Wild chimpanzees in fragmented habitat: Diversity in genetics and behavior

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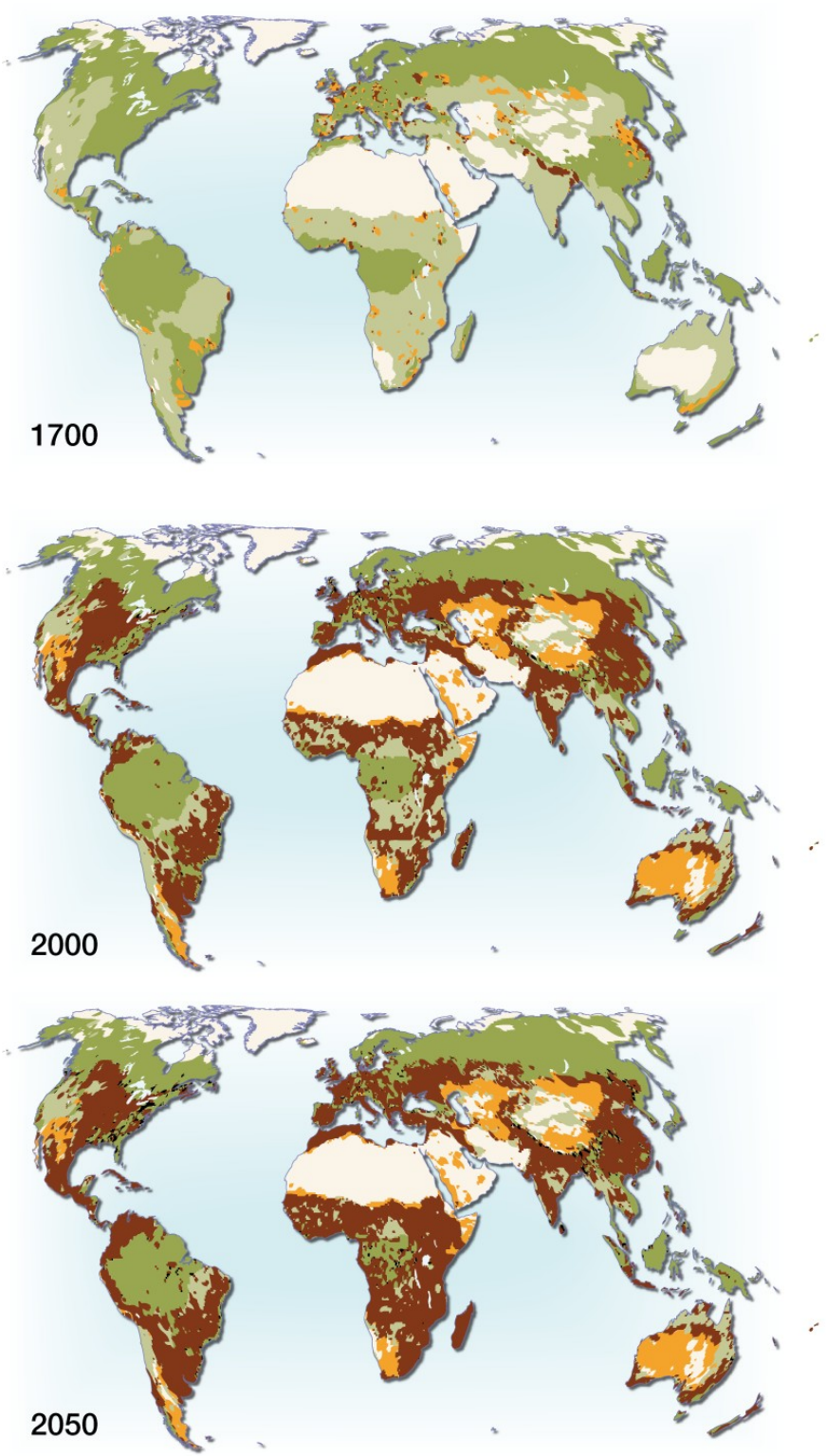
Contents

Generally, Africa is thought to have rich land in biodiversity

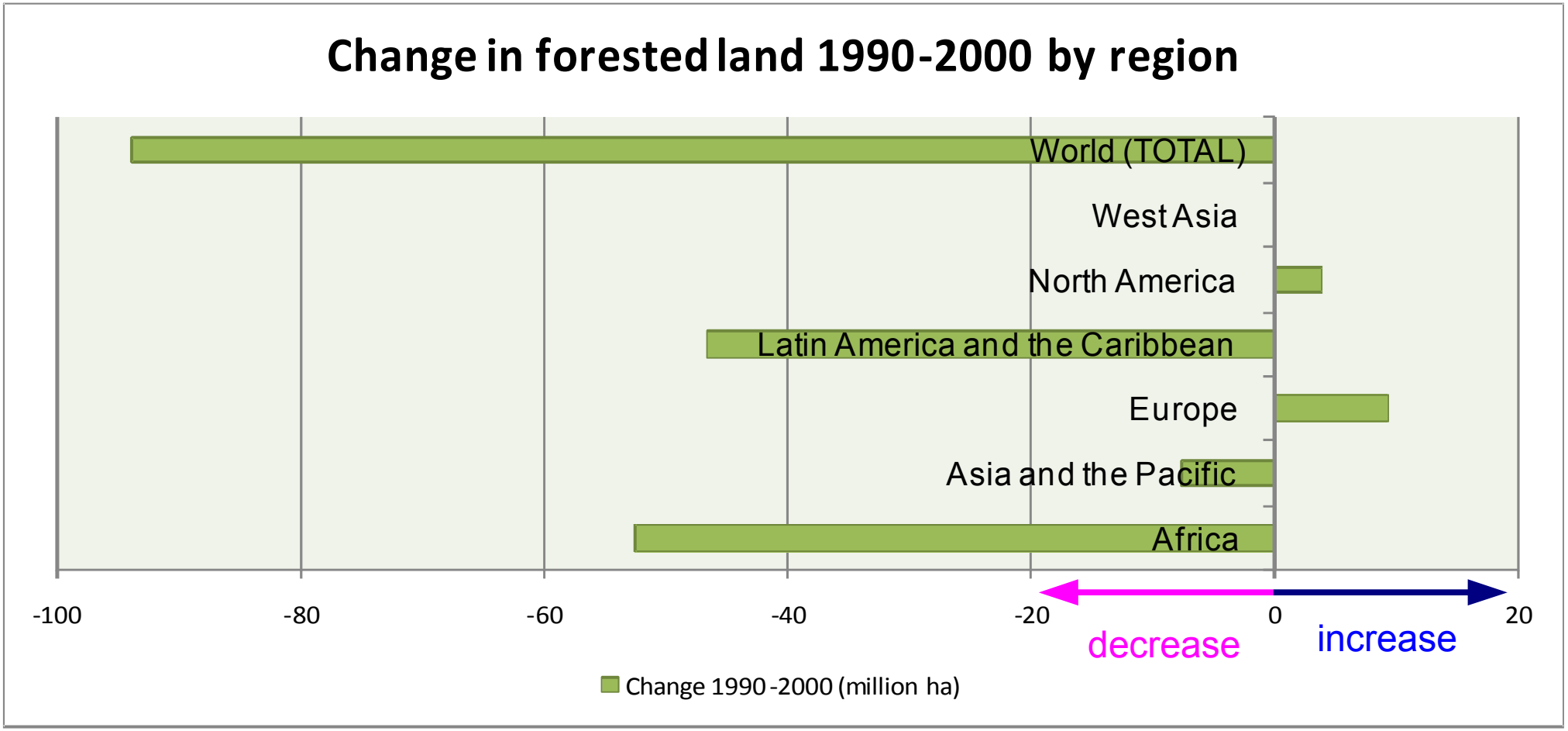
Awash NP. Ethiopia, East Africa

Bossou Guinea RP., West Africa



Projected land use changes. UNEP/GRID-Arendal Maps and Graphics Library. 2009. http://maps.grida.no/go/graphic/projected-land-use-changes. (Accessed July 20, 2010)

