The Fourth Dimension:

An Overview of Altitudinal Migration

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Convention

Overview topics:

+ The fourth dimension: Phenomena, perceptions and definitions
+ Animal groups, regions and ecosystems involved
+ Spatio-temporal dimensionality
+ Altitudinal movements on the community and population level
+ Proximate factors influencing altitudinal movements
+ Important differences between altitudinal migration and longi-latitudinal migration
+ Important conservation implications
+ Altitudinal migration and CMS

Phenomena, perceptions and definitions – setting the stage...

No standard (widely accepted) definition exists(?)!

– In a few studies, ad-hoc definitions are given, in others definitions are implicit, in the majority they appear not to have been contemplated consciously...

Variety of terms used:

altitudinal

elevational

vertical

x

migration

movement

disper sal

displacement

nomadism

hilltopping

escape movement

intratropical migration

local movement .....

In a complementary DEFINITION to Baker's (1978) very broad concept of migration, "altitudinal migration" might be taken as:

The act of moving from one spacial unit to another, but always including a movement in the vertical dimension.

This would include, for instance:

-> Daily vertical migration of plankton in oceans and lakes

-> Vertical migration of soil organisms, benthic mesopsammon

-> Change in flight altitude of volant animals: birds etc.

Interesting, but too heterogeneous!

A possible, still broad definition:

***Animal populations or parts of these show regular to-and-fro movements, always including a change in altitude in a* mountainous area.**

Altitudinal migration in taxa other than birds:

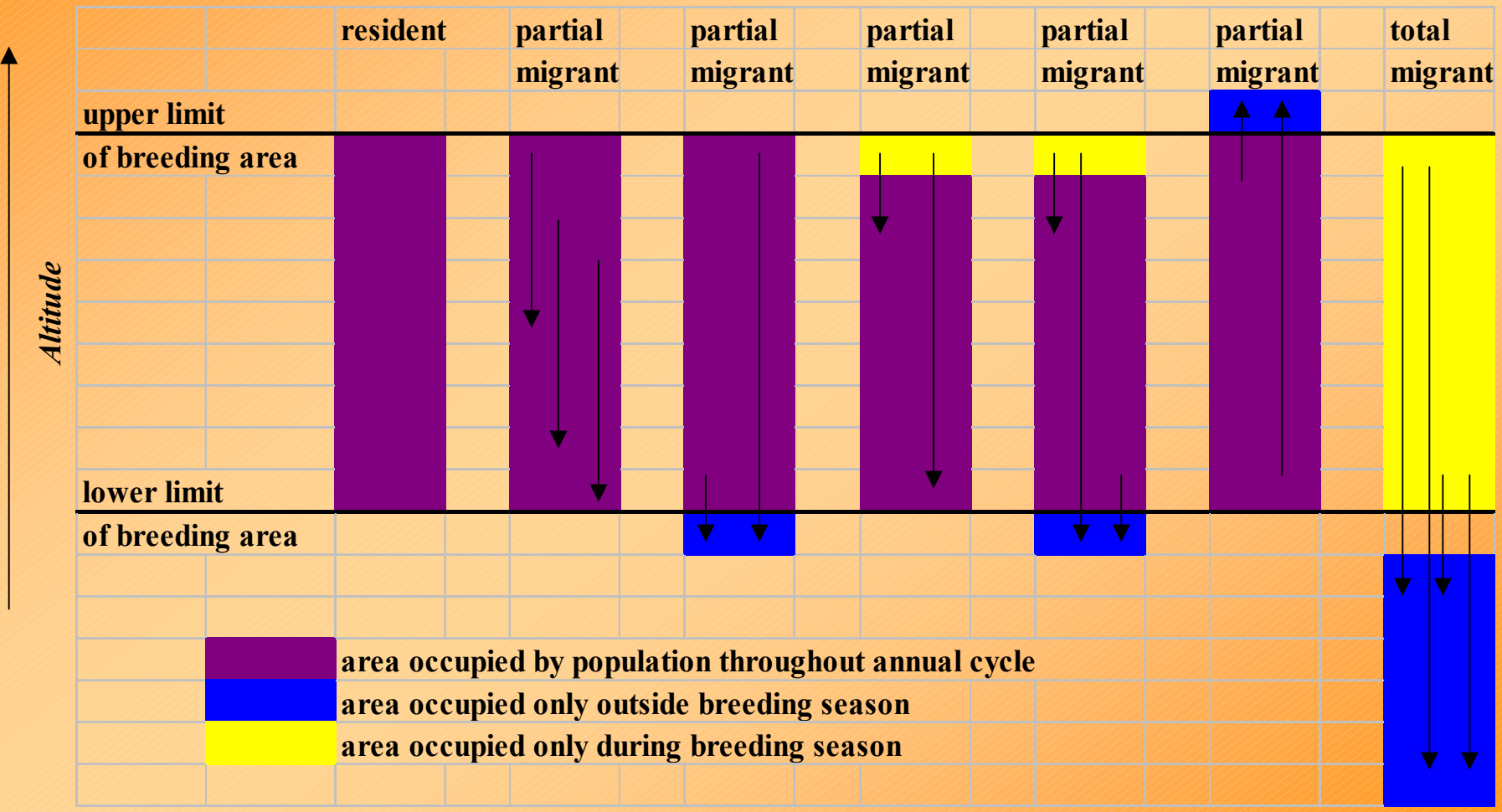
Insecta:	Lepidoptera	Costa Rica	Haber 1993, Stevenson & Haber 2000*, Haber & Stevenson in prep.
		California	Shapiro 1986
		Kenya	Awodey 1978
	Hymenoptera: Vespidae	Costa Rica	Hunt et al. 1999*
	Hymenoptera: Apidae	Japan	Tomono & Sota 1997
	Diptera	Japan	Arakawa et al. 1991*, Kurahashi et al. 1991*
	Coleoptera	China	Xu & Liu 1998
	...		
Pisces	Salmonidae	Europe, N-America	
	...		
Mammalia	Chiroptera	Costa Rica	Timm & LaVal 2000*
		Galápagos Islands (Ecuador)	McCracken *et al.* 1997
		Mexico	Montalvo 1997
		Chile	Sanborn & Crespo 1957
	Primates	Sumatra (Indonesia)	Buij et al. 2002
		China	Fooden 1986
	Perissodactyla	Costa Rica	Lawton 2000*
	Artiodactyla	Rocky Mountains (USA)	Gruell 1958, Moisan 1958, Shaw 1958, Robel 1960, Hebert 1973, Oosenbrug & Theberge 1980, Morgantini & Hudson 1983
		Himalaya (India)	Sarkar et al. 1999
		Japan	Takatsuki et al. 2000
		Southern Alps (New Zealand)	Tustin & Parkes 1988
		Alps (France)	Géroudet 1972*, Rochat 1996
		Alps (Italy)	Parrini et al. 2003
		Pyrennees (Spain)	Herrero et al. 1996
		Norway	Albon & Langvatn 1992, Mysterud 1999
	Carnivora: Ursidae	Spain	Caussimont et al. 1993
	Carnivora: Felidae	Rocky Mountains (USA)	Logan & Irwin 1984

