"Evolutionary Biology and Biodiversity conservation: Scientific and Social Aspects"

Extinction risk analysis and biodiversity conservation

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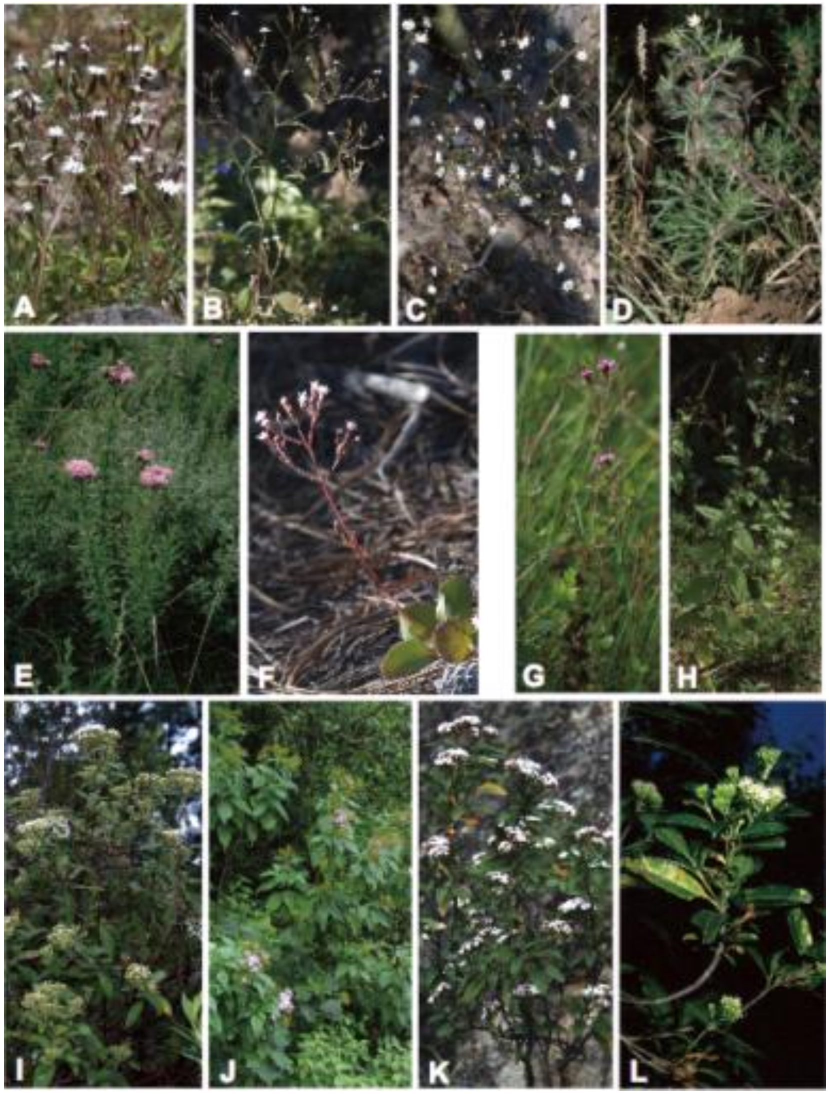
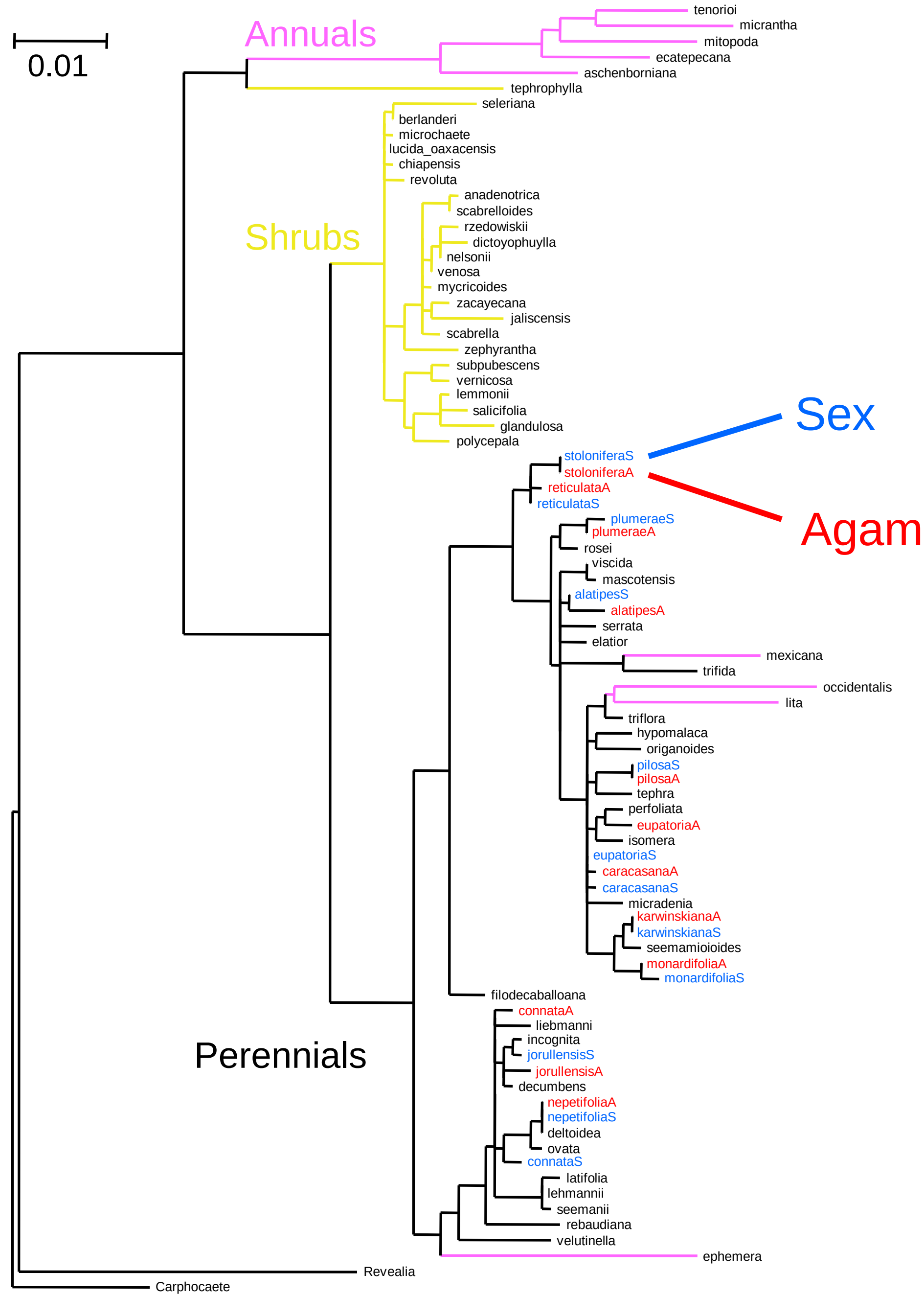
FAPESP auditorium in São Paulo, 10-11 November 2008

Phylogeny of Stevia





Genetic backgrounds of floral traits in daylily and nightlily

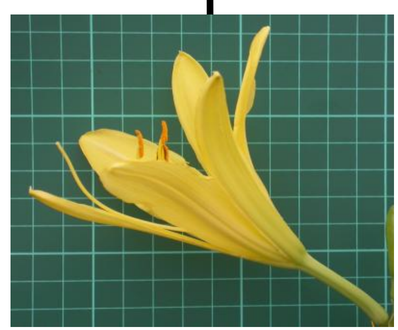
H. fulva

H. citrina

F1

Crossing experiments:
A. A. Yasumoto
Segregation analysis in F2:
K. Nitta

F2



Three key questions in biodiversity conservation

- How rapidly are we loosing species diversity?
  - *Assessment*: Extinction risk analysis for 1,697 vascular plant taxa in Japan
- How efficiently can we conserve species diversity?
  - *Technology*: Conservation of all plant species by transplanting forest blocks
- How quantitatively can we describe “niches” of threatened species?
  - *Modeling*: Plant species diversity in Yaku Island

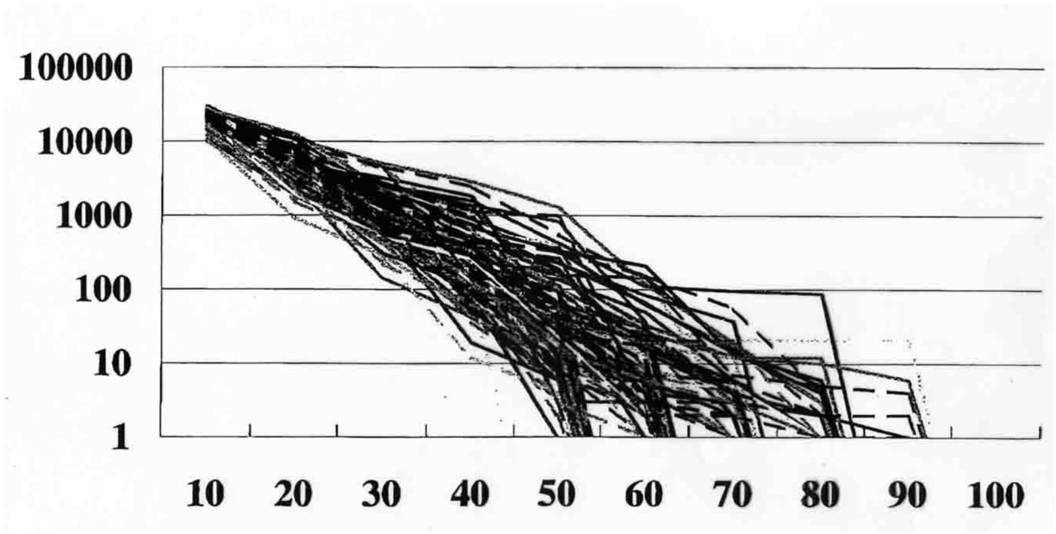
How have species been diverged & maintained?