Africa is the most critical region of forest decrease

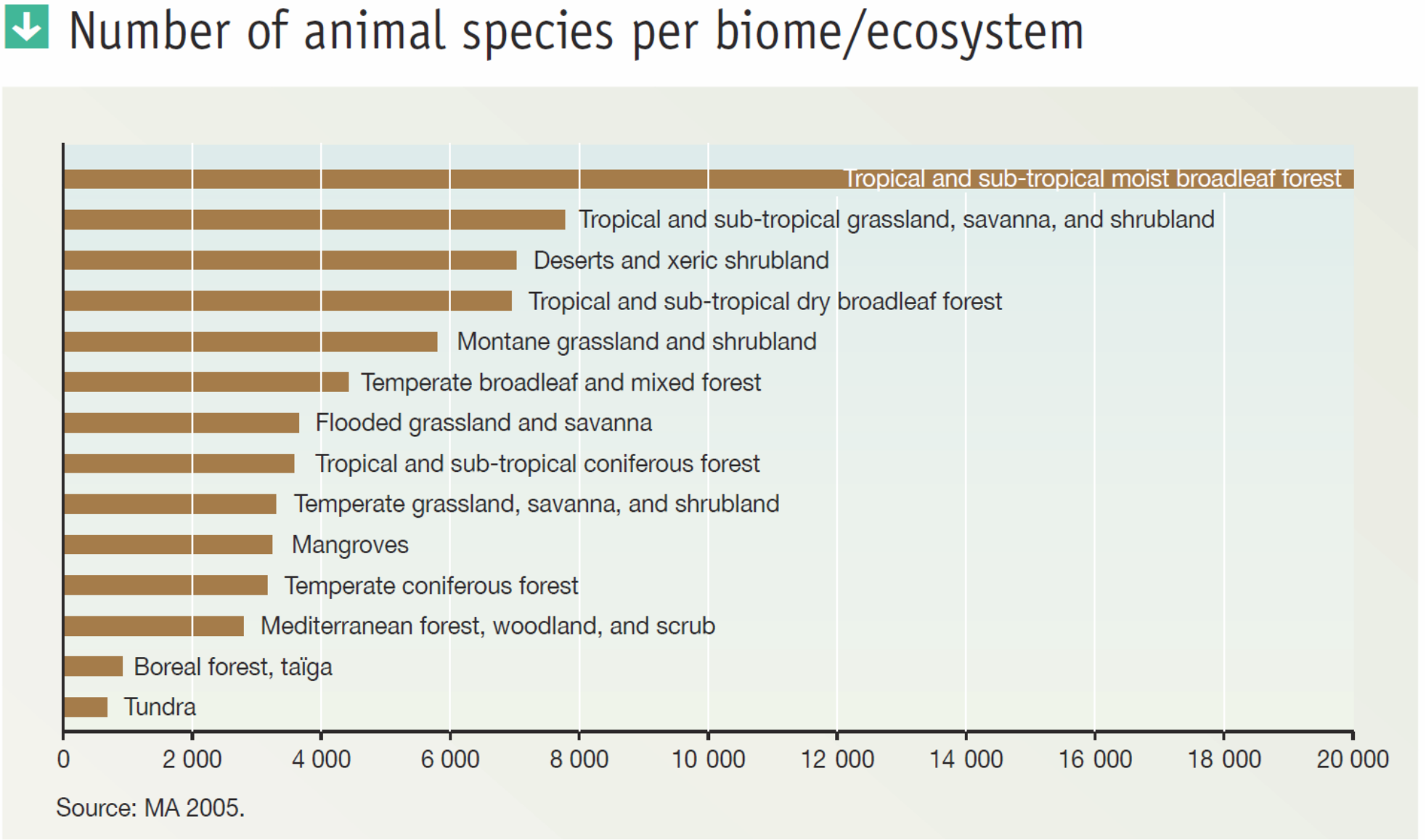


Global Forest Resources Assessment 2000. FAO Forestry Paper 140. Rome, Food and Agriculture Organization http://www.fao.org/forestry/fo/fra/

Africa: decrease 0.7%/yr

http://www.unep.org/geo/geo3/english/178.htm

Forests are critically important for maintaining biological diversity (CIFOR and others 1998)



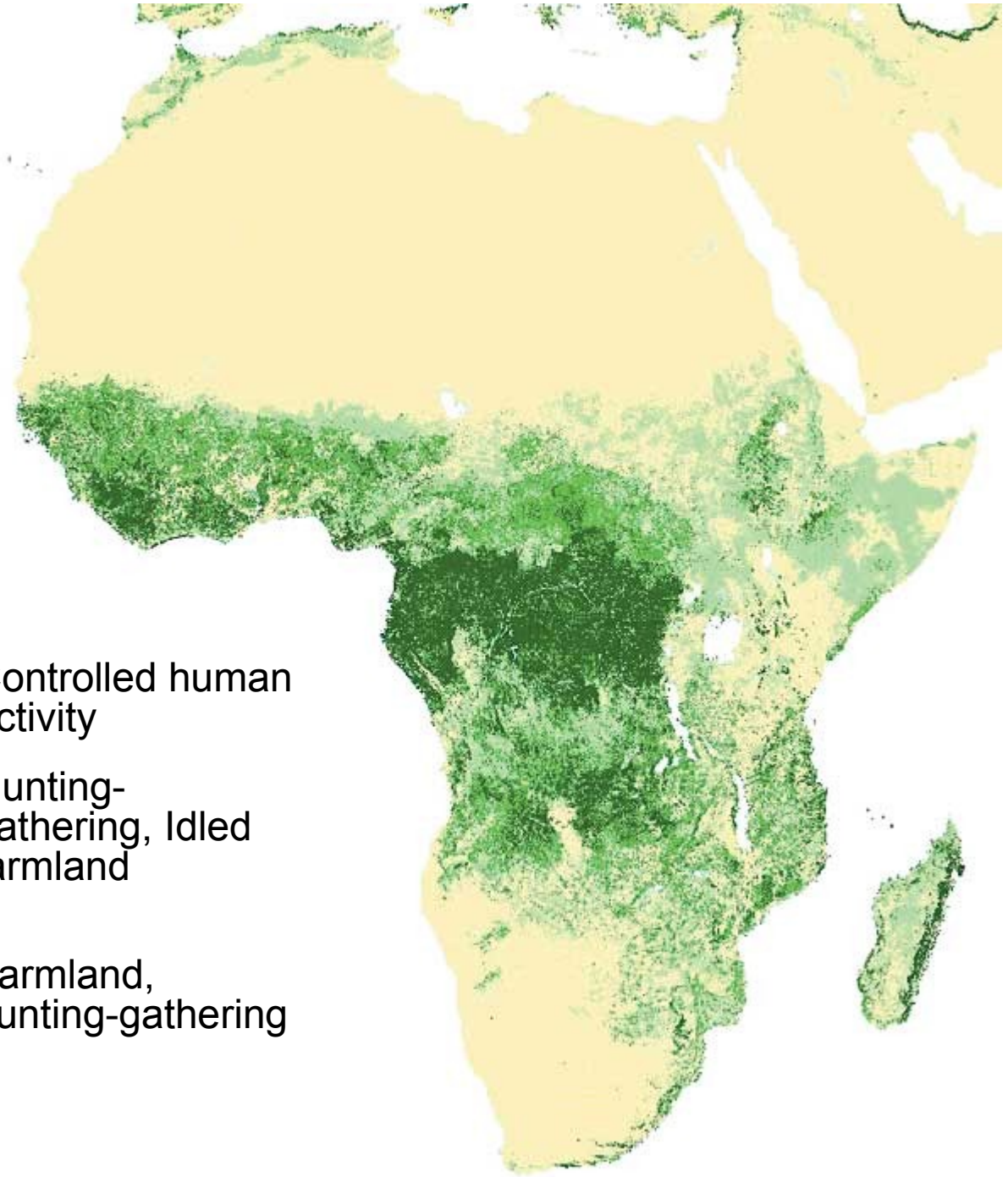
Apes (Chimpanzees, bonobos, Gorillas, Orangutans, Gibbons) need wide forest to live!

Larger animals are at greater risk of extinction than smaller animals

r Unstable environment	***K*** Stable environment
most of the individuals die within a short time but a few live much longer	most individuals live to near the maximum life span
many offsprings are produced	few offsprings are produced
early maturity	late maturity, often after a prolonged period of parental care
small size of organism	large size of organism

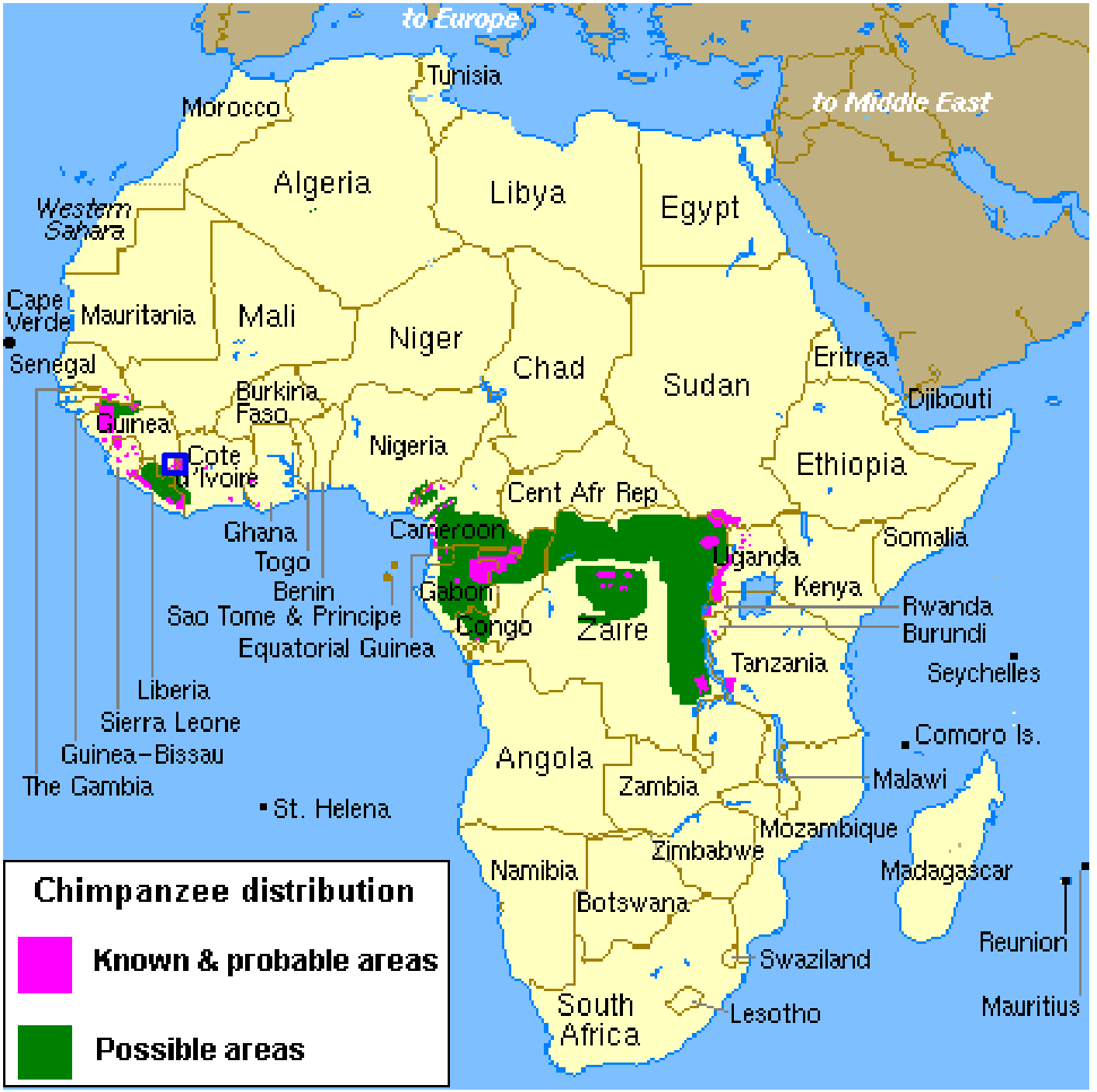
K-strategist-> fragile against environmental changes

