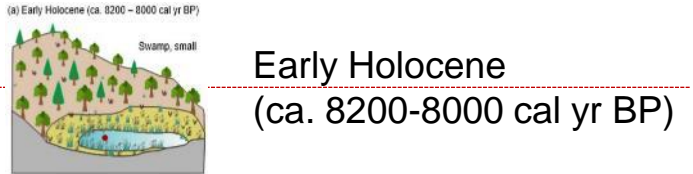
Late Holocene
(ca. 500 cal yr BP)



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Early Holocene
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Lee et al., 2021

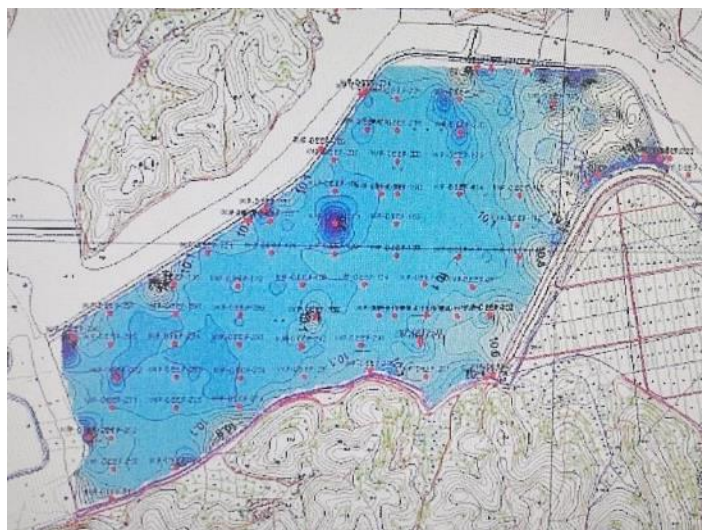
10.2	4172-2222	Pinus
10.3	4227-2277	Cucurbita
10.4	4630+190	Cucurbita
11	4544-2594	Pinus, Brassica
11.1	4575-2625	Pinus, Linaria sp
11.7	4710+130	Pinus
11.8	4680+150	Brassica, Moricandia foetida
11.9	4887-2937	Sarcococca, Bassia, Artemisia, Brassica, Rubiaceae
12.1	5146-3196	Pinus
12.4	5544-3594	Picea, Pinus, Actaea simplex
12.5	5780+130	Pinus, Cucurbita, Carex
12.6	5712-3762	Pinus

13	5899-3949	Asparagales, Allium
13.1	5946-3996	Capsicum, Nicotiana solanifolia, Physoclaina physaloides
13.3	6041-4091	Theaceae, Cryptocoryne nurii, Mammillaria, Musa
13.4	6086-4136	Encephalartos, Pinus, Larix, Quercus, Theaceae
13.5	6133-4183	Theaceae, Cryptocoryne nurii, Chamaecrista
13.6	6181-4231	Pinus, Pueraria, Dendrobium, finlayianum
13.7	6229-4279	Pinus, Larix, Magnolia odora
13.8	6276-4326	Pseudotsuga menziesii, Larix, Camellia sinensis, Theaceae, Cryptocoryne nurii
13.9	6322-4372	Larix, Theaceae, Daucus, Turgenia latifolia, Brassica, Cucurbita, Flemingia, sootepensis, Pityohypnidium
14	6370-4420	Picea, Larix, Theaceae, Cryptocoryne nurii, Orchidaceae
14.1	6430+110	6415-4465 Larix
14.2	6455-4505	Pinus
14.4	6533-4583	Larix
14.5	6572-4622	Pinus, Linaria sp
14.6	6611-4661	Theaceae, Cryptocoryne nurii
14.8	6390+90	6694-4744 Trapa
14.9	6760-4810	Pinus
15.1	6914-4964	Larix, Theaceae, Cryptocoryne nurii
15.2	6991-5041	Larix, Quercus, Forsythia suspensa, Cucurbita
15.3	7070-5120	Larix, Wrightia tinctoria, Anadenanthera colubrina, Elymus, libanoticus, Smilax aspera
15.5	7226-5276	Theaceae, Ruprechtia obovata
15.7	7383-5433	Triticum
15.8	7462-5512	Melastomataceae, Miconia, Streptophyta sp
15.9	7541-5591	Pinus, Meriania involucrata, Miconia
16	7617-5667	Picea
16.2	7820+120	7729-5779 Camellia sinensis, Betula, Perilla
16.3	7765-5815	Pinus, Larix
16.4	7799-5849	Larix, Theaceae, Cryptocoryne nurii
16.5	7834-5884	Pinus, Theaceae
16.6	7868-5918	Pinus, Larix, Acanthomitha, Orchidaceae
16.7	7902-5952	Pinus, Cucurbita, Linaria sp
16.9	7970-6020	Pinus, Larix
17	8005-6055	Pinus
17.2	8090+50	8073-6123 Brassica, Trapa
17.4	8140-6190	Larix
17.6	8207-6257	Pulsatilla dalurica
17.7	8240-6290	Pinus, Larix
17.8	8170+150	8270-6320 Pinus, Quercus, Theaceae, Cryptocoryne nurii, Acananthera uniflora
17.9		Pinus, Larix