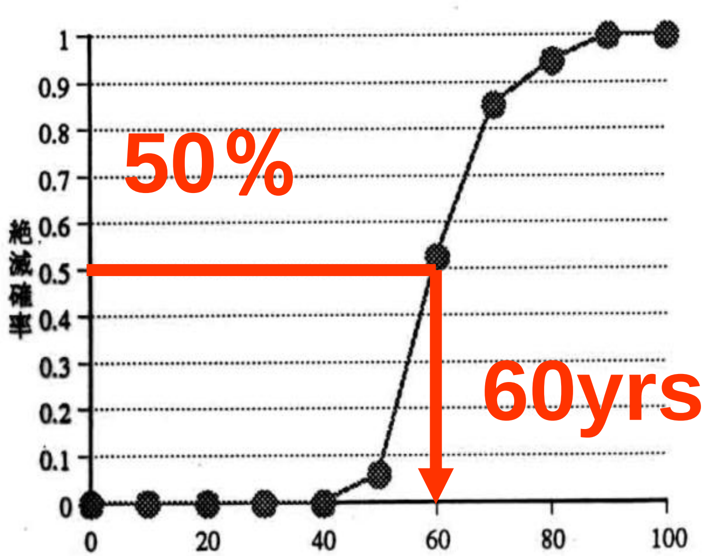
Red Data Book of Japanese vascular plants

Environment Agency (2000)

Extinction risk analysis

Population sizes & decline rates surveyed
for 1,549 taxa of vascular plants
in 4,457 grids of 100 km^2





In the case of Primula sieboldii

Extinction probabilities computed for 10-100 yrs

Revised red list (2007)

- 1,665 taxa (2000)→1,690 taxa(+25 in 2007)
  - CR: 564 → 523 （ -41 ）
  - EN: 480 → 491 （ +11 ）
  - VU: 612 → 676 （ +64 ）

2000

2007

	改訂前のレッドリストのランク								
新ランク	EX	EW	CR	EN	VU	NT	DD	ランク外	総計
EX	16		11				4	2	33
EW	1	5	2						8
CR	1		343	65	47	10	10	47	523
EN			148	211	72	7	5	48	491
VU			38	175	379	17	8	59	676
NT			2	22	103	105	1	22	255
DD	1		3		5		16	7	32
ランク外	1		17	7	15	6	8		54
総計	20	5	564	480	621	145	52	185	2072

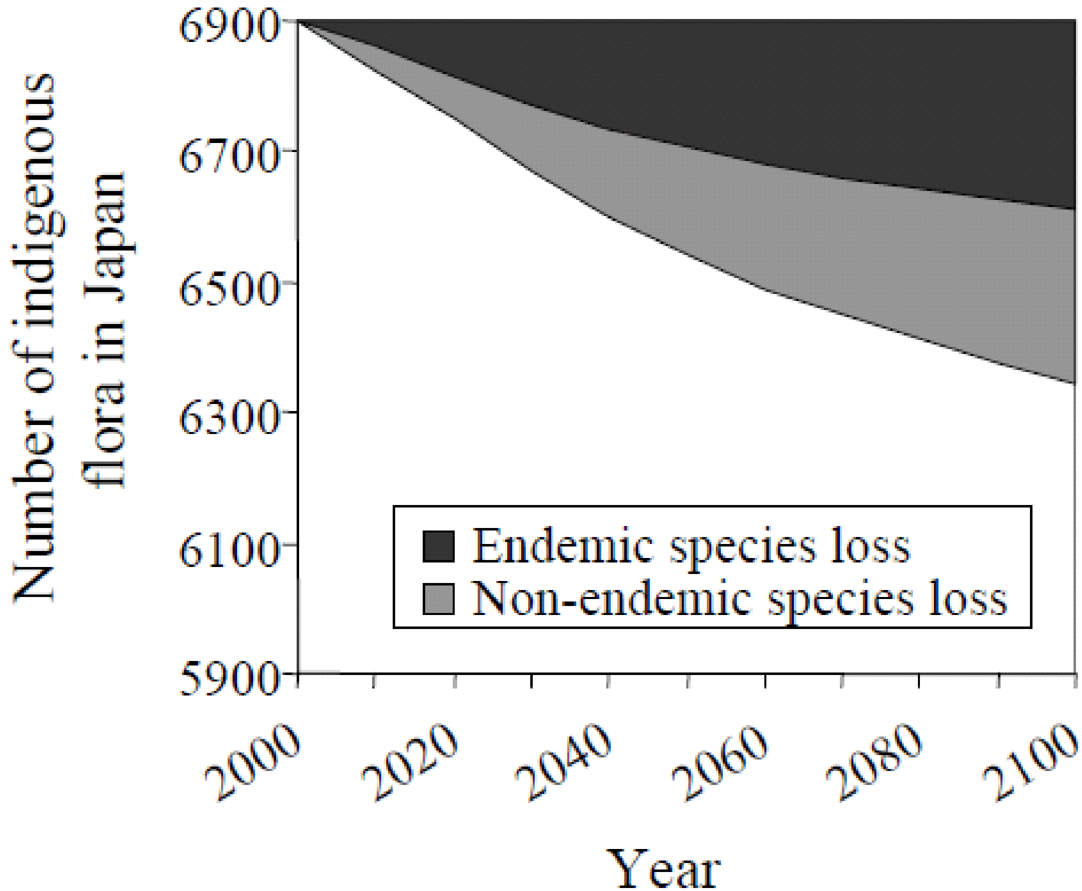
Transition during two surveys

		Population size in 1994-1995							
		Extinct	<10	<100	<1000	>1000	Uncertain	No answer	Sum
	Nearly Extinct	24	62	38	4		102	410	640
Population size in 2003-2004	Extinct	1069	199	148	45	11	345	704	2521
	<10	79	1633	446	62	9	377	2815	5421
	<50	44	312	1076	136	21	290	2387	4266
	<100	20	122	2301	311	43	266	1297	4360
	<1000	12	57	313	1066	151	183	1391	3173
	<10000	5	4	37	67	214	58	367	752
	>10000	3		7	10	65	10	77	172
	Uncertain	131	844	880	220	47	2923		5045
	No survey	23	88	67	9	2	103	1569	1861
	No answer	212	380	834	338	71	745	258	2838
	Sum	1622	3701	6147	2268	634	5402	11275	31049

More population declines than increases

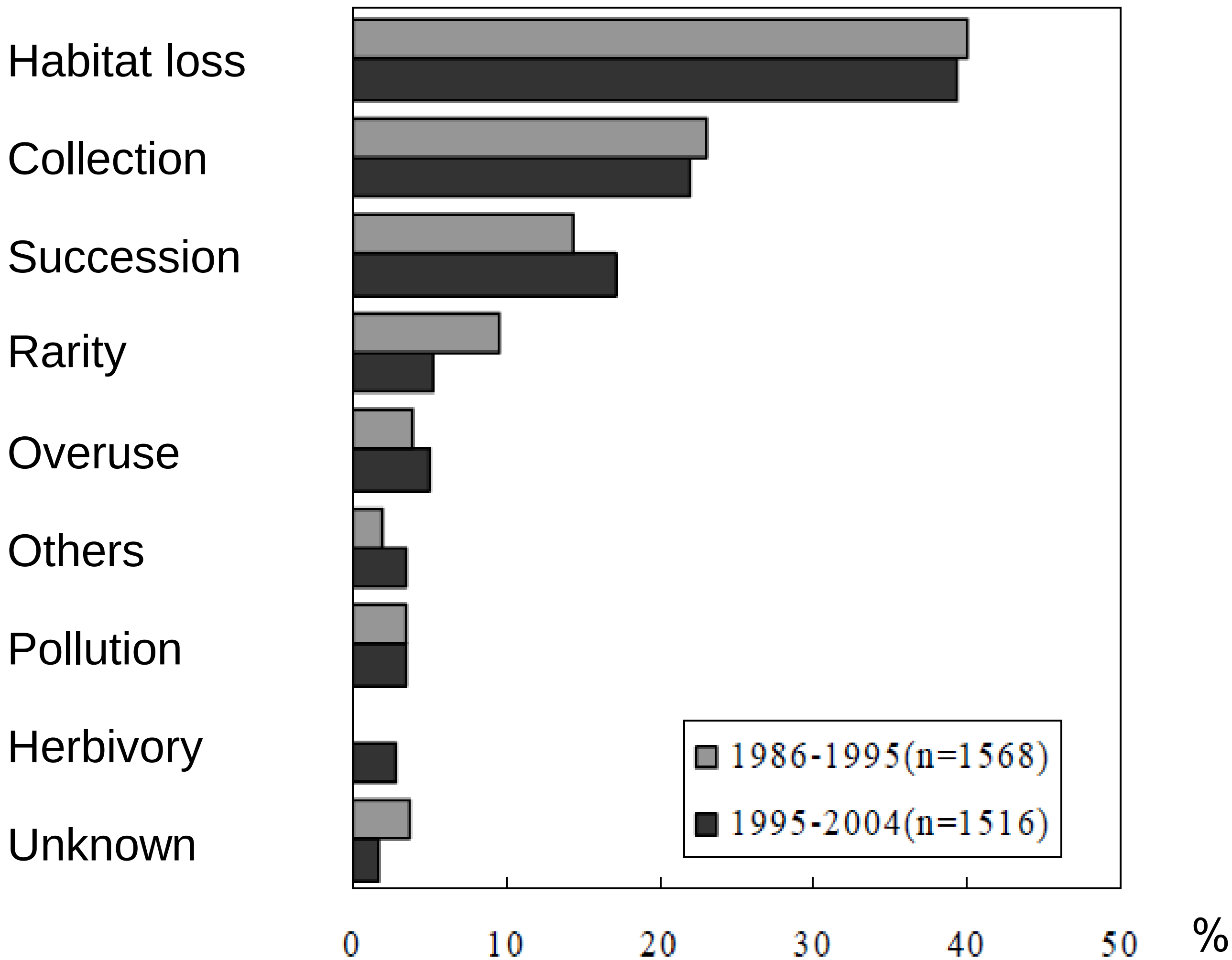
Projection for next 100 years

Based on extinction risk analysis for 1,697 vascular plant taxa



553 taxa
(7.9%)