Forests are among the most biologically rich terrestrial ecosystems. Yet deforestation, forest degradation and poaching mean that habitats are lost and the survival of many forest species is increasingly threatened. (UNEP, FAO, UNFF: 2009)

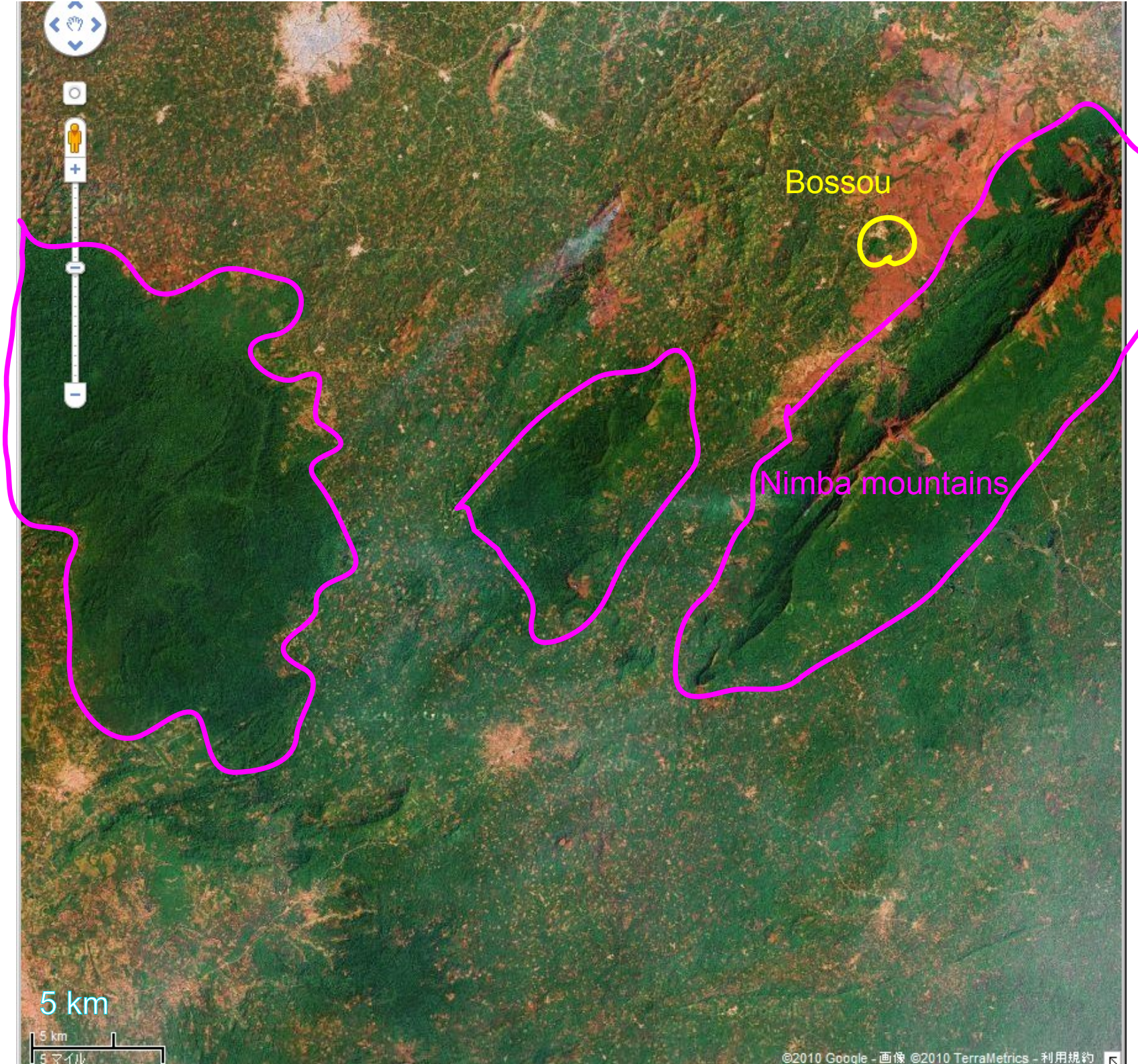


Dark green	Closed forest	Controlled human activity
Mid-green	Open (10-40%) & fragmented forest	Hunting-gathering, Idled farmland
Light green	Shrub-land, & bushland	Farmland, hunting-gathering

by FAO Forestry Paper 140 http://www.unep.org/geo/geo3/english/fig98.htm

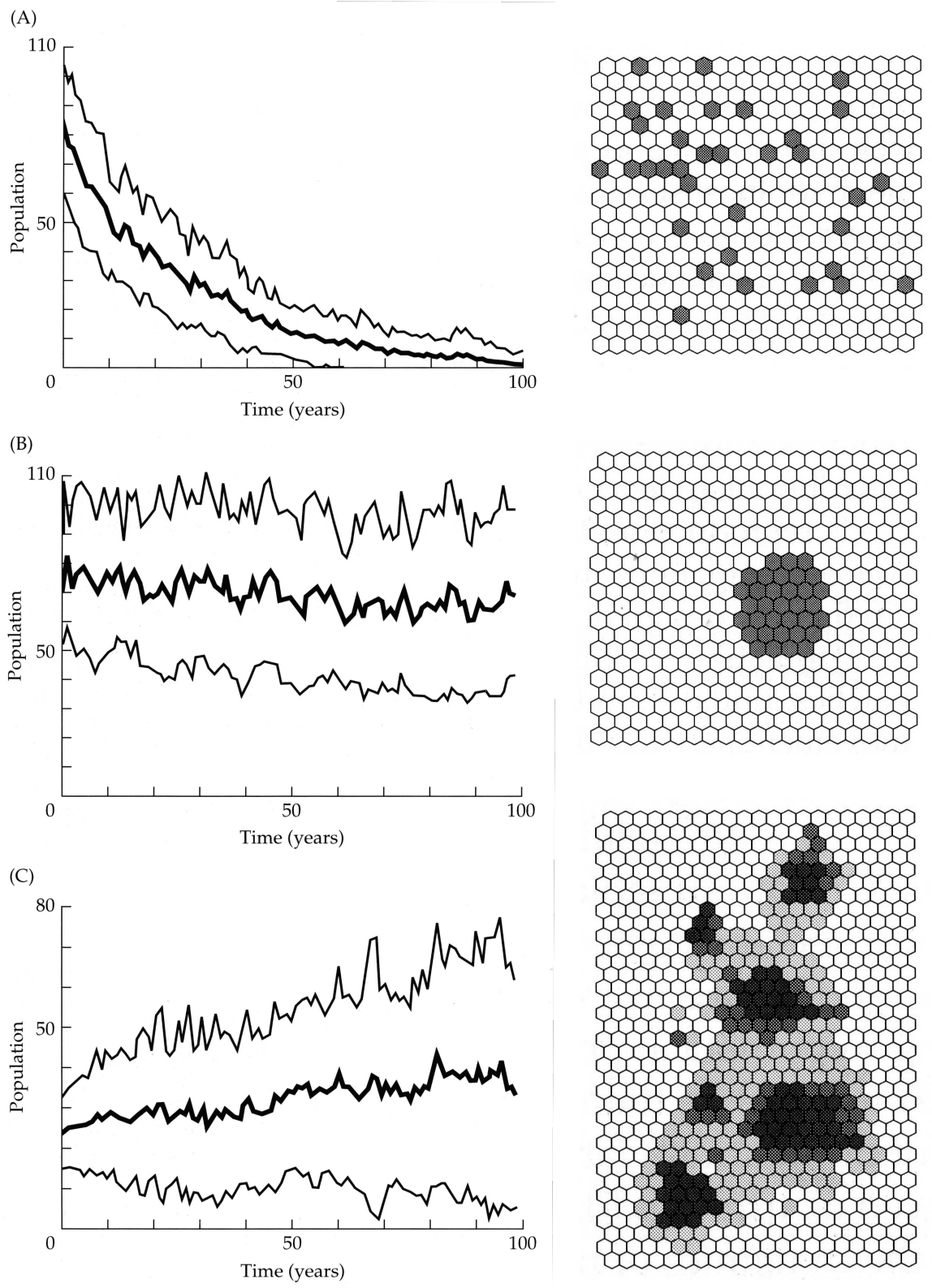


http://www.solcomhouse.com/about.htm


Bossou
Nimba mountains
5 km
5 km
5 マイル
©2010 Google - 画像 ©2010 TerraMetrics - 利用規約