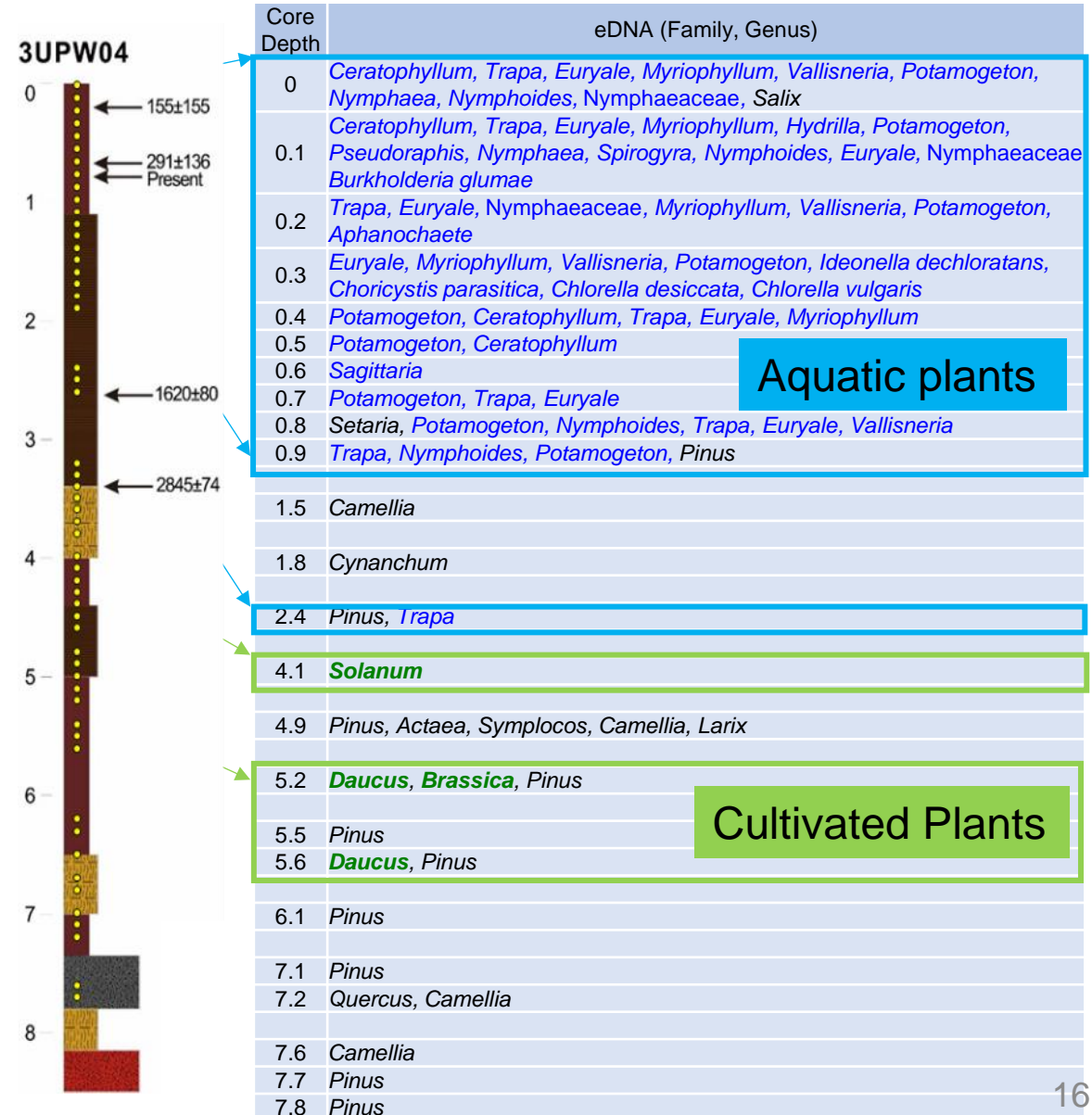
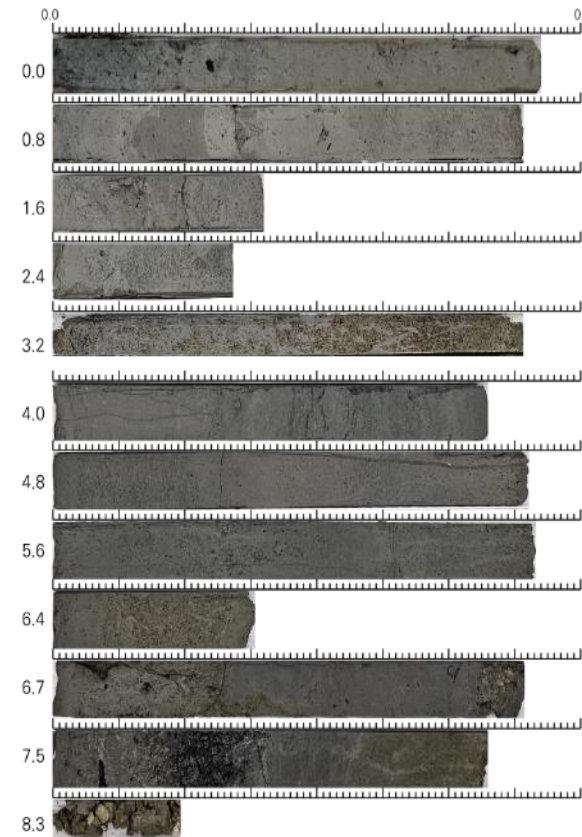


Results of soil cores: Site 2

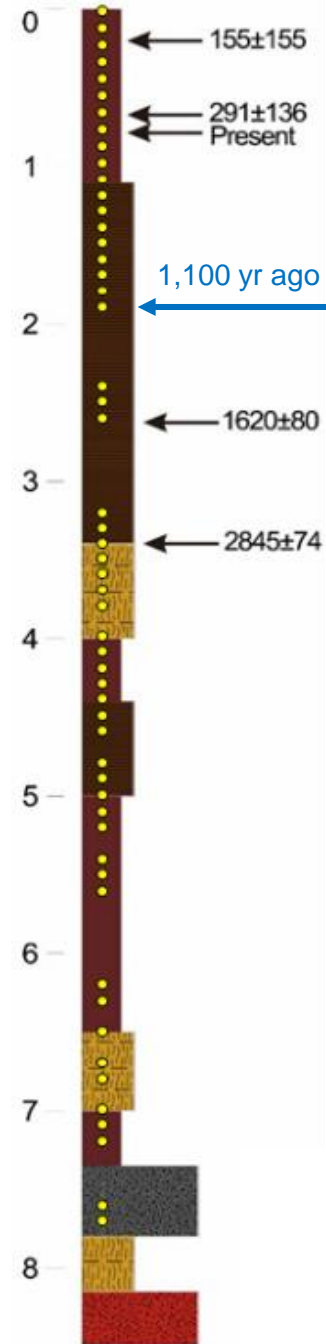
- Upo wetland Core 1
<Core 1: 23UPW04>



23UPW04 (0 - 8.4m)