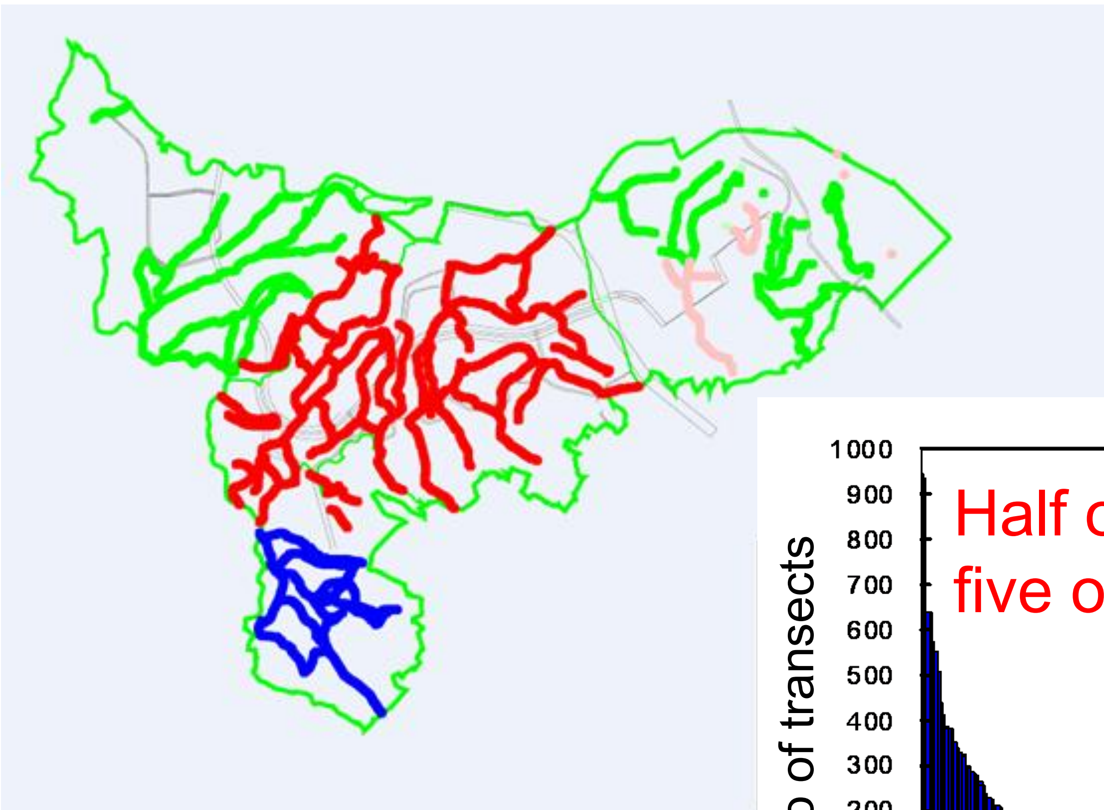
Major threats



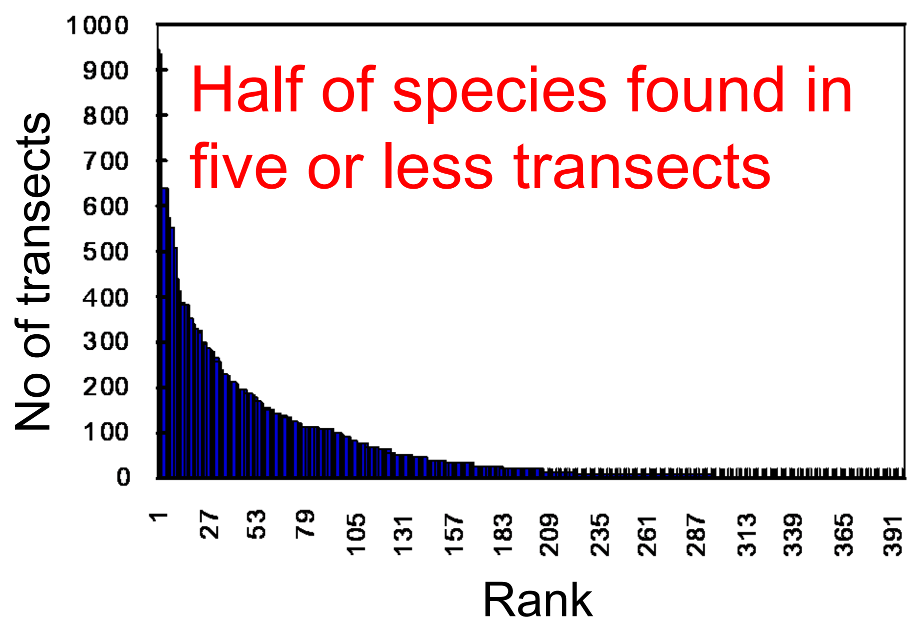
New campus of Kyushu Univ

Quantitative distribution surveys

List plant spp in 1300< transects of 10m×4m



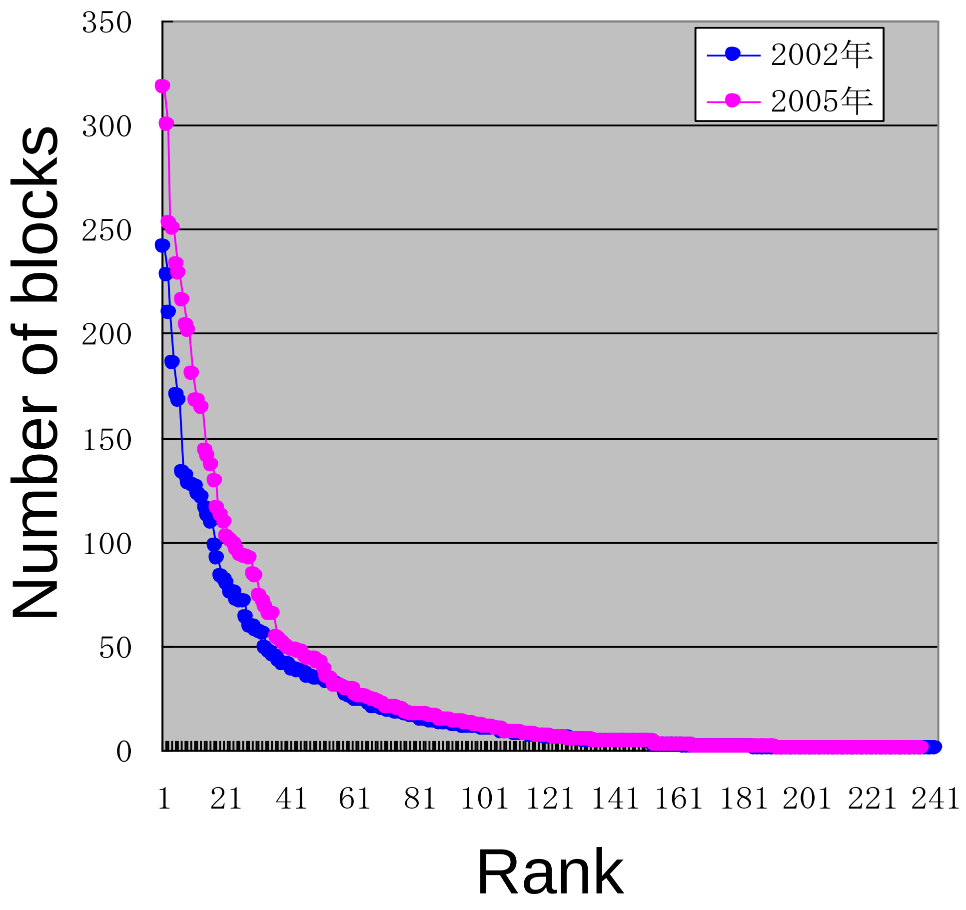
Goal:
conservation of
all plant species



Forest transplantation

Diversity in transplanted forest blocks

509 of ca. 4,000 blocks are being monitored.



In 509 blocks;