Scattered habitat is a vulnerable distribution pattern

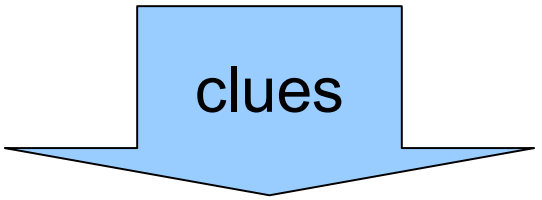
Results of computer simulation comparing suitable habitat distribution pattern based on Spotted Owl's demographic parameters.
(A) Scattered
(B) Clumped
(C) Clustered



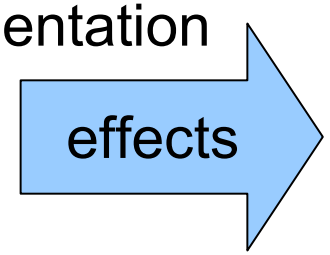
Principle of Conservation Biology p.229 Fig 7.12

Question in this presentation

Bossou:
chimpanzee community (population) inhabits small forests



forest fragmentation



demography

emigration/immigration between community

genetic variation

mate choice behavior

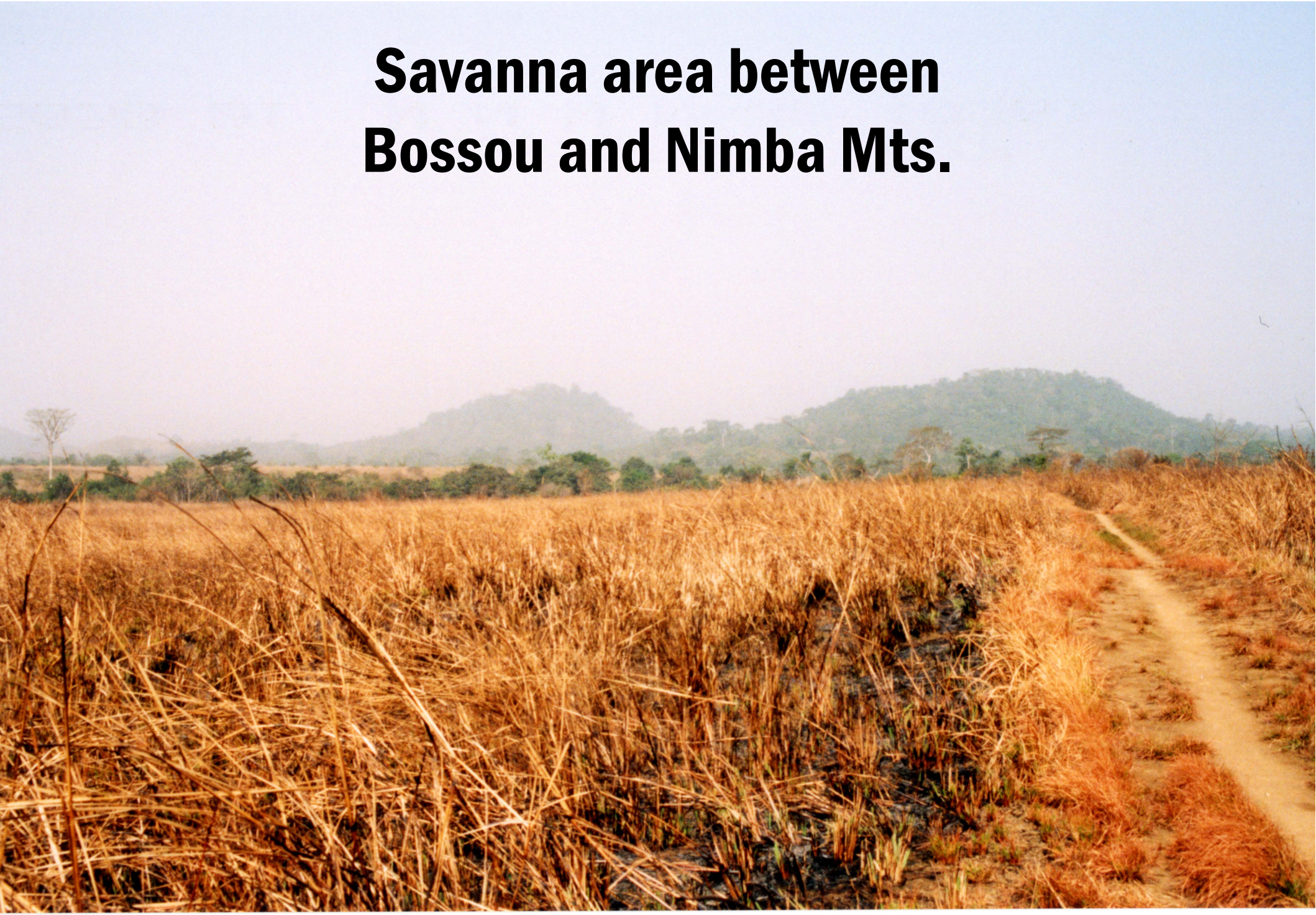
How will forest fragmentation affect wild chimpanzees?

1.2 Feature of the Bossou Community

Feature of Bossou chimpanzee community

	Bossou	Typical
Contact with neighboring community	No (Isolated?)	Frequent
Community size	About 20 (small)	40 ~ 150

Savanna area between Bossou and Nimba Mts.



Shimada MK. 2000, *Pan African News* 7: 7-10

Feature of Bossou chimpanzee community

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Contact with neighboring community	No (Isolated?)	Frequent
Community size	About 20 (small)	40 ~ 150
Migration & Transfer between communities	Not observed	By Females

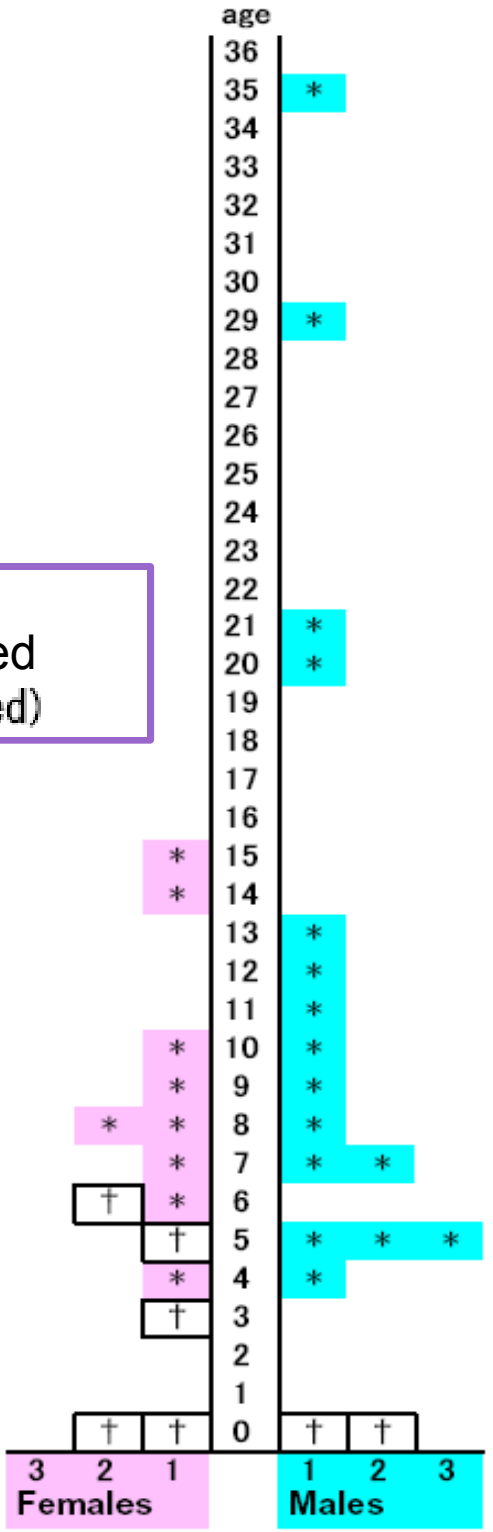
Feature of Bossou chimpanzee community

	Bossou	Typical
Contact with neighboring community	No (Isolated?)	Frequent
Community size	About 20 (small)	40 ~ 150
Migration & Transfer between communities	Not observed	By Females
Emigration	By both sexes	Mainly by females

Feature of Bossou community:
Males also disappeared

Number of disappeared chimpanzees in Bossou community

Number of head
*: Emigrated or died
†: died (confirmed)