3UPW04



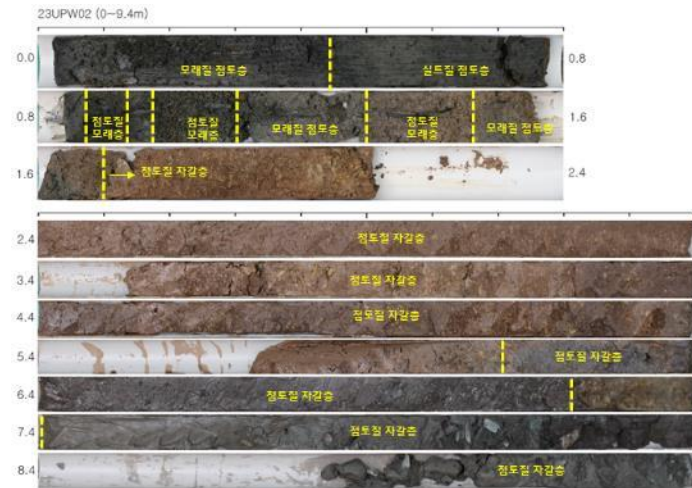
Upo wetland creation

Core Depth	Cal yr BP	Cal yr BC/AD	eDNA (Family, Genus)	
0			<i>Ceratophyllum, Trapa, Euryale, Myriophyllum, Vallisneria, Potamogeton, Nymphaea, Nymphoides, Nymphaeaceae, Salix</i>	
0.1			<i>Ceratophyllum, Trapa, Euryale, Myriophyllum, Hydrilla, Potamogeton, Pseudoraphis, Nymphaea, Spirogyra, Nymphoides, Euryale, Nymphaeaceae, Burkholderia glumae</i>	
0.23	123	modern	modern	<i>Trapa, Euryale, Nymphaeaceae, Myriophyllum, Vallisneria, Potamogeton, Aphanochaete</i>
0.3				<i>Euryale, Myriophyllum, Vallisneria, Potamogeton, Ideonella dechloratans, Choricystis parasitica, Chlorella desiccata, Chlorella vulgaris</i>
0.4				<i>Potamogeton, Ceratophyllum, Trapa, Euryale, Myriophyllum</i>
0.5				<i>Potamogeton, Ceratophyllum</i>
0.6				<i>Sagittaria</i>
0.7	187	modern	modern	<i>Potamogeton, Trapa, Euryale</i>
0.8	-3651	modern	modern	<i>Setaria, Potamogeton, Nymphoides, Trapa, Euryale, Vallisneria</i>
0.9				<i>Trapa, Nymphoides, Potamogeton, Pinus</i>
1.5				<i>Camellia</i>
1.8				<i>Cynanchum</i>
2.64	1812	169	107	<i>Pinus, Trapa</i>
3.42	2828	-845	-911	
4.4	2605	-619	-691	<i>Solanum</i>
4.64	2811	-834	-888	<i>Pinus, Actaea, Symplocos, Camellia, Larix</i>
5.15	2673	-693	-753	<i>Daucus, Brassica, Pinus</i>
5.47	2992	-1012	-1072	<i>Pinus</i>
5.6				<i>Daucus, Pinus</i>
6.06	3819	-1840	-1898	<i>Pinus</i>
7.3	4808	-2827	-2889	<i>Quercus, Camellia</i>
7.57	3721	-1742	-1800	
7.6	3752	-1769	-1835	<i>Camellia</i>
7.93	111703	-109695	-109811	<i>Pinus</i>

Results of soil cores: Site 2

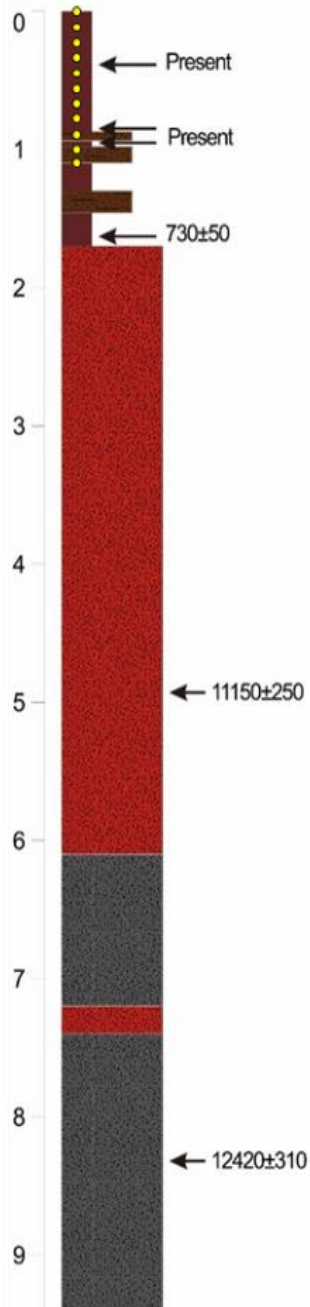
- Upo wetland Core 2

<Core 2: 23UPW02>



Core Depth	eDNA (Family, Genus)	Core Depth	eDNA (Family, Genus)	Core Depth	eDNA (Family, Genus)
0	<i>Spirodela, Potamogeton, Trapa, Salvinia, Euryale, Ceratophyllum, Hydrocharis, Zannichellia, Castanopsis, Salix, Callitriche</i>	3	<i>Pinus</i>	6.1	<i>Pinus</i>
0.1	<i>Spirodela, Potamogeton, Zannichellia, Trapa, Nymphaea, Salvinia, Euryale, Ceratophyllum, Hydrocharis, Quercus, Salix, Humulus</i>	3.1	<i>Pinus</i>	6.2	<i>Pinus</i>
0.2	<i>Hydrocharis, Trapa, Nymphaea, Victoria, Salvinia, Euryale, Ceratophyllum, Potamogeton, Zannichellia, Robinia, Salix, Cnidium</i>	3.2	<i>Pinus</i>	6.3	<i>Pinus</i>
0.3	<i>Hydrocharis, Salvinia, Trapa, Euryale, Ceratophyllum, Potamogeton, Zannichellia, Salix, Humulus, Nicotiana, Lindernia, Persicaria</i>	3.3	<i>Pinus</i>	6.4	<i>Pinus, Quercus</i>
0.4	<i>Spirodela, Trapa, Nymphaea, Salvinia, Euryale, Ceratophyllum, Potamogeton, Salix, Humulus, Bolboschoenus, Eleocharis, Lindernia, Plantago, Callitriche</i>	3.4	<i>Pinus</i>	6.5	
0.5	<i>Trapa, Salvinia, Euryale, Persicaria, Ceratophyllum, Nymphaea, Potamogeton, Pinus, Robinia, Quercus, Populus, Salix, Humulus, Calystegia, Bolboschoenus, Eleocharis, Setaria, Lindernia, Artemisia, Callitriche</i>	3.5		6.6	<i>Pinus</i>
0.6	<i>Spirodela, Trapa, Salvinia, Ceratophyllum, Euryale, Potamogeton, Robinia, Lindernia, Bolboschoenus, Persicaria</i>	3.6	<i>Pinus</i>	6.7	<i>Pinus, Quercus, Castanopsis</i>
0.7	<i>Ceratophyllum, Trapa, Euryale, Potamogeton, Zannichellia, Robinia, Quercus, Prunus, Pinus, Bolboschoenus, Setaria, Draba, Lindernia, Astragalus, Persicaria</i>	3.7	<i>Pinus, Camellia</i>	6.8	<i>Pinus</i>
0.75	<i>Persicaria, Trapa, Euryale, Ceratophyllum, Potamogeton, Miscanthus, Populus, Salix, Pinus, Robinia, Chenopodium, Beckmannia, Humulus, Bolboschoenus, Oenanthe</i>	3.8	<i>Quercus</i>	6.9	
0.9	<i>Spirodela, Salvinia, Persicaria, Ceratophyllum, Trapa, Hydrocharis, Potamogeton, Pinus, Chenopodium, Astragalus, Calystegia, Bolboschoenus, Persicaria, Oenanthe</i>	3.9	<i>Pinus</i>	7	
2	<i>Pinus</i>	4	<i>Pinus</i>	7.1	
2.1		4.1	<i>Pinus</i>	7.2	<i>Pinus</i>
2.4		4.2	<i>Pinus</i>	7.3	<i>Pinus</i>
2.5	<i>Pinus</i>	4.3	<i>Pinus</i>	7.4	<i>Pinus</i>
2.6	<i>Pinus</i>	4.4		7.5	
2.7	<i>Pinus</i>	4.5	<i>Pinus</i>	7.6	<i>Pinus</i>
2.8	<i>Pinus, Gymnanthemum, Lactuca</i>	4.6		7.7	<i>Quercus</i>
2.9	<i>Pinus</i>	4.7		7.8	<i>Pinus</i>
		4.8	<i>Camellia</i>	7.9	<i>Pinus</i>
		4.9		8	
		5		8.1	<i>Pinus</i>
		5.1	<i>Quercus</i>	8.2	<i>Pinus</i>
		5.2	<i>Pinus</i>	8.3	<i>Pinus</i>
		5.3	<i>Pinus, Quercus</i>	8.4	<i>Pinus, Quercus</i>
		5.4	<i>Pinus</i>	8.6	<i>Pinus</i>
		5.8	<i>Pinus</i>	8.7	<i>Pinus</i>
		5.9		8.8	<i>Pinus</i>
		6	<i>Pinus</i>		