241spp in 2002

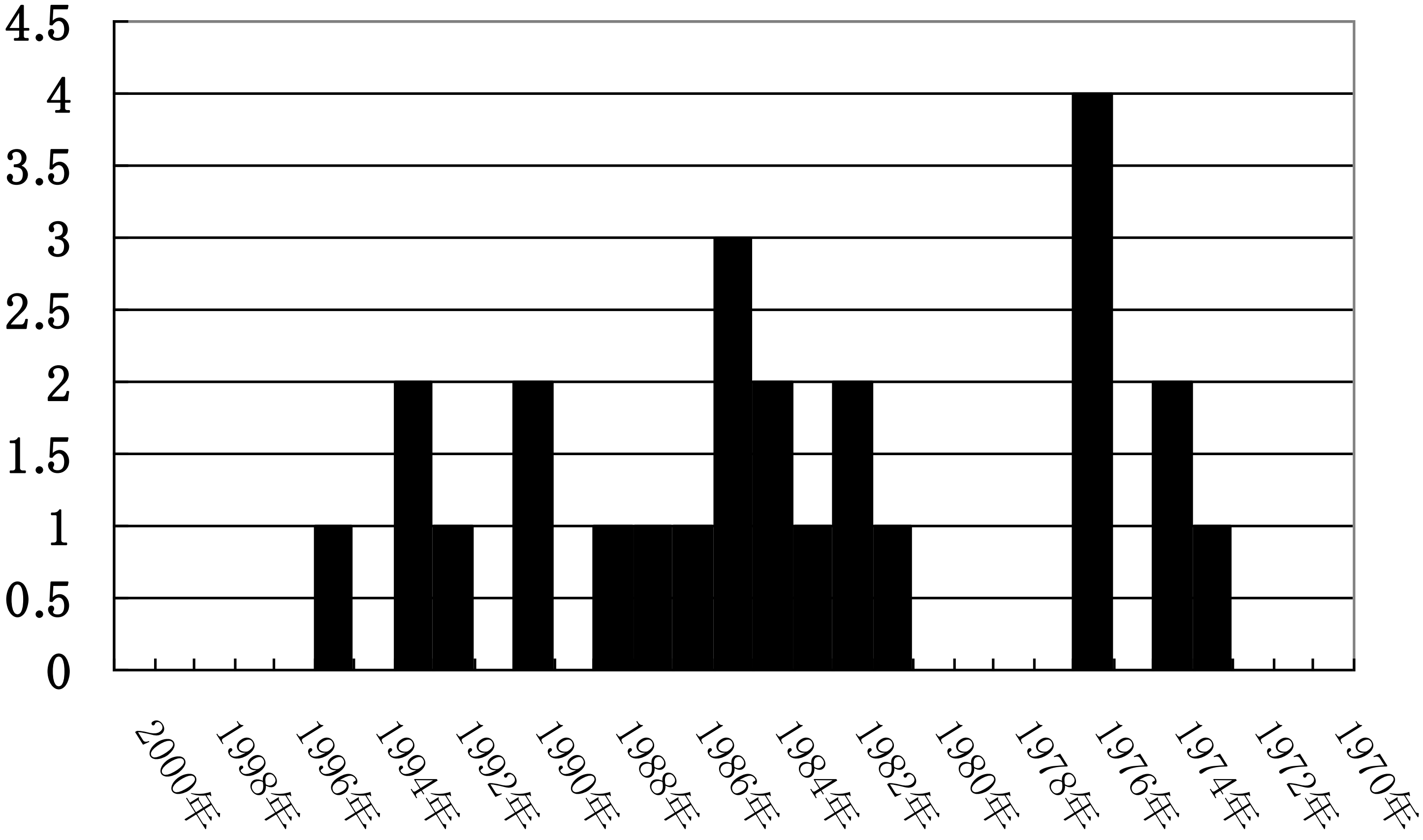
- 58spp

+ 54spp

237spp in 2005

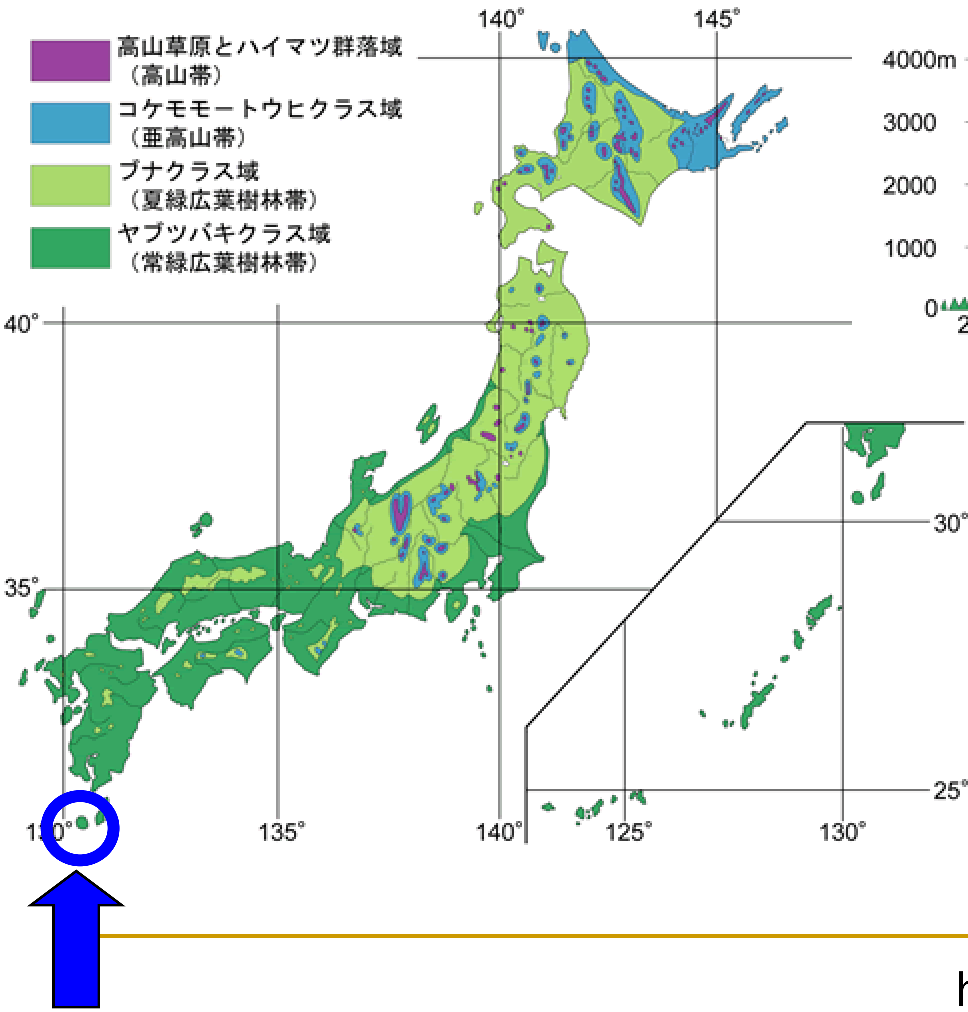
About half of species are found in <5 blocks

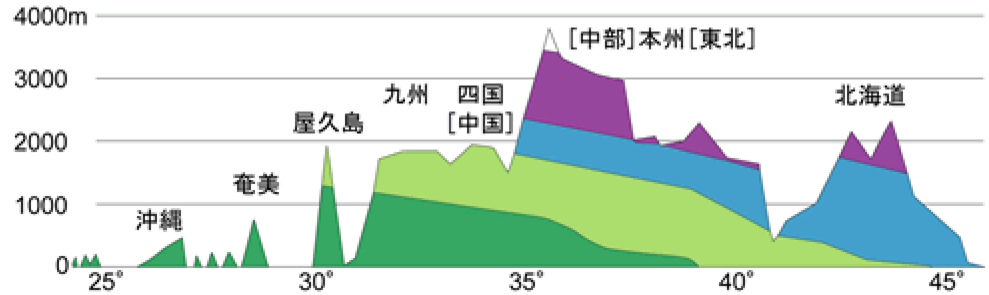
Age structure of soil seeds



Estimated by Tandem Accelerator Mass Spectrometry

Vegetation of Japan



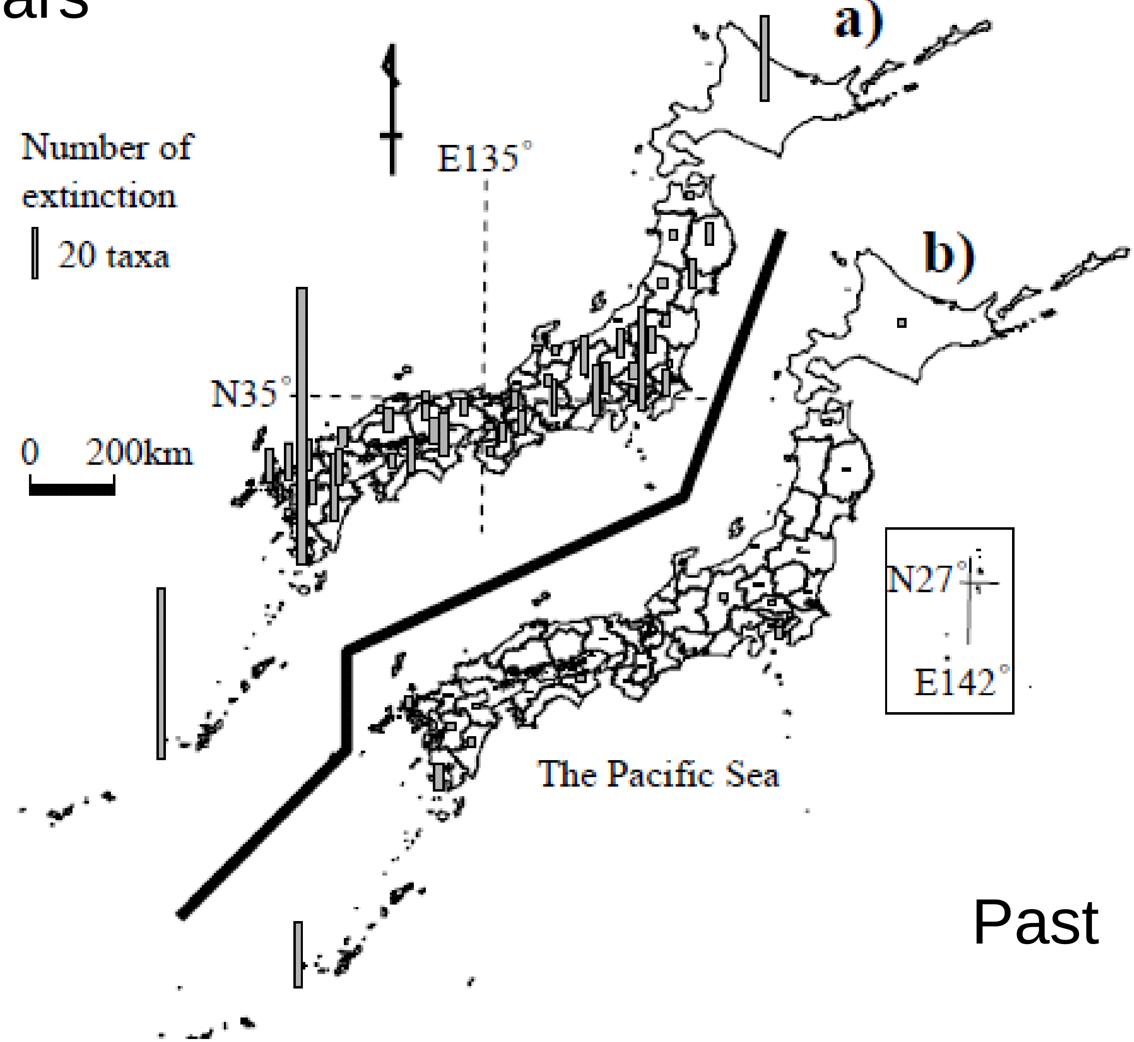


Yaku-shima (Yaku Island)