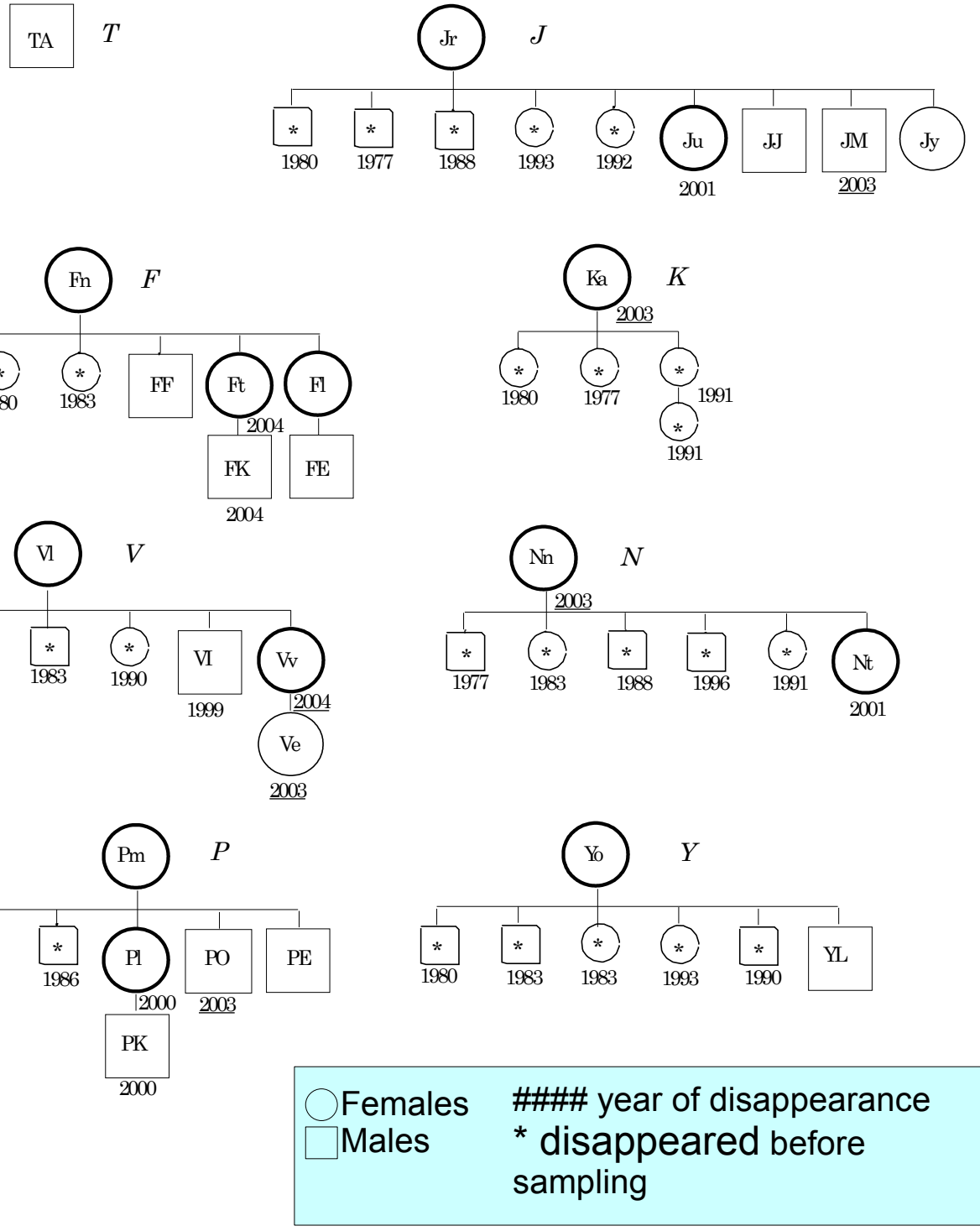
Matrilines of Bossou community:

1978:Started observation by Kyoto University Researcher (Dr. Sugiyama)

Member of adults/sub-adults
One Male
Seven Females
No info. of relation among them

Recorded Matrilines (RMs): Based on mother-offspring records *(Italic Letter)*

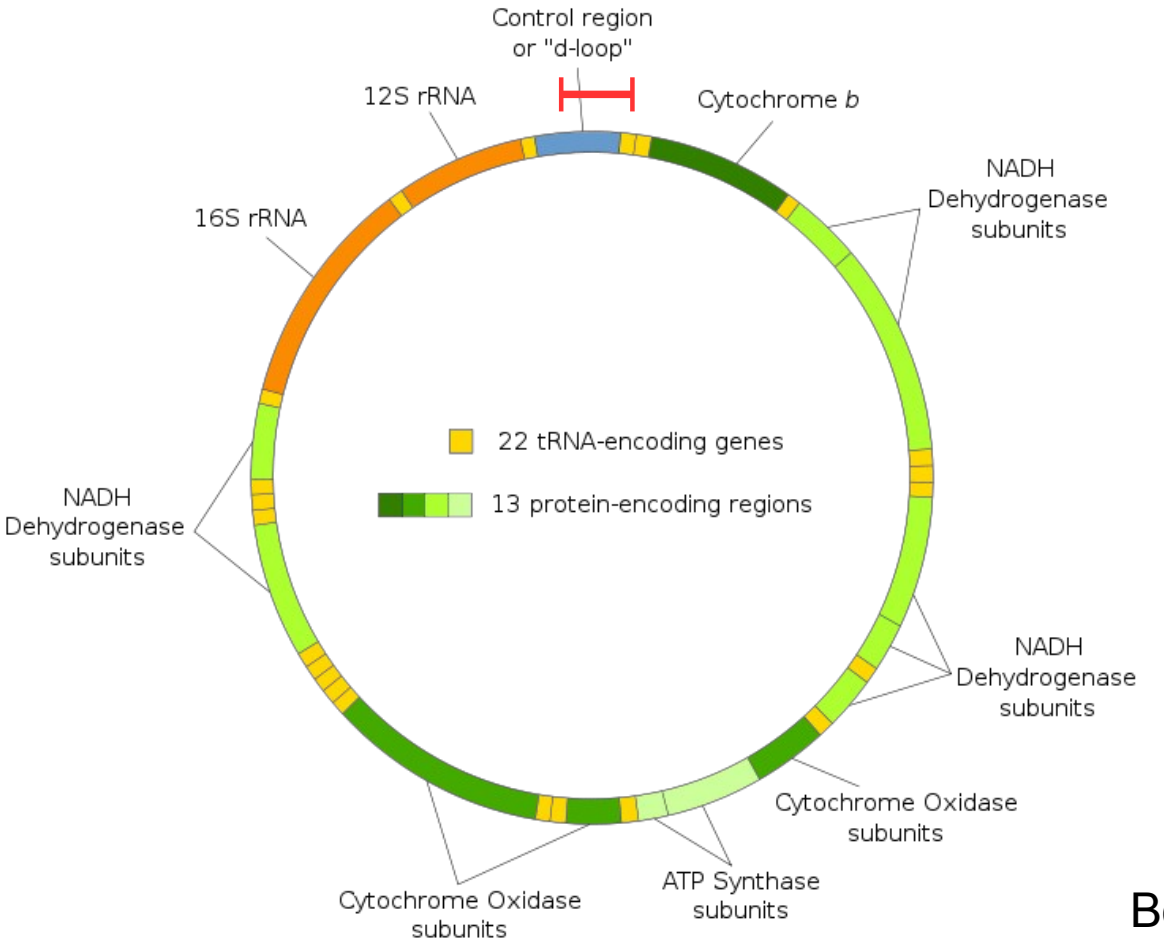
Genetic Matrilineages (GMs): Maternal Lineage identified by genetic marker (mtDNA)



2 Methods:
Genetic Marker used
Genotyping

mtDNA sequencing

c.a. 650bp sequencing



http://commons.wikimedia.org/wiki/

No recombination:

→ good for trace back along genealogy

Female inheritance:

Generally, female chimps migrate among communities, while males stay and guard territory.

→ mtDNA geographic distribution represents female migration (migration of male can be seen only in one generation)