23UPW02



Wetland creation

Dry land

23UPW-02	Cal yr BP	Calyr BC/AD	eDNA(Genus)
0			<i>Spirodela, Potamogeton, Trapa, Salvinia, Euryale, Ceratophyllum, Hydrocharis, Zannichellia, Castanopsis, Salix, Callitriche</i>
0.1			<i>Spirodela, Potamogeton, Zannichellia, Trapa, Nymphaea, Salvinia, Euryale, Ceratophyllum, Hydrocharis, Quercus, Salix, Humulus</i>
0.2			<i>Hydrocharis, Trapa, Nymphaea, Victoria, Salvinia, Euryale, Ceratophyllum, Potamogeton, Zannichellia, Robinia, Salix, Cnidium</i>
0.3			<i>Hydrocharis, Salvinia, Trapa, Euryale, Ceratophyllum, Potamogeton, Zannichellia, Salix, Humulus, Nicotiana, Lindernia, Persicaria</i>
0.4	-283	modern	<i>Spirodela, Trapa, Nymphaea, Salvinia, Euryale, Ceratophyllum, Potamogeton, Salix, Humulus, Bolboschoenus, Eleocharis, Lindernia, Plantago, Callitriche</i>
0.5			<i>Trapa, Salvinia, Euryale, Persicaria, Ceratophyllum, Nymphaea, Potamogeton, Pinus, Robinia, Quercus, Populus, Salix, Humulus, Calystegia, Bolboschoenus, Eleocharis, Setaria, Lindernia, Artemisia, Callitriche</i>
0.6			<i>Spirodela, Trapa, Salvinia, Ceratophyllum, Euryale, Potamogeton, Robinia, Lindernia, Bolboschoenus, Persicaria</i>
0.7			<i>Ceratophyllum, Trapa, Euryale, Potamogeton, Zannichellia, Robinia, Quercus, Prunus, Pinus, Bolboschoenus, Setaria, Draba, Lindernia, Astragalus, Persicaria</i>
0.75			<i>Persicaria, Trapa, Euryale, Ceratophyllum, Potamogeton, Miscanthus, Populus, Salix, Pinus, Robinia, Chenopodium, Beckmannia, Humulus, Bolboschoenus, Oenanthe</i>
0.9	-1212	modern	<i>Spirodela, Salvinia, Persicaria, Ceratophyllum, Trapa, Hydrocharis, Potamogeton, Pinus, Chenopodium, Astragalus, Calystegia, Bolboschoenus, Persicaria, Oenanthe</i>
0.9	-962	modern	

23UPW-02	Cal yr BP	Calyr BC/AD	eDNA
1.65	828	1152	1092 <i>Pinus</i>
2.5			<i>Pinus</i>
2.6			<i>Pinus</i>
2.7			<i>Pinus</i>
2.8			<i>Pinus, Gymnanthemum, Lactuca</i>
2.9			<i>Pinus</i>
3			<i>Pinus</i>
3.1			<i>Pinus</i>
3.2			<i>Pinus</i>
3.3			<i>Pinus</i>
3.4			<i>Pinus</i>
3.6			<i>Pinus</i>
3.7			<i>Pinus, Camellia</i>
3.8			<i>Quercus</i>
3.9			<i>Pinus</i>
4			<i>Pinus</i>
4.1			<i>Pinus</i>
4.2			<i>Pinus</i>
4.3			<i>Pinus</i>
4.5			<i>Pinus</i>
4.8			<i>Camellia</i>
4.95	9805	-7790	-7920 <i>Quercus</i>
5.1			<i>Pinus</i>
5.2			<i>Pinus</i>
5.3			<i>Pinus, Quercus</i>
5.4			<i>Pinus</i>
5.8			<i>Pinus</i>
6			<i>Pinus</i>
6.1			<i>Pinus</i>
6.2			<i>Pinus</i>
6.3			<i>Pinus</i>
6.4			<i>Pinus, Quercus</i>
6.6			<i>Pinus</i>
6.7			<i>Pinus, Quercus, Castanopsis</i>
6.8			<i>Pinus</i>
7.2			<i>Pinus</i>
7.3			<i>Pinus</i>
7.4			<i>Pinus</i>
7.6			<i>Pinus</i>
7.7			<i>Pinus</i>
7.8			<i>Pinus</i>
7.9			<i>Pinus</i>
8.1			<i>Pinus</i>
8.2			<i>Pinus</i>
8.34	10556	-8520	-8692 <i>Pinus</i>
8.4			<i>Pinus, Quercus</i>
8.6			<i>Pinus</i>
8.7			<i>Pinus</i>
8.8			<i>Pinus</i>