http://www.vegetation.jp/zu/index.html

Extinction / Prefecture

Next 100 years



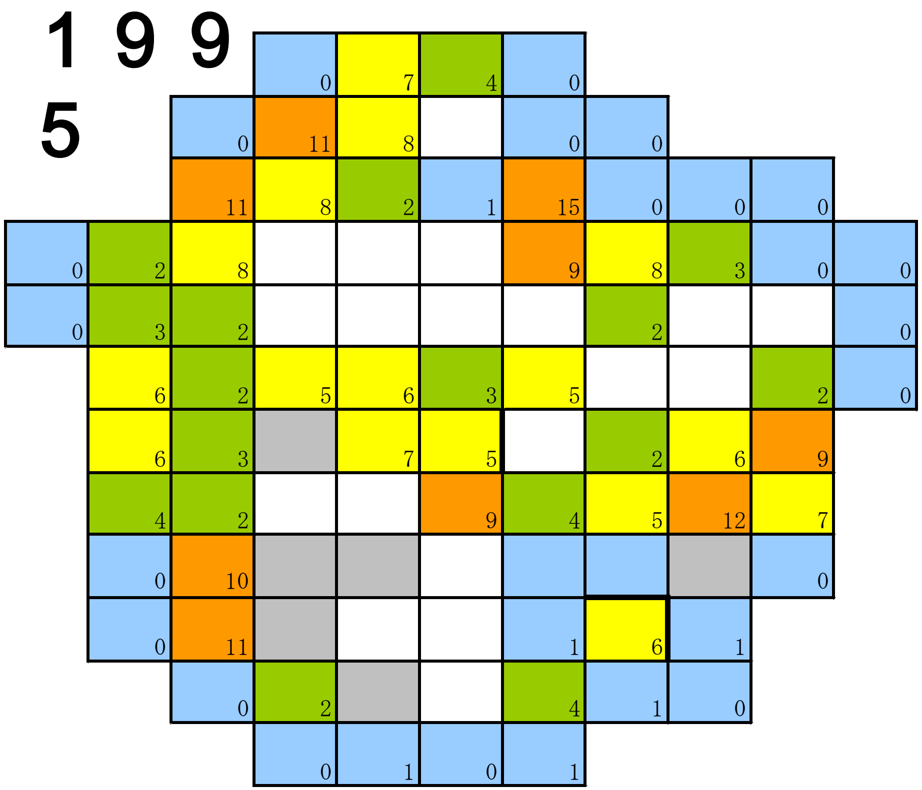
Past

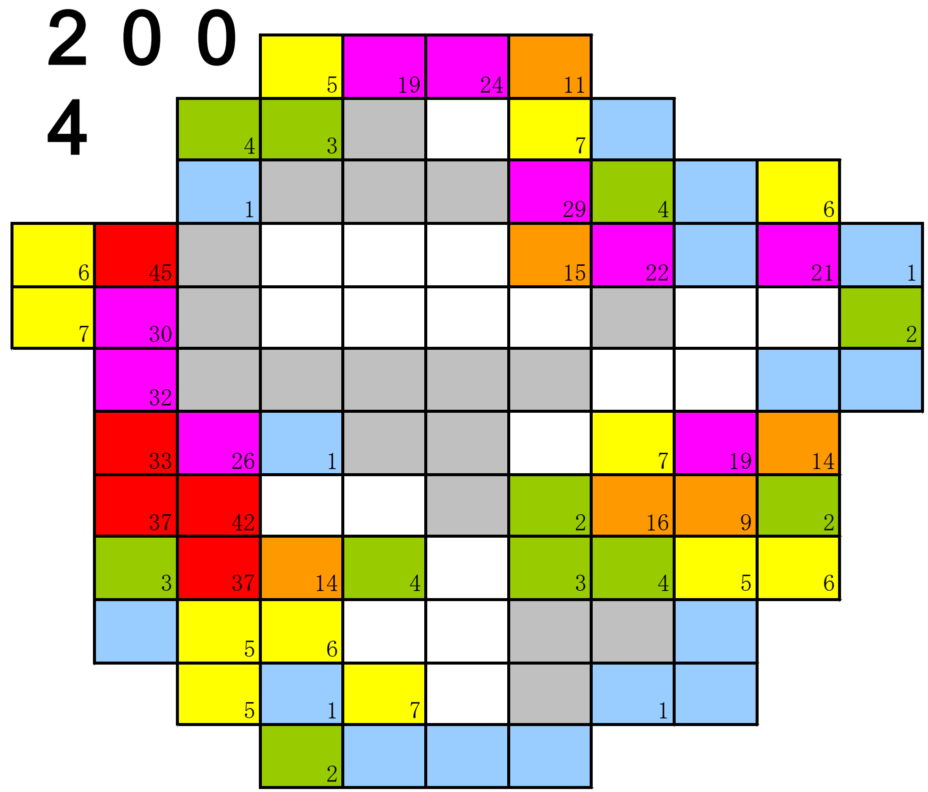
Yaku deer threatens endemic plants of Yaku Island

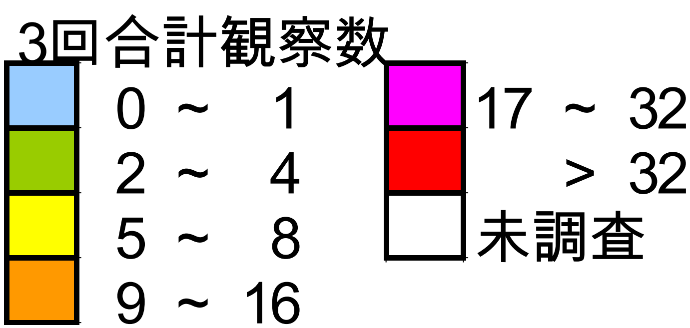
Endemic plants in Yaku Island:
47 spp, 2 subspp, 30 varieties
(Yahara et al 1987)