Bossou: each individual was identified

Nimba: anonymous sample

3 Phylo-geography: Among West African chimpanzees, Between Bossou and Nimba mountains.

Molecular phylogenetic tree of mtDNA haplotypes

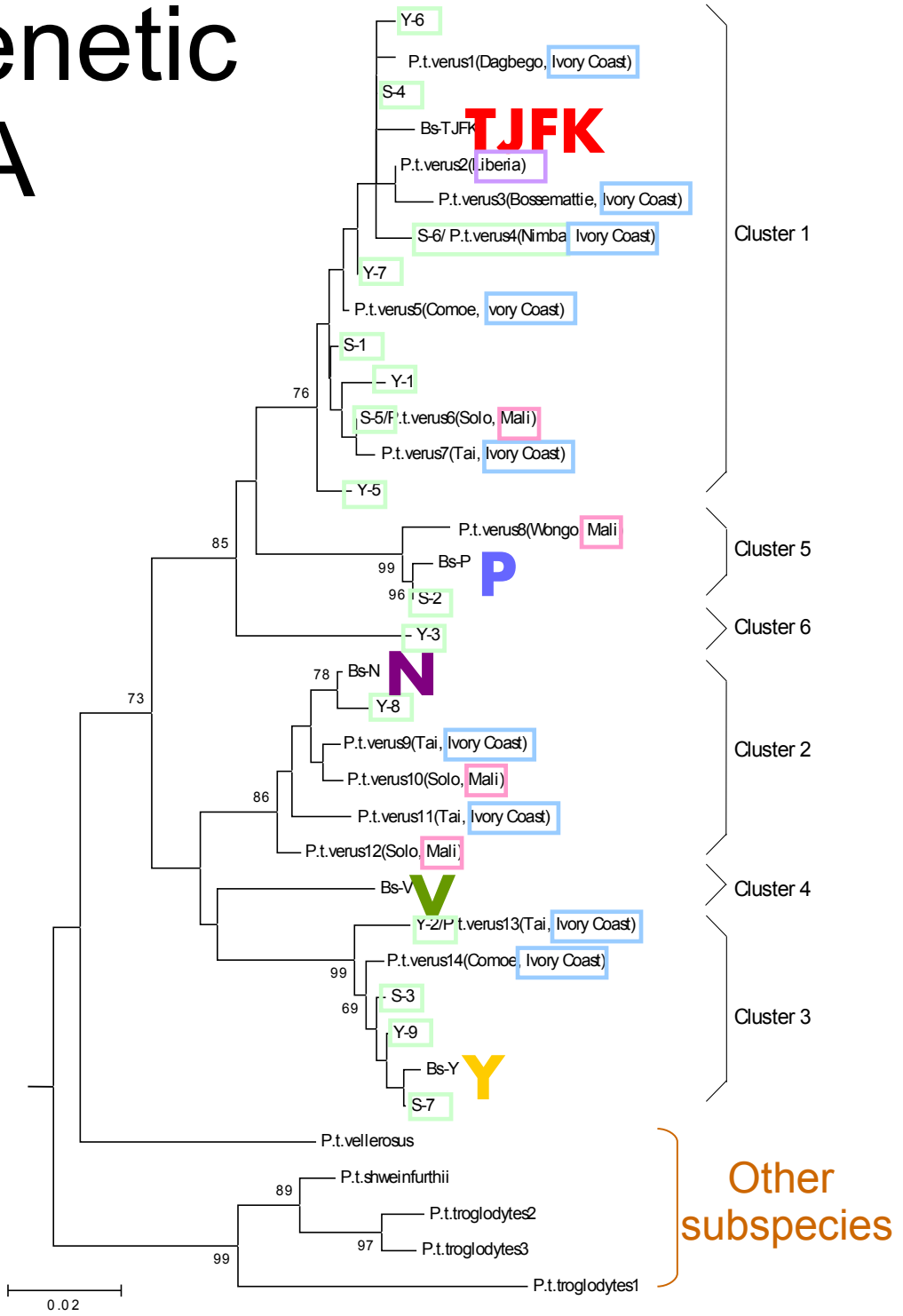
from Bossou

Our sequencing
- from Nimba Mt.

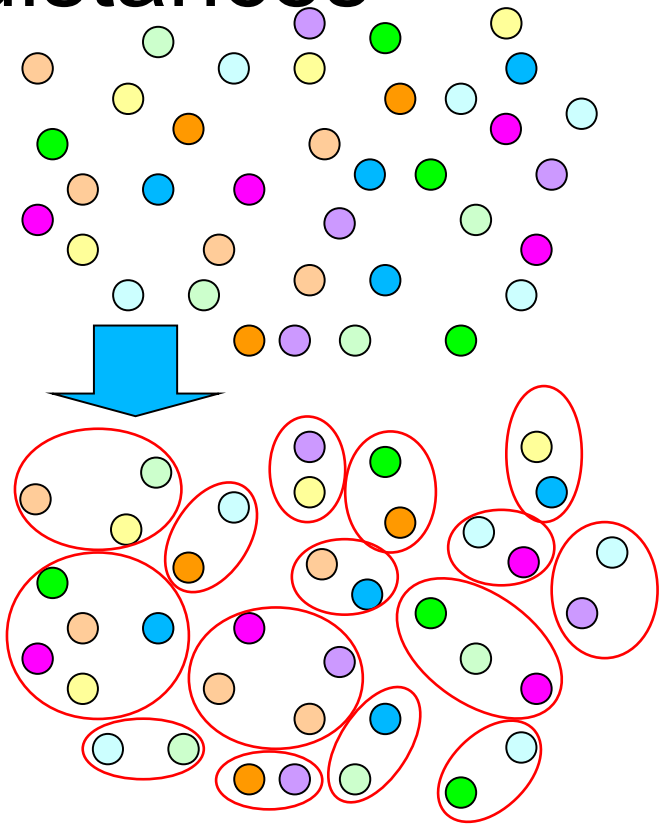
DB
- from Ivory Coast
- from Mali
- from Liberia

No correlation between genetic and geographic distances

No sharing of haplotypes between Bossou and Nimba



Estimation of demographic history: Explanation of the non-correlation between genetic & geographic distances



MtDNA haplotypes of West African chimpanzees (*P. t. verus*) is known to be distributed widely and homogeneously over their habitat.

It is likely that ancestral population of the subspecies expand rapidly and mixed well through long migration.

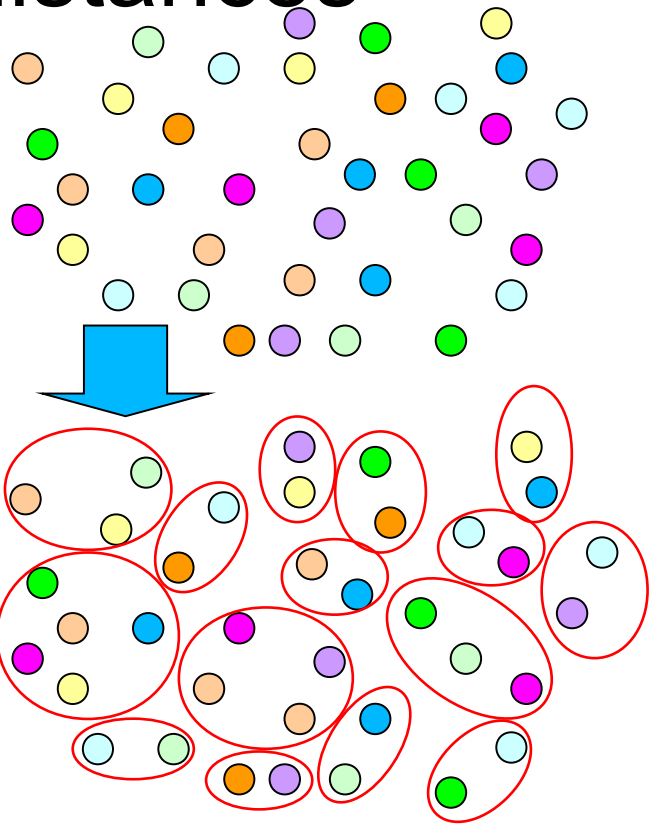
Insufficient time has passed to form a clear pattern in the geographic distribution of mtDNA haplotypes.

Since mtDNA control region has rapid evolutionary rate, no haplo-group formation suggests that ancestral population must be sub-divided into sub-populations recently.

No sharing of haplotype suggests no or few migration between Bossou & Nimba.

(Shimada *et al*. 2004, Am J Primatol 64:261)

Estimation of demographic history: Explanation of the non-correlation between genetic & geographic distances



Before subdivision of the ancestral population:

- there were many haplotypes,
- those haplotypes were mixed well (panmixia),
- it is plausible in some cases that chimpanzees can not recognize their kin-ship even if they share the identical mtDNA haplotype (distant relatives).

When the ancestral population was divided:

- it is rare that distant relatives meet again after long-distance migration and become founders of a small sub-population.

→ we assumed that sharing the identical haplotype in a small community was a sign of close relatives.