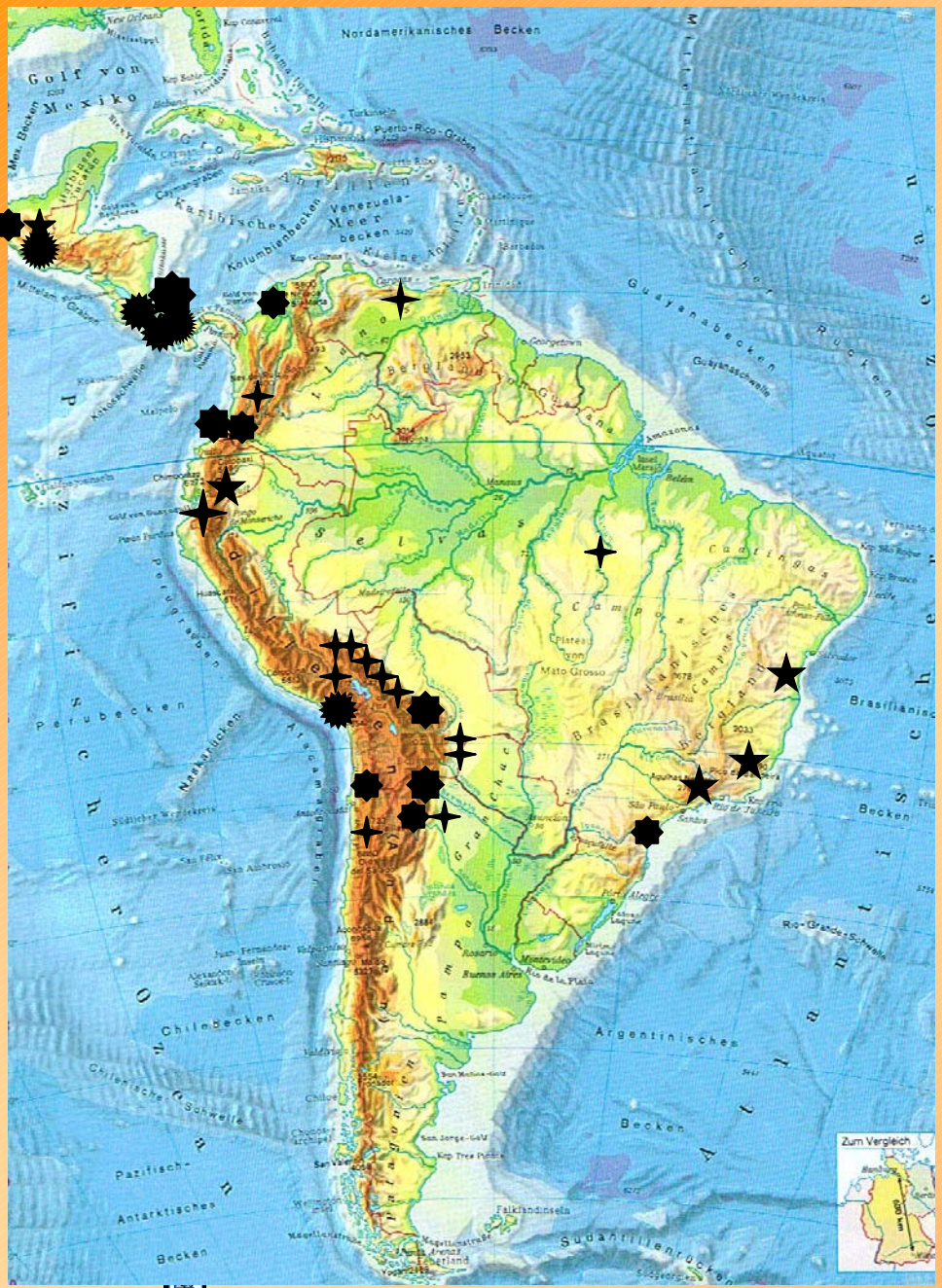
Ecosystem used by altitudinal migrant birds:

Ecosystem	# Studies (n=116)*
Diverse	15
Temperate alpine open land/subalpine shrubs	7
Temperate montane conifer forests	8
Temperate montane mixed forests	6
Temperate montane broadleaf forests	5
Puna/Páramo	12
Tropical arid/semi-arid lowlands/tablelands	11
Polylepis woodland	1
Tropical humid forests	67
Subtropical humid/semi-humid montane forest	4

* multiple counts possible

Spatio-temporal dimensionality of altitudinal migration





Sonntag, 20. Juni 2004 (4).jpg

Studies of altitudinal migration of birds in South America

- Single or few spp., raw data
- Few spp. in detail or number of spp., but raw