An endemic subspecies of Japanese Shika deer

Changes in deer counts

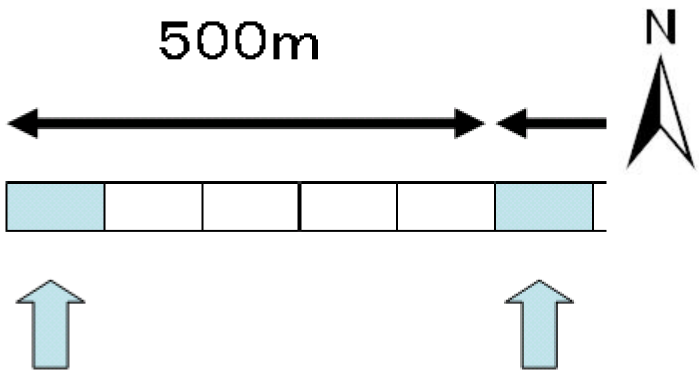




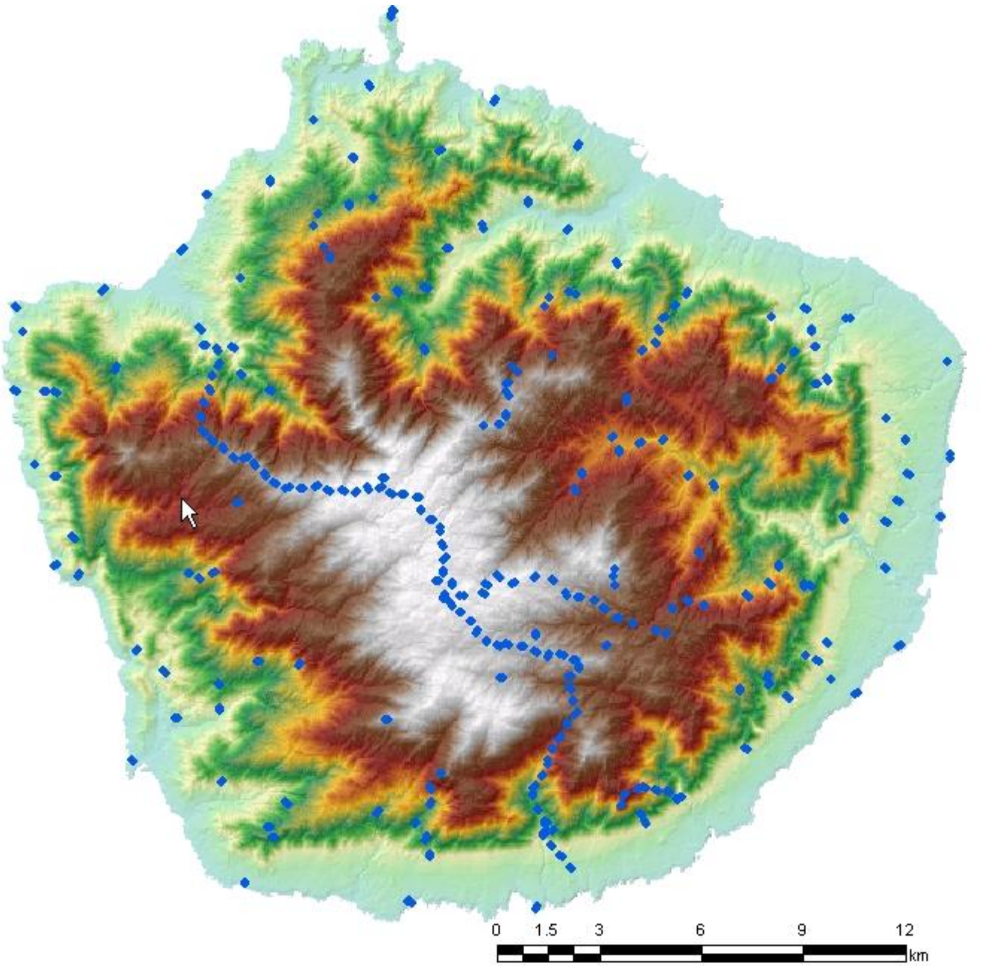


Counting deer at night

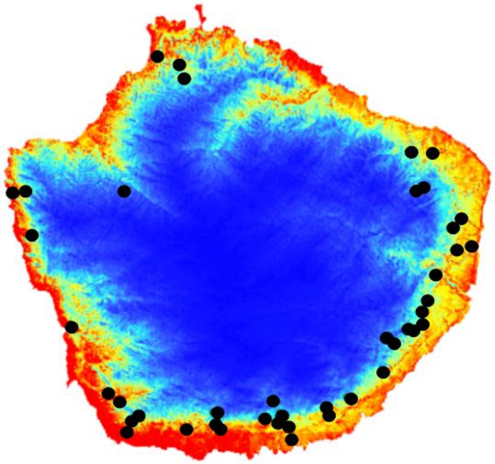
Distribution surveys in Yaku Island



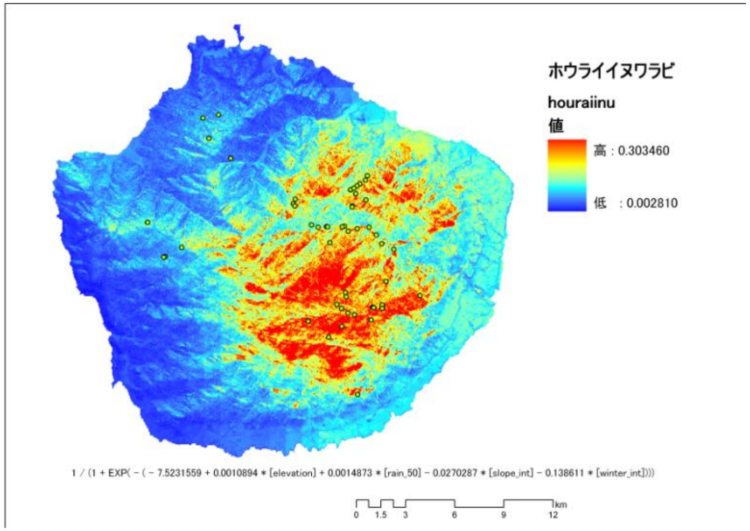
- List all spp of vascular plants in a transect of 100m x 4m
- 270 transects

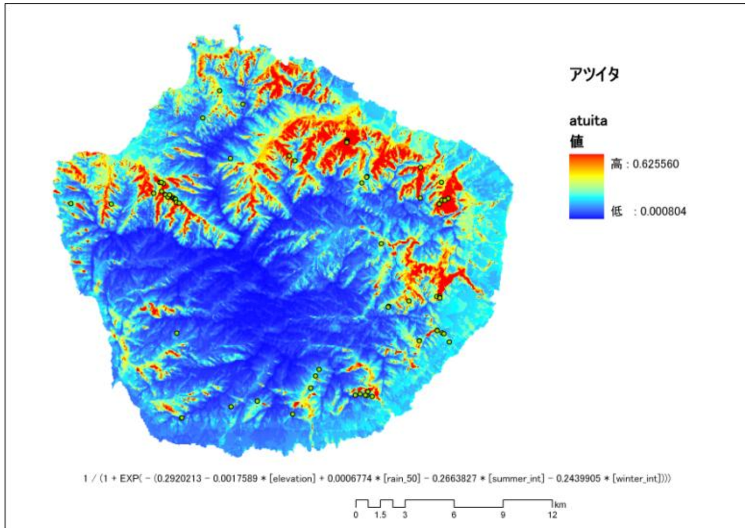


Ecological niche modeling



$$\log \frac{p}{1-p} = ax + by + ... + c$$





By Satoshi Tagawa

Models with deer density (*d*)

Calanthe triplicata

Univariate model

$$\log\frac{p}{1-p} = \underline{-0.33d} + c$$

Multivariate model

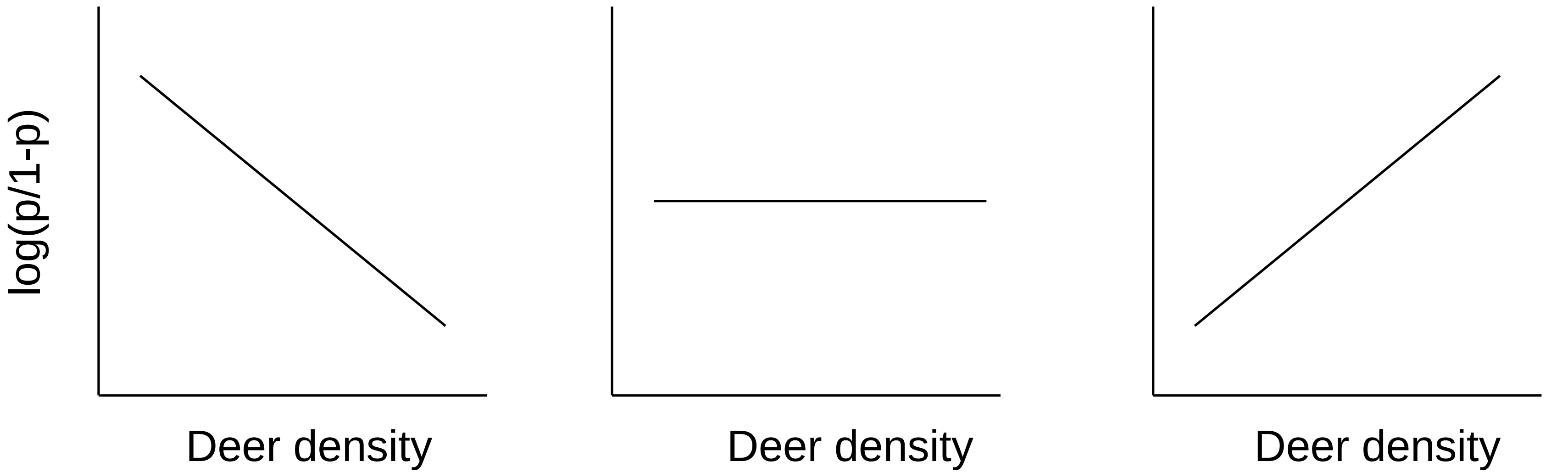
$$\log\frac{p}{1-p} = \underline{-4.02d} + 40.62Elev - 130.4Elev^2$$

$$-12.21sumI + 12.66sumI^2$$

$$-6.76winI + 8.42winI^2 + a + c$$

By Satoshi Tagawa

Sister species comparison



Calanthe triplicata C. arismaefolia		
Athyrium masamunei	A. tozenense	
Athyrium reflexipinnum	A. palustre	
Chionographis japonica		C. koidzumiana

Conclusions for three key questions

- How rapidly are we loosing species diversity?
  - 8 % loss of vascular plants during next 100 yrs.
- How efficiently can we conserve species diversity?
  - Forest block transplantation is an efficient solution.
  - Management of shika deer is a new challenge.
- How quantitatively can we describe “niches” of threatened species?
  - Logistic regression for presence/absence data provides a predictable model,
  - even when “realized niches” are changing.

More general questions

- How have many species been diverged and maintained?
- How frequently do sister species differ
  - in resistance to natural enemies
  - in altitudinal distribution
  - in microhabitat preference
  - in flowering time
  - in reproductive system
  - in polyploidy
  - etc ?

Two basic findings in Yaku Island

- Altitude is a primary determinant of “niche”.
  - usually selected as an explanatory variable in the best model under AIC
- Many tree species have similar altitudinal “niches”.

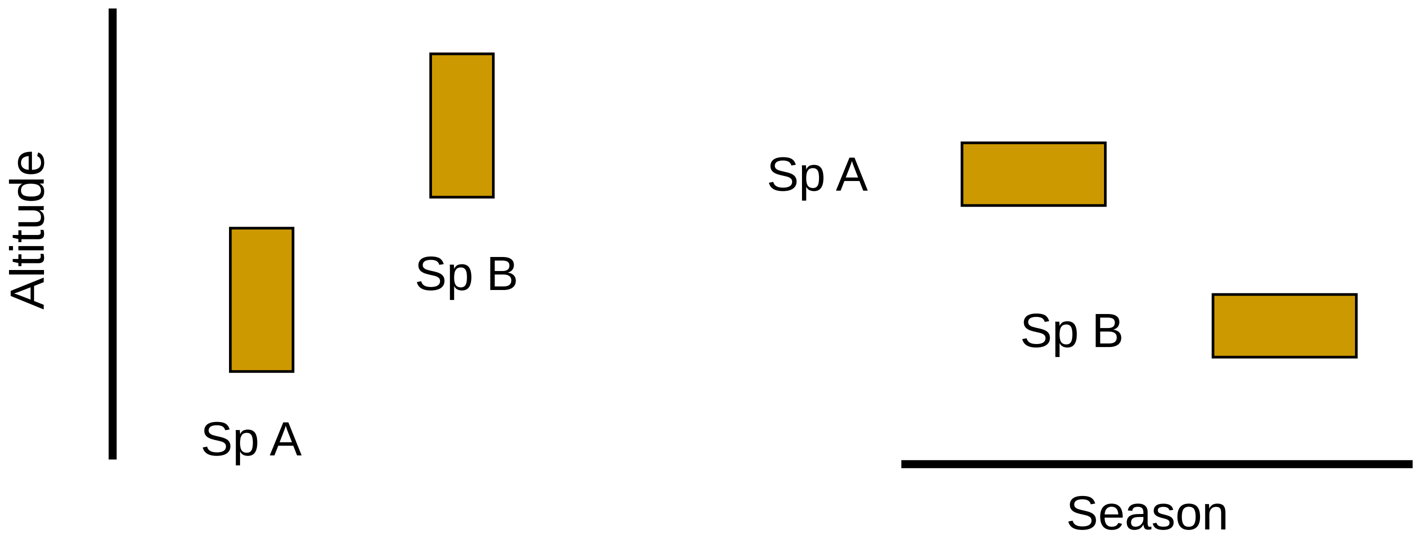
Lauraceae 100m 1400m

Machilus thunbergii	1	1	1	1	1	1																				
Machilus japonica	1	1	1	1	1	1	1	1	1	1	1															
Neolitzea sericea		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1										
Neolitsea aciculata	1	1	1	1	1	1	1	1	1	1	1	1	1													
Cinnamomum camphora	1	1																								
Cinnamomum tenuifolium	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1										
Litzea cubeba				1																						
Litzea acuminata		1	1	1	1	1	1	1	1	1	1															
Lindera erythrocarpa																			1	1	1	1	1	1	1	1