4 Materlineage Within the Bossou Community

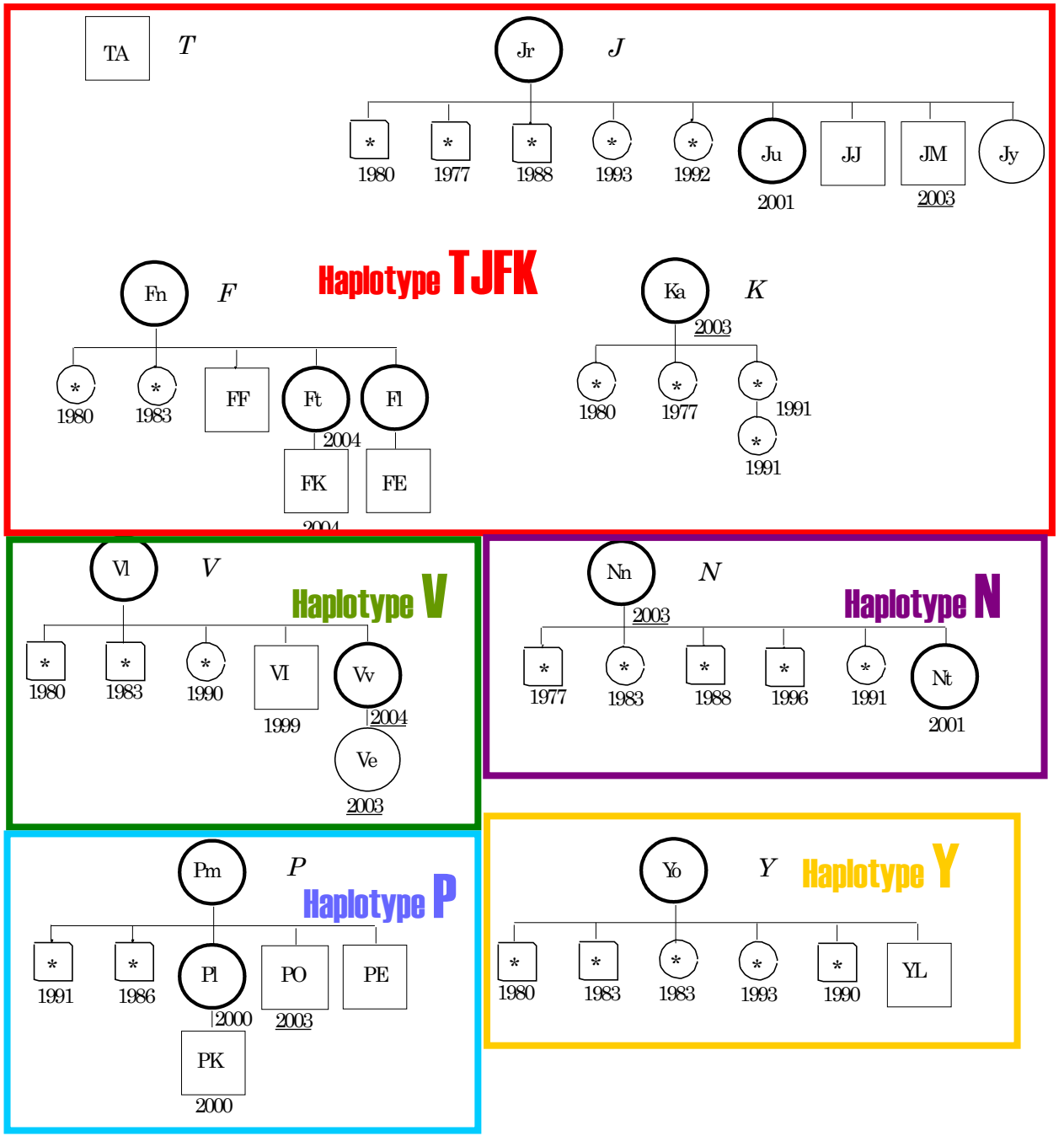
Result of focal sampling in Bossou

4 of the 8 original adult members of the Bossou community are likely matrilineal relatives

The Majority

(>50% in every year)

Minorities



Social Affinity between Individuals

The relationship among *T,J,F*, & *K* is close enough for chimpanzees to recognize it!

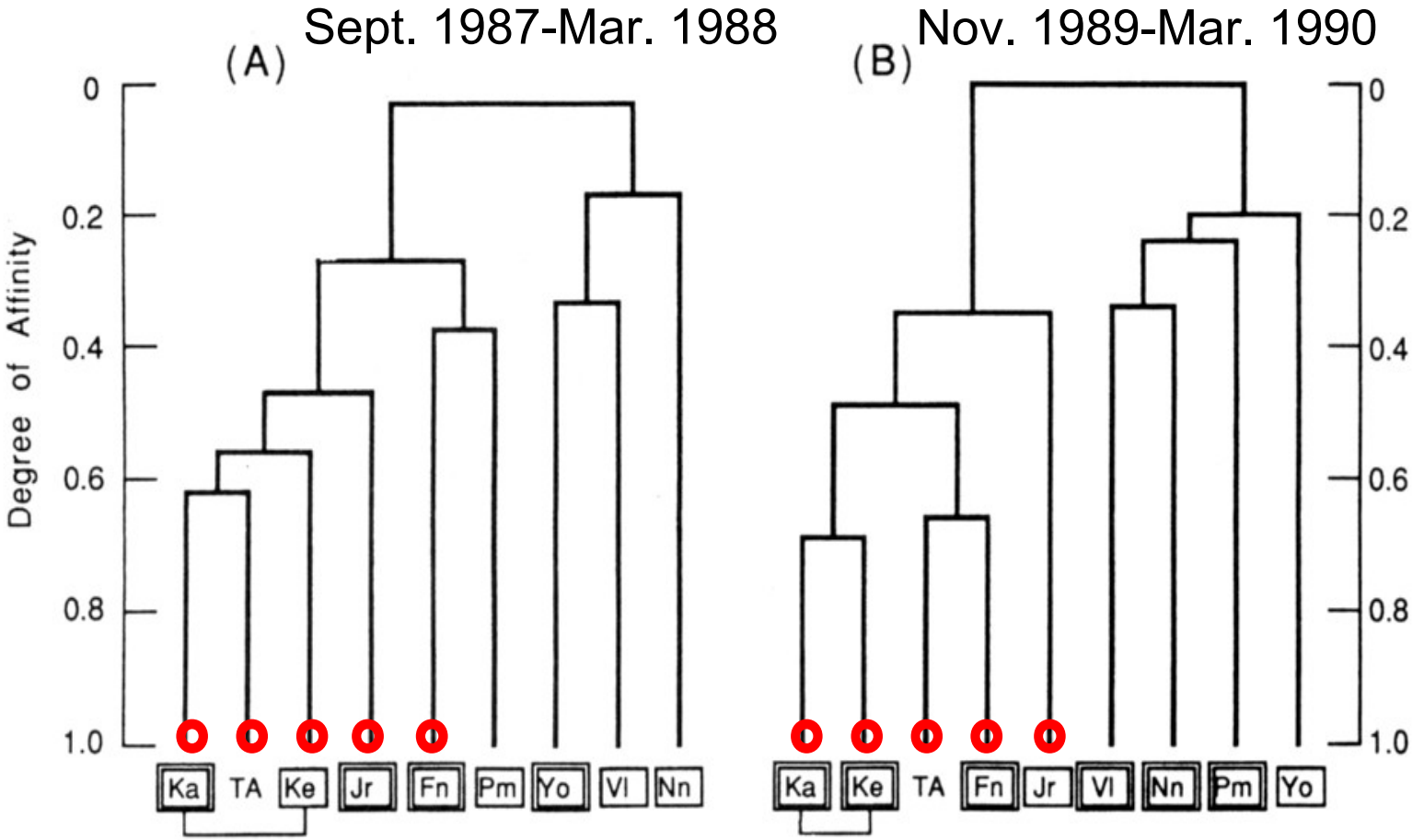


Fig. 5. The effect of the presence of infants on affiliation among the chimpanzees. The dendrograms were calculated by the ratio of sharing the same party by two females and by Ward-method cluster analysis. Single-line rectangles, lactating females; double-line rectangles, cycling females; no rectangle, an adult male. The connection between *Ka* and *Ki* represents their mother–daughter relation.

Haplotype TJFK

Sakura 1994 *Int J Primatol*

5 Migration Behavior and Kinship within the Bossou Community

Shimada, *MK* et al. 2009, Folia Primatol.

Question

Let's suppose that maternal relationship sufficiently close for chimpanzees in Bossou to recognize kinship.

- Chimpanzees usually avoid incest.
- Bossou chimpanzee community is small and skewed in genetic matrilineage.

Is it hard to find mating candidate within Bossou community?

How does the small size and skewed composition of matrilineage affect chimpanzees' behavior, such as mating and migration?

Sex Ratio for Mate (SRM)

i.e., Ratio of
Number of Mating Candidate (opposite sex)
to
Number of Competitors (same sex)
for each emigration event by individual *e*

$[SRM]_{MIX}(e)$: SRM without incest avoidance

$[SRM]_{DTN}(e)$: SRM with incest avoidance

Sex	Mt-type	*n*	SRM		Difference	
			DTN	MIX	MIX - DTN	(%)
Females	Major	6	0.136	0.373	0.237	63.7
			(0.001)	(0.004)	(0.001)	(19.7)
	Minors	4	0.170	0.356	0.187	52.4
			(0.002)	(0.003)	(0.001)	(54.9)
	Subtotal	10	0.150	0.366	0.217	59.2
			(0.001)	(0.003)	(0.002)	(63.0)
Males	Major	2	0.438	3.500	3.063	87.5
			(0.008)	(0.500)	(0.383)	(0.0)
	Minors	5	0.601	2.833	2.232	78.9
			(0.042)	(0.556)	(0.355)	(22.2)
	Subtotal	7	0.554	3.024	2.470	81.4
			(0.036)	(0.560)	(0.464)	(32.3)

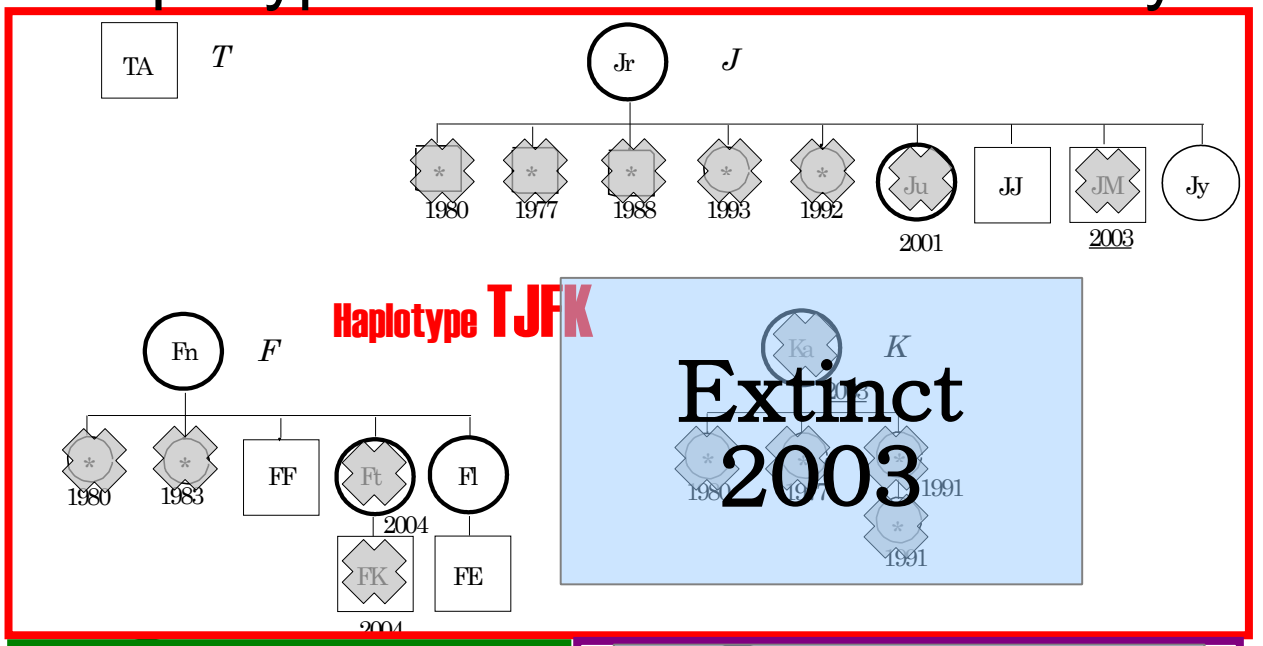
Difficulty to find mating candidate: Males >>Females, Major (TJFK)>Minors (others)

This may accelerate male emigration, conversely, ignorance of incest avoidance..