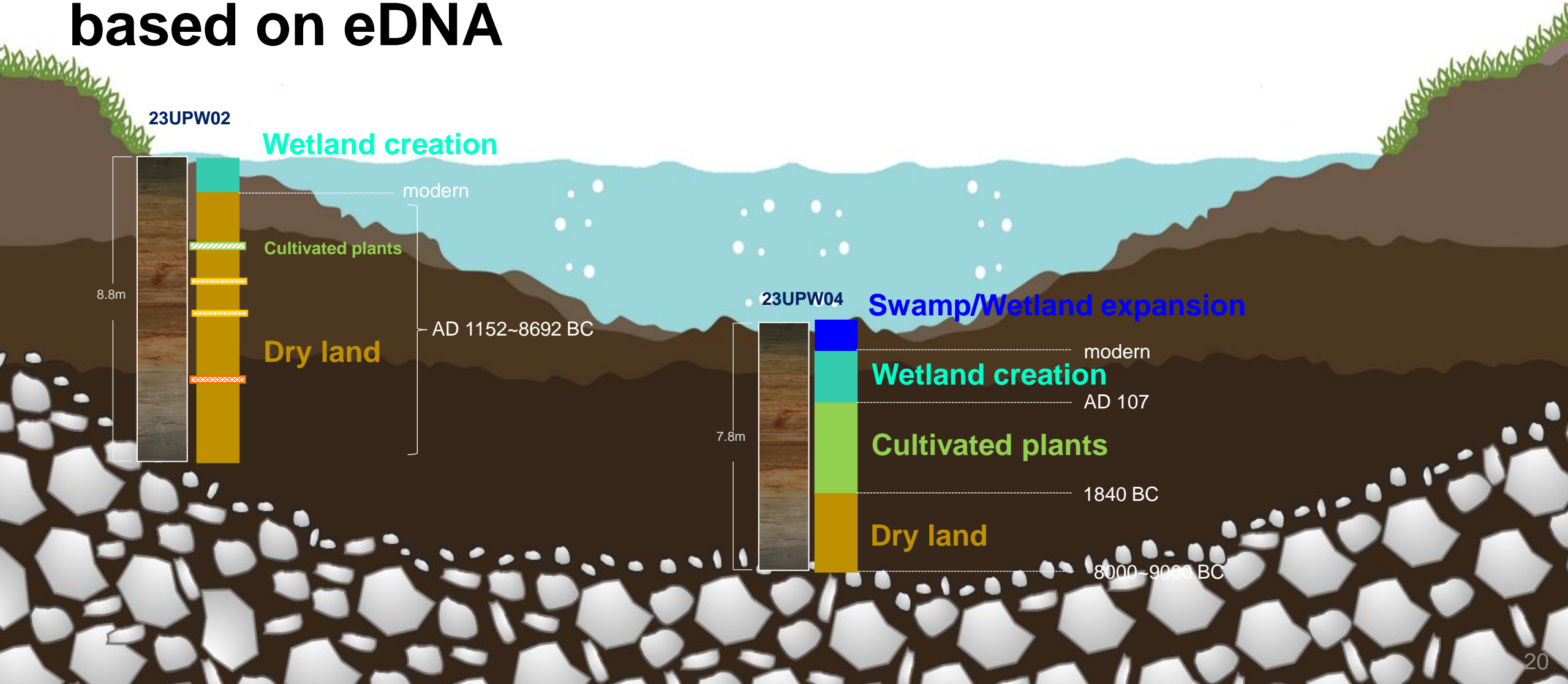
Cultivated plants

Temperate & tropical regions of E Asia

Mainly in tropical and subtropical Asia
JN, JJ in Korea

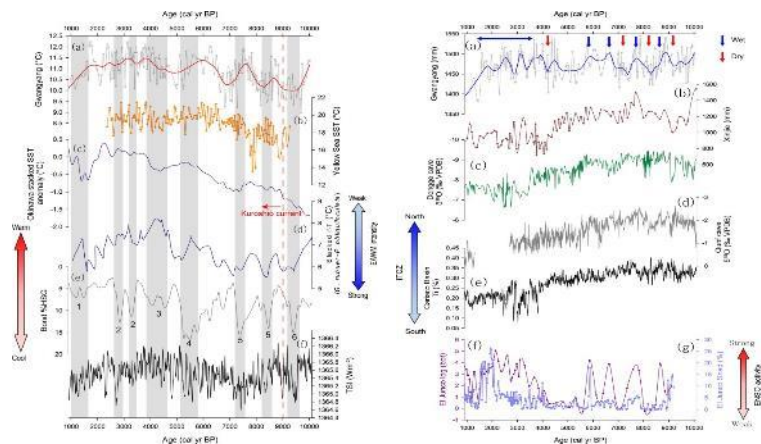
Schematic reconstruction

showing Holocene plant cover & wetland evolution **in the Upo Wetland**
based on eDNA

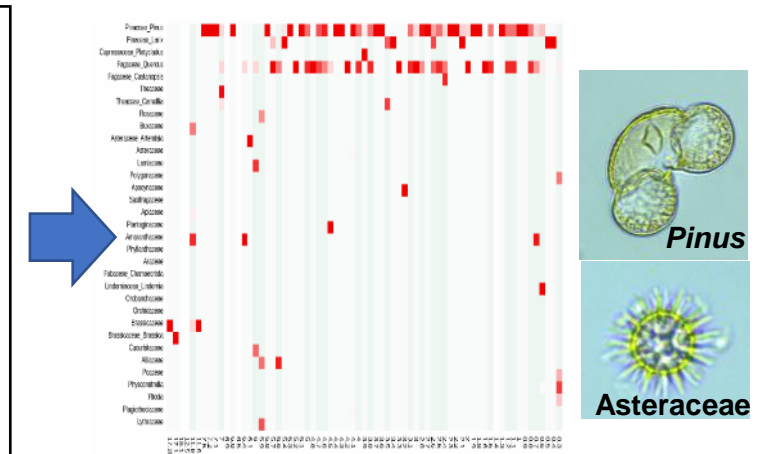
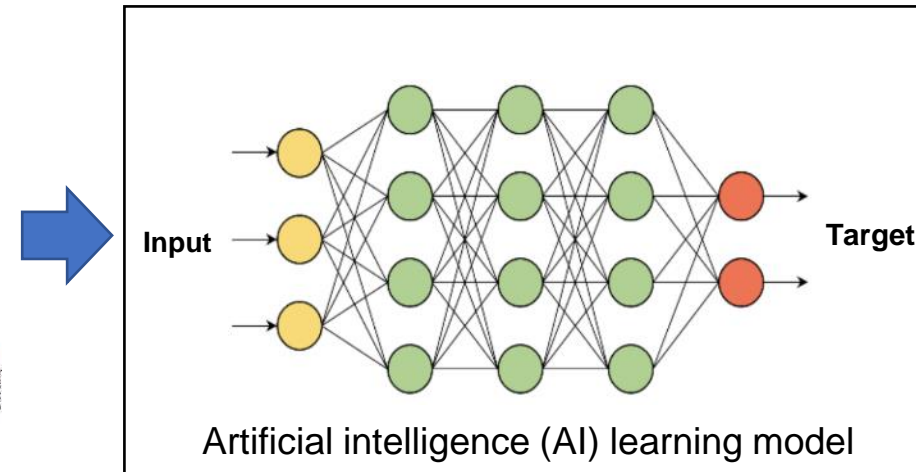


AI Model for Biodiversity Monitoring based on correlation analysis between past temperature and eDNA/pollen data in sediment layers

- A model utilizing correlations between Topyeong Stream eDNA & pollen data and temperature/precipitation trends
- Projecting future temperature data onto the established model to predict future species composition



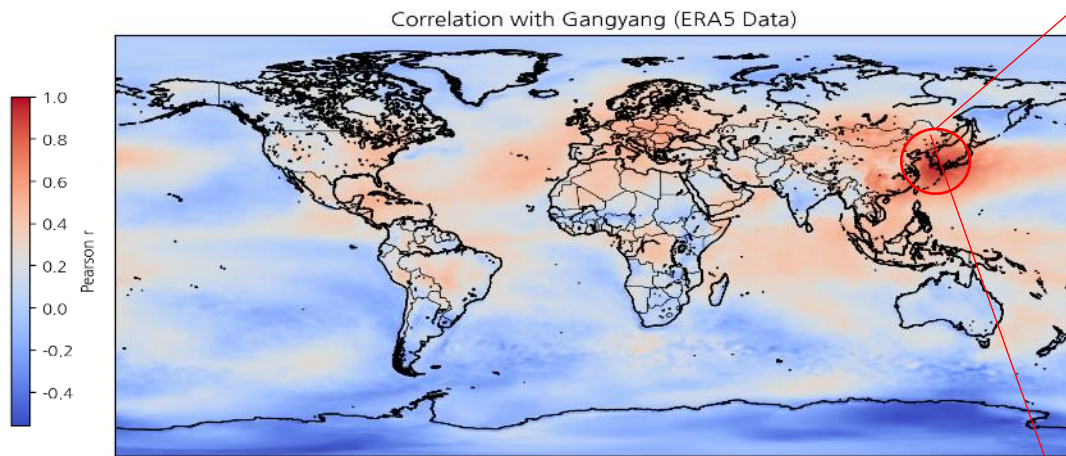
Temperature/precipitation data



eDNA/pollen data in sediment layers

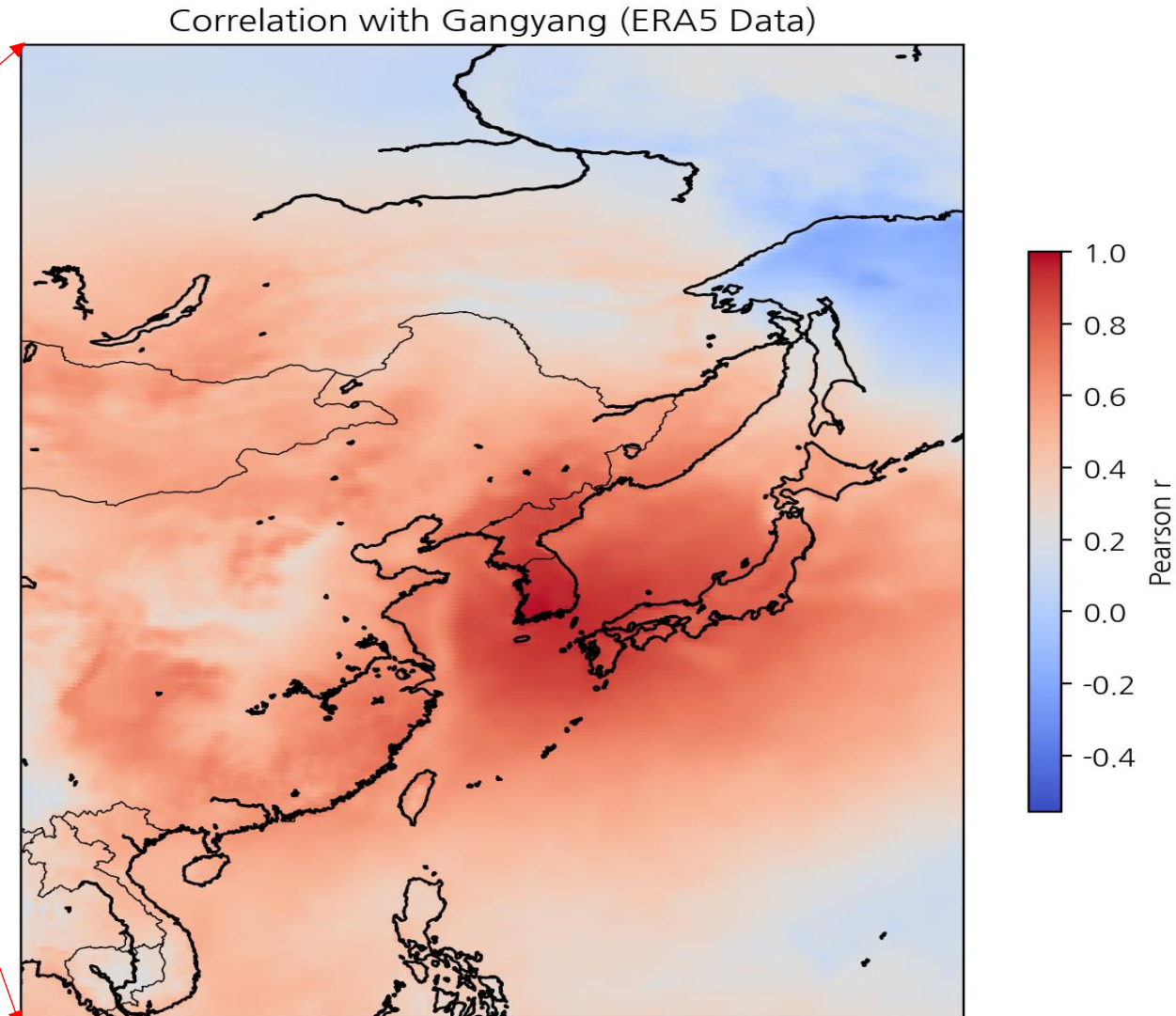
Reconstruction of past climate data for AI model development

- Applicable across the entire Korean Peninsula



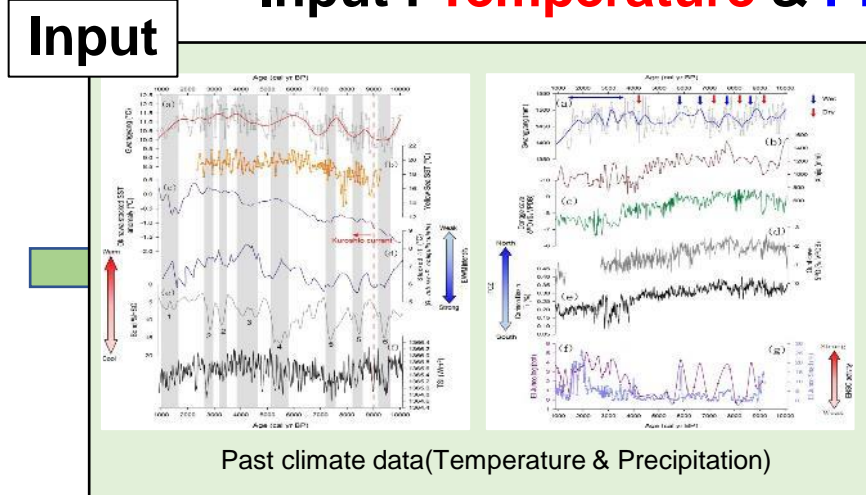
< Gwangyang model >

Category	Details
Period	8,000 years ago (Holocene)
Utilized Data	Pollen, Tann (Mean Annual Temperature), MTCO (Mean Temperature of Coldest Month), MTWA (Mean Temperature of Warmest Month), Pann (Annual Precipitation), Psum (Seasonal Precipitation)
Climate Information	Temperature & Precipitation
Data Coverage	89 locations across the Korean Peninsula
Temperature Trend	Declining temperature trend from the Holocene to the 2000s



AI Model for Biodiversity Monitoring based on correlation analysis between past temperature and eDNA/pollen data in sediment layers

- Input : **Temperature** & **Precipitation**

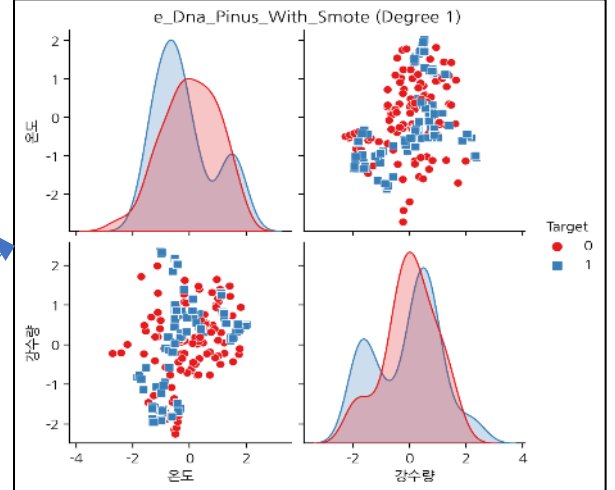


Slinear interpolation

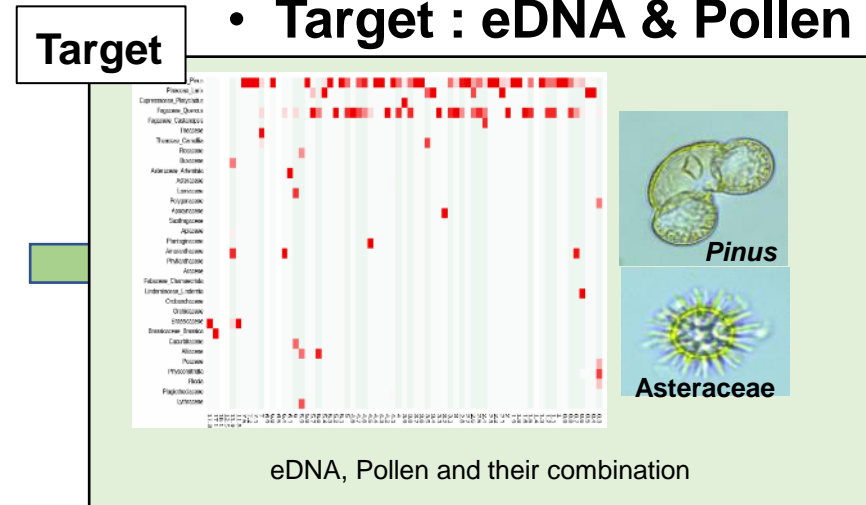
Scaling

- Degree1
- Degree2
- Degree3
- Shifted

SMOTE analysis



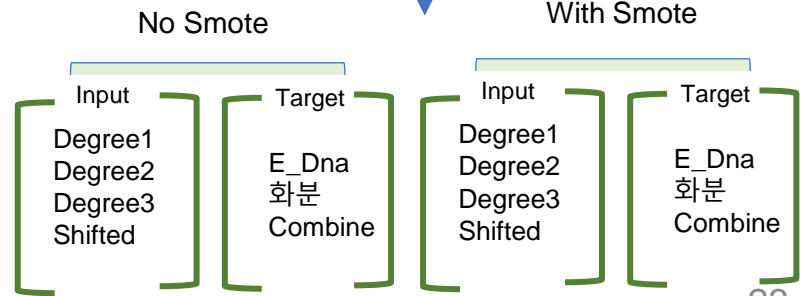
*Synthetic Minority Over-sampling Technique



eDNA

Pollen

eDNA + Pollen



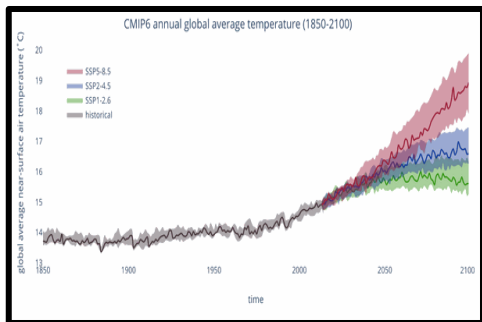
Application of CMIP6 future climate scenarios to the developed AI model system

- Prediction of vegetation changes under future climate change(Temperature & Precipitation)

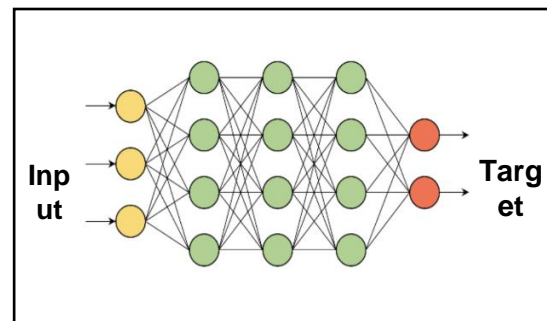
✓ **Tropical**

✓ **Temperate : *Pinus*, *Quercus***

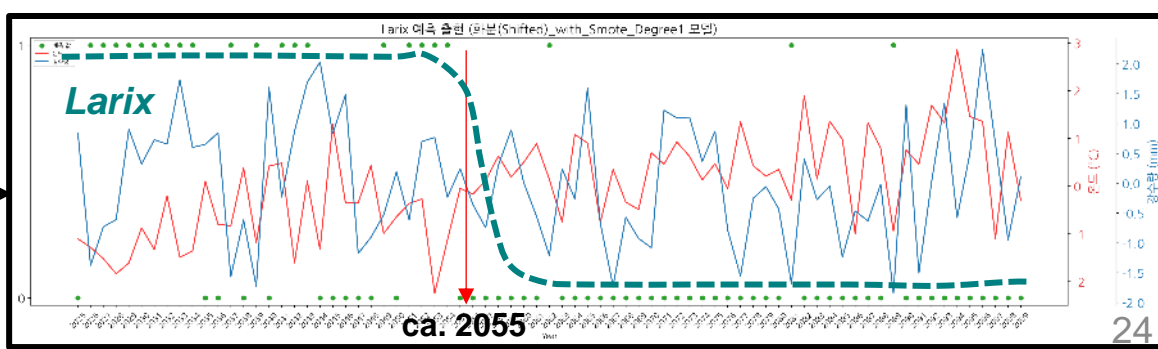
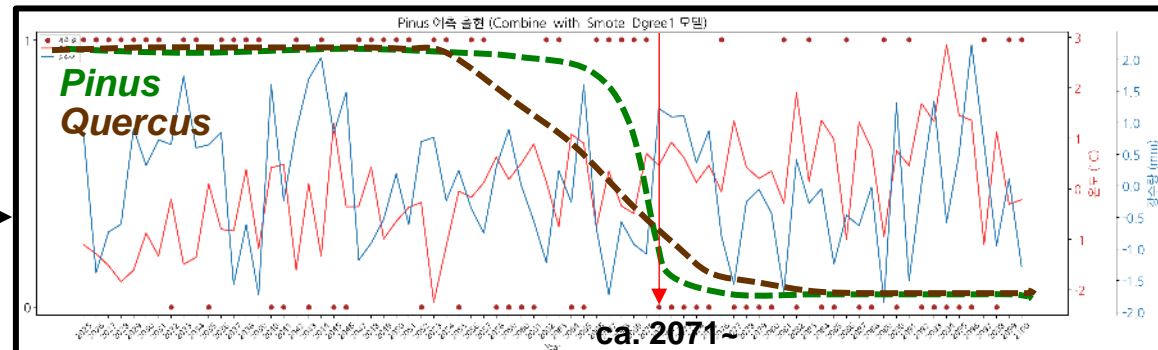
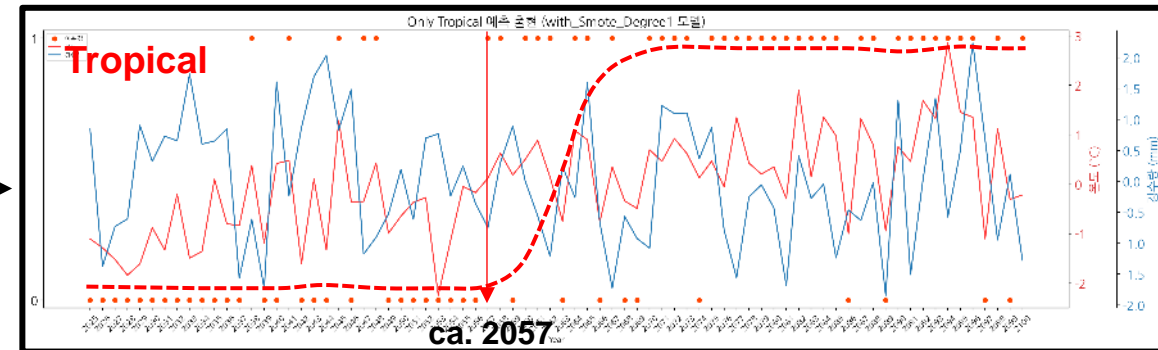
✓ **Boreal & cold temperate : *Larix***



Climate Change Projections(CMIP6)



Artificial intelligence (AI) learning model



* CMIP6 scenario assumes advancements in renewable energy and continuous eco-friendly economic growth.

Summary

- **We conducted eDNA analysis on past sediment layers in temperate regions** and confirmed its feasibility.
- **We demonstrated that analyzing eDNA from soil cores can help reconstruct past environmental changes.**
- Finally, we **attempted to develop an AI model prototype to predict future biodiversity changes based on the correlation between past climate change and taxa occurrences.**

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Deajeon University

Dr. Sang-Hun Oh

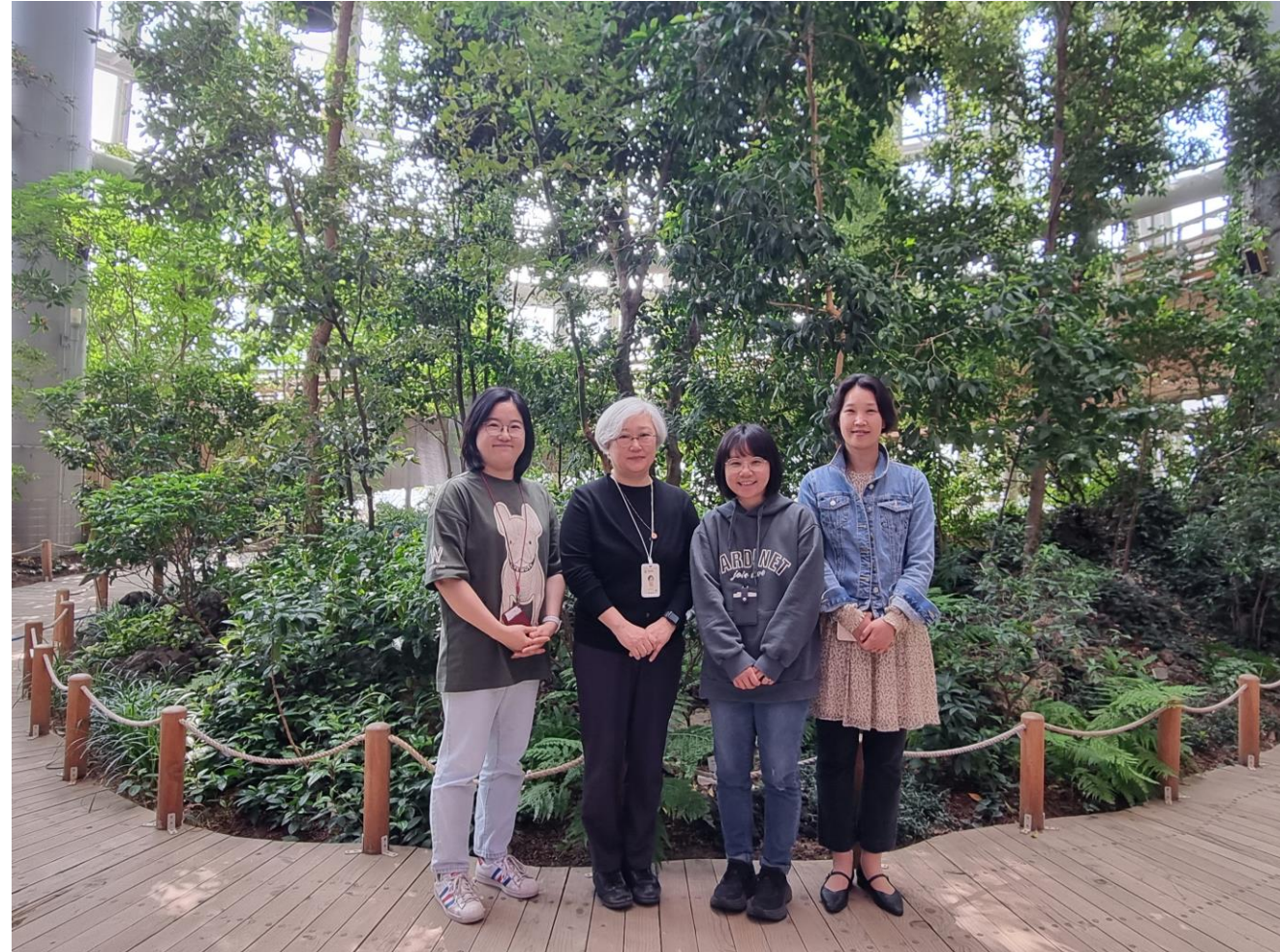
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Jeonnam National University

Dr. Jong-Yeon Park



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