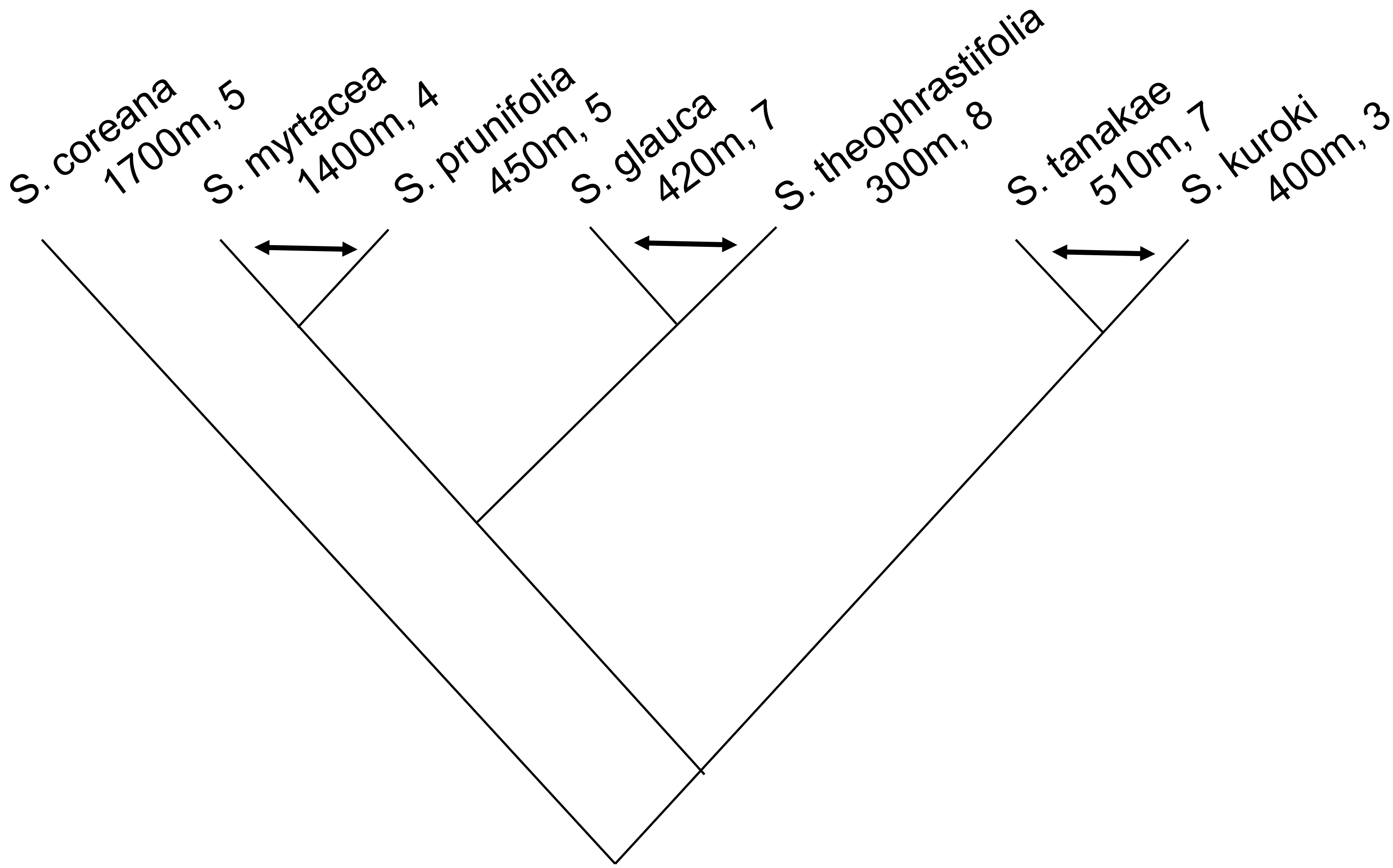
Altitudinal gradient

A simple hypothesis

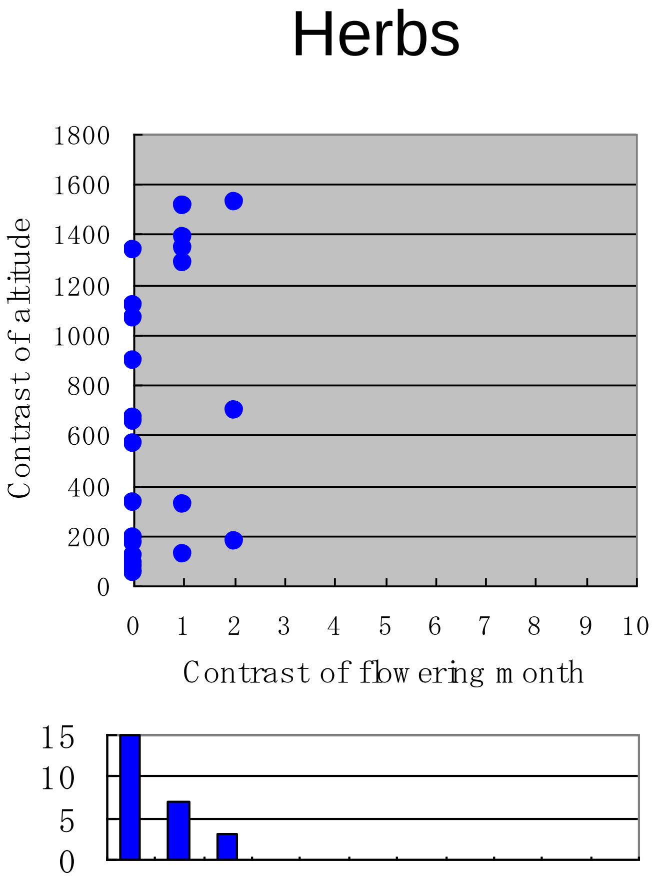
- Seasonal isolation is more important than spatial isolation in tall trees

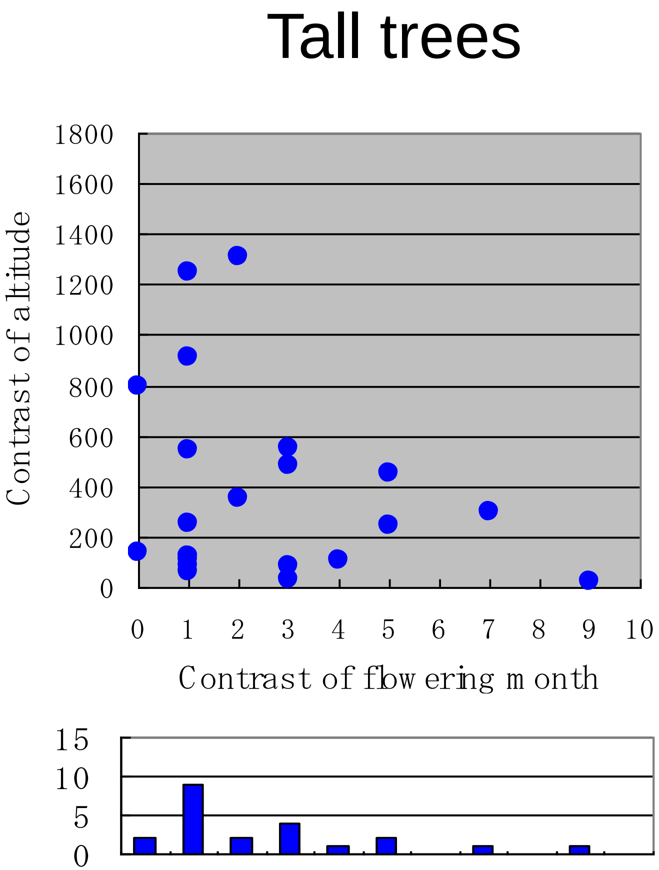


Sister species comparison in *Symplocos*

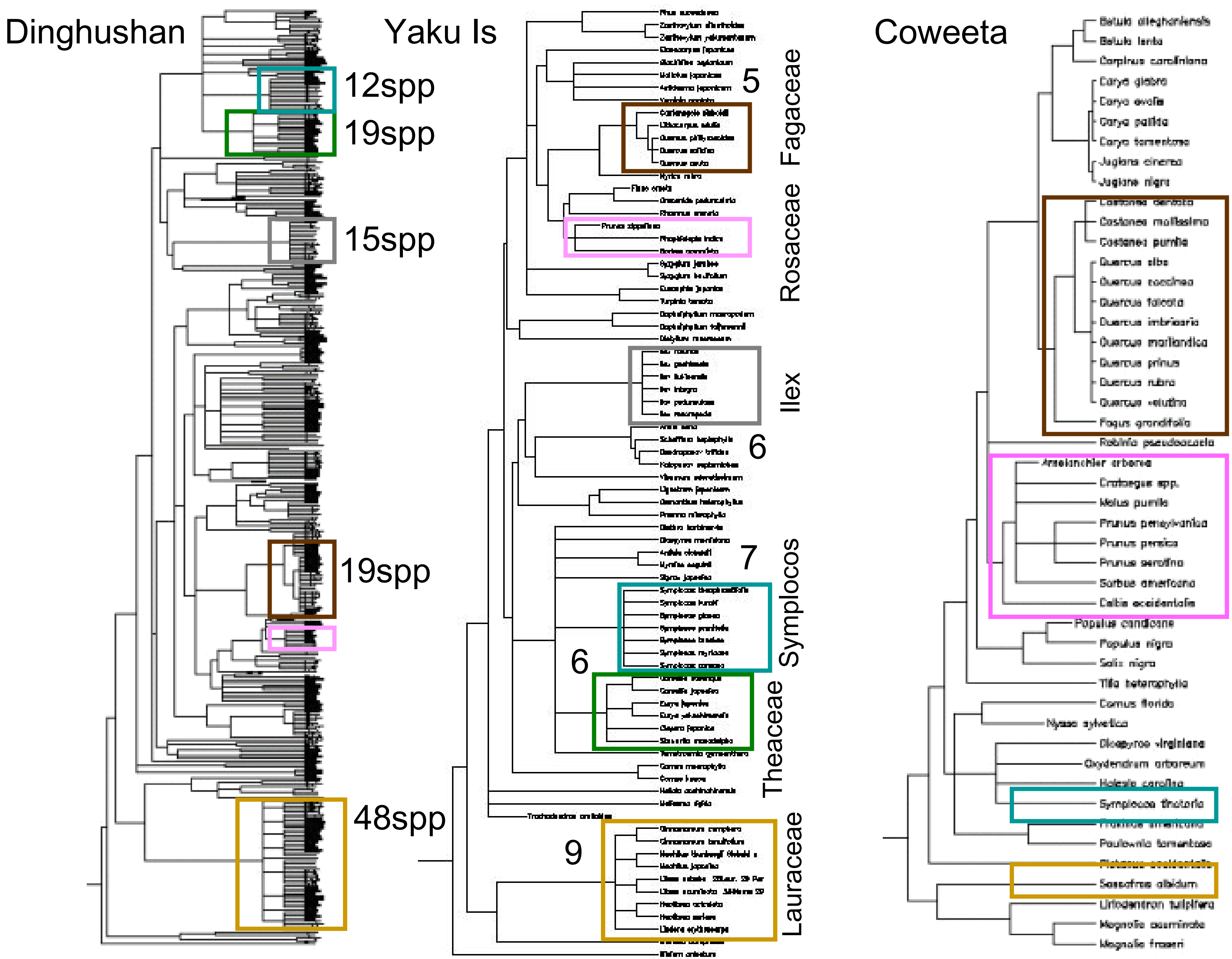


Comparison of independent contrasts





Shorter winter may explain geographical gradients of tree species diversity



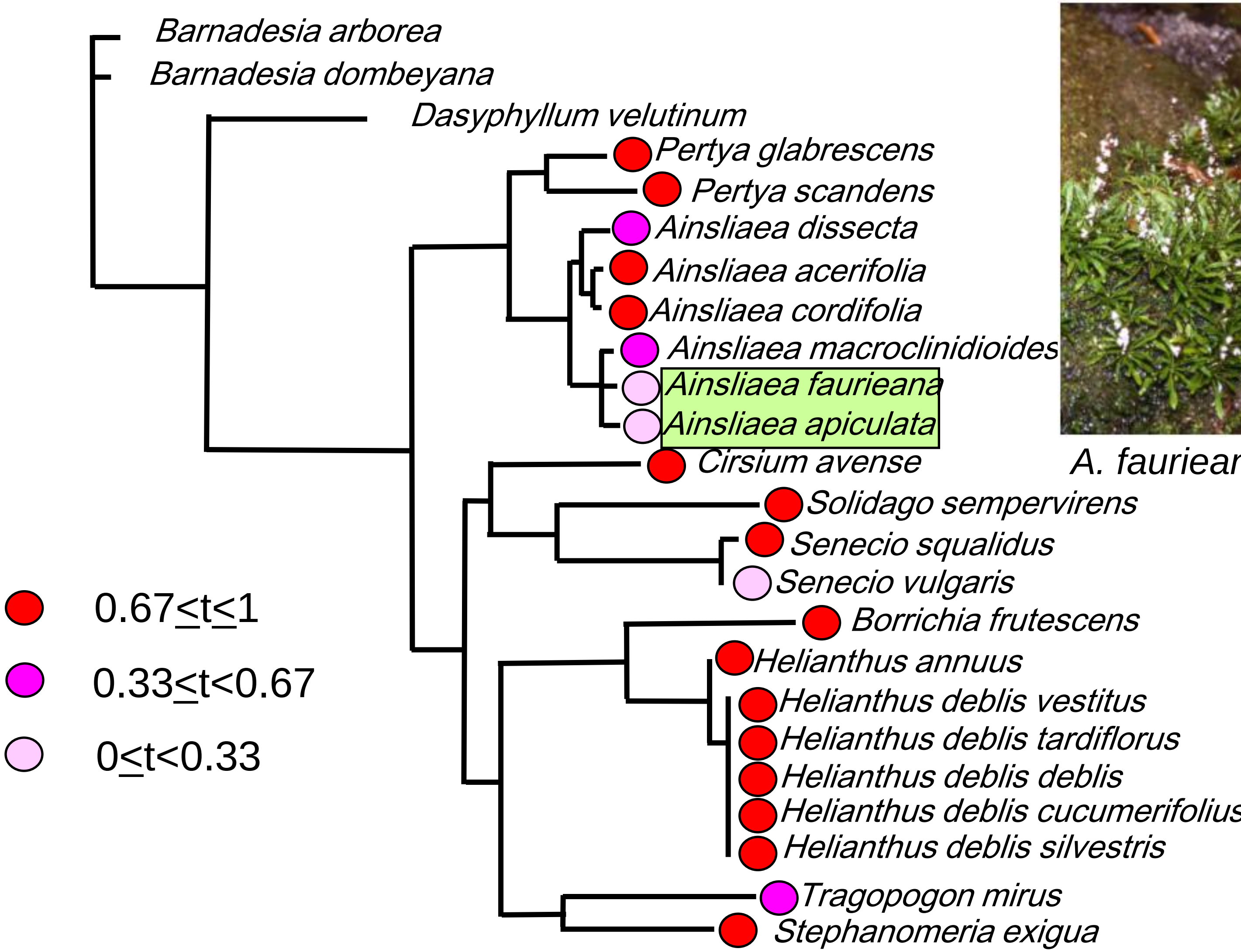
Drawn with Phylomatic (Webb & Donoghue 2005)

Reproductive system changes between sister species; cases in Yaku Island

- Tall trees; 1 / 21 pairs
  - *Camellia* spp (bee vs bird pollination)
- Shrubs; 1/13 pairs
  - *Rhododendron* spp (bee vs butterfly)
- Herbs; 4/27 pairs
  - *Ainsliaea* spp (chasmogamous vs cleistogamous)
  - *Chionographis* spp (outcrossing vs selfing)
  - *Calanthe* spp (outcrossing vs selfing)
  - *Pellionia* spp (sexual vs agamospermous)

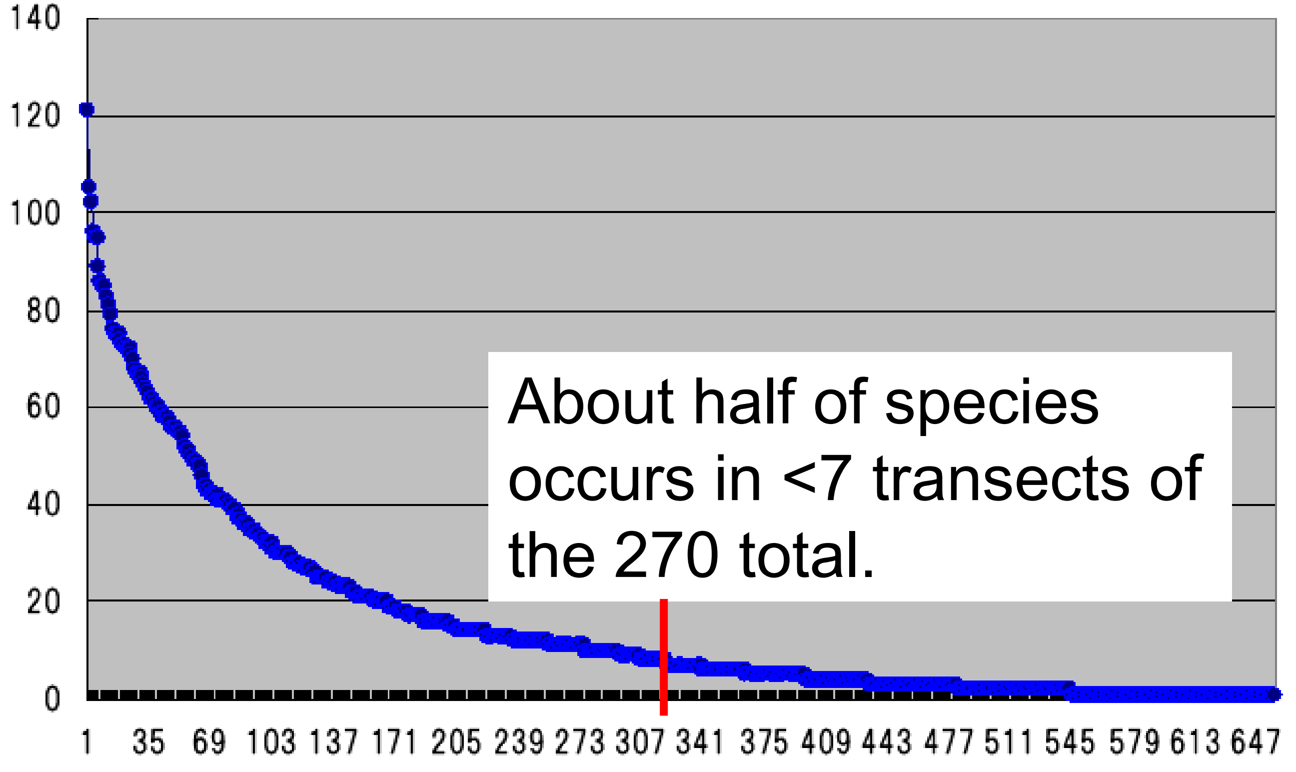
Less frequent in tall trees which show frequent changes in flowering season

Outcrossing rate changes in Asteraceae



A. faurieana A. apiculata

Rank-abundance relationship in Yaku Is



- Random demographic process under dispersal limitation
  - Especially in tall trees; except for reproductive processes
- Why some species are rare remains uncertain

How is species diversity maintained?

- Many trees are similar in altitudinal distribution and probably in eco-physiological traits, but diverged in flowering season.
  - Random demographic process under dispersal limitation is a primary determinant of species diversity.
  - Large area is critical in conserving species diversity.
- Many herbs are diverged in altitudinal distribution and microhabitat.
  - Spatial niche differentiation is a primary determinant of species diversity.
  - Habitat heterogeneity is critical in conserving species diversity.