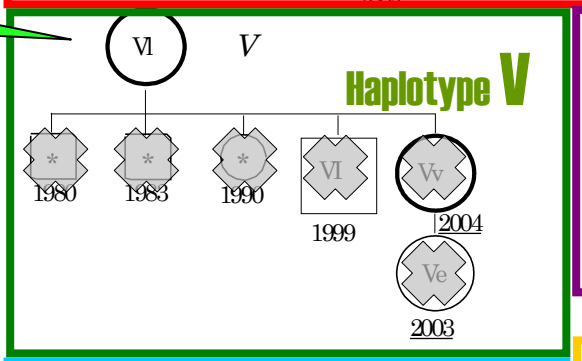
6 Chronological Changes in Genetic Diversity within the Bossou Community

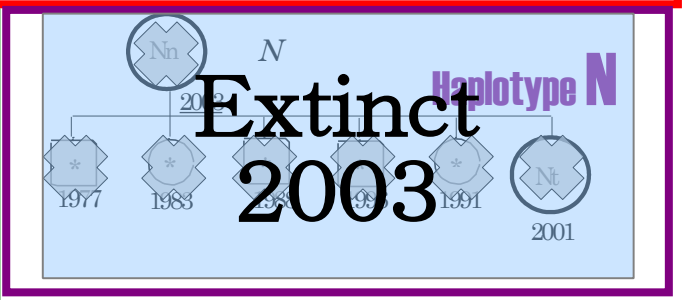
Maintainance of mtDNA haplotype within Bossou community

Highly likely that one haplotype only will maintain.

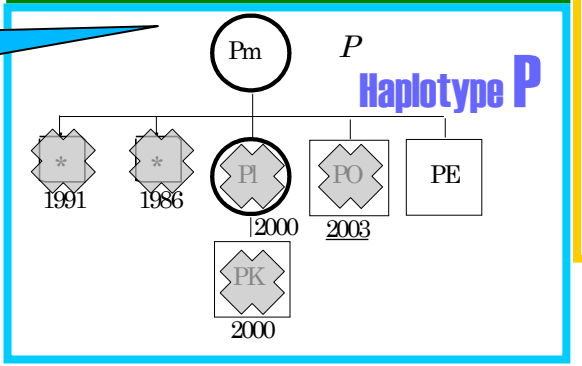


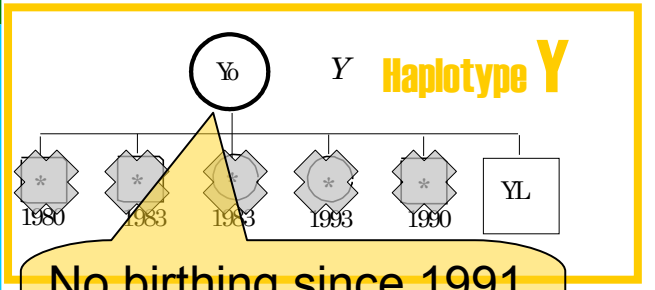
No birthing since 1991





No birthing since 1998, No female offspring in the community



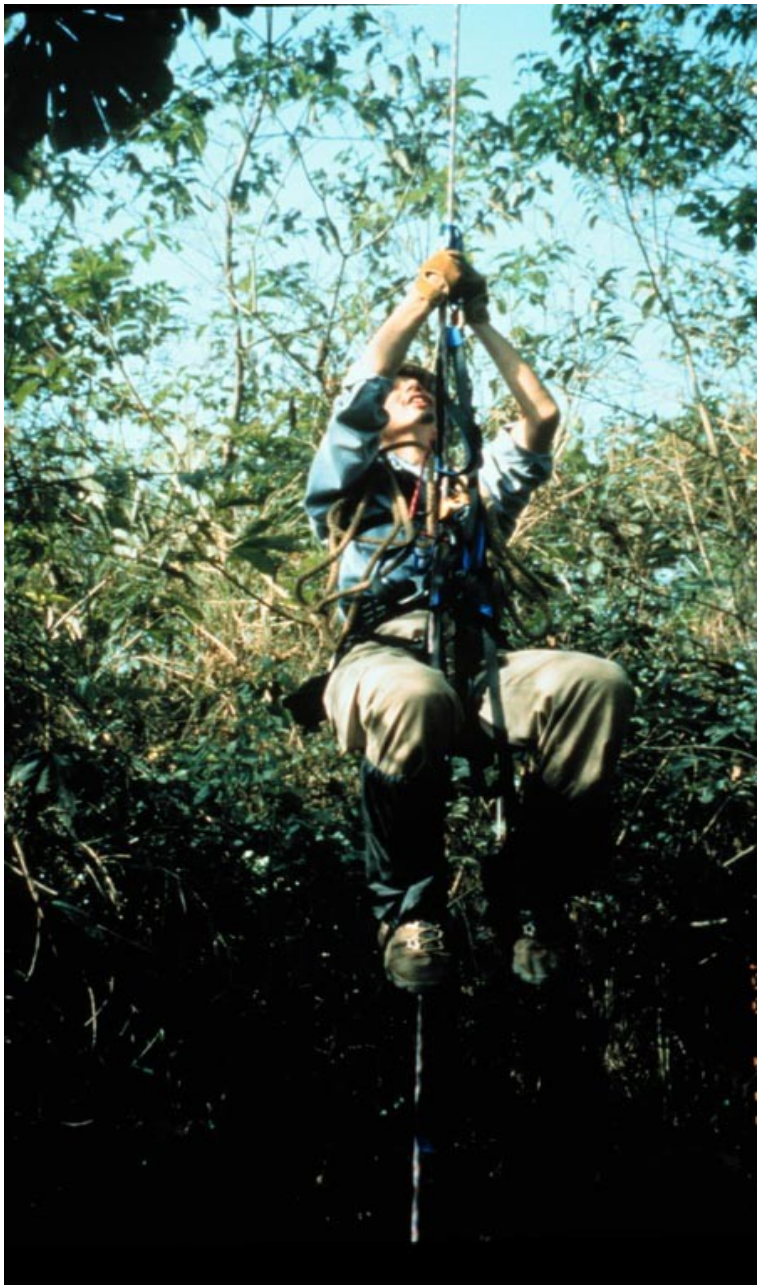


No birthing since 1991, No female offspring in the community

7 Lesson from this study: Sample Collection

Lesson from this study

Sampling



Lesson from this study

Sampling

Sample Types	Urine	Feces	Wadges	Hairs (ground)	Hairs (night bed)
Accessibility in field	★☆☆	★☆☆	★☆☆	★★★	★★☆
Traceability of sample to individual	★★☆	★★☆	★★☆	★☆☆	★★☆
Reliability of experimental results	★★★	★★☆	★★☆	★☆☆	★☆☆

Habituated or not?

Safe for animals or not?

Mixing up with samples from other individuals
(eg., dropping at the same position, body contact)

A mysterious case

Fresh sample or not?

Two-round or nested PCR--less reliable

Shimada, MK *in press*.

Summary

MtDNA sequencing of Bossou and Nimba chimpanzee communities and subsequent analyses revealed that

1) no clear population structure emerged as in other populations of West African chimpanzee (*P. t. verus*), suggesting that gene flow was sufficient in the common ancestral population of West African chimpanzees;

2) there is no matrilineal gene exchanges between Bossou and Nimba chimpanzees among the current generations;

3) 4 of the 8 original adult members of the Bossou community are likely matrilineal relatives, which results in a skewed frequency of one mtDNA haplotype occupying about 50%;

4) so far, the matrilineal genetic diversity of the Bossou community is still relatively stable, but there is a high risk of haplotype extinction due to a skewed haplotype distribution and a predicted relaxation of incest avoidance;

5) hair samples showed an inferior result to other sample types, such as urine, feces, and wadges (chewed up fruit remains).

Conclusion

Our phylogeographic studies revealed that

1) Forests were fragmented rapidly in the West Africa,

2) Which affected breeding history of the West African chimpanzees

Our demographic analysis suggested that

3) Forest fragmentation affects mating and migration behavior of chimpanzees.

4) Forest fragmentation accelerate bottleneck effect through behavioral change.

Acknowledgments

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For further contribution

Thank you for your attention!

If you interested in current status of Bossou / Nimba, visit
http://www.greenpassage.org/index.html

If you want to contribute to save Bossou chimpanzee, donate for Green Corridor Project

郵便振替口座名:「緑の回廊」
口座番号:００８３０－１－５５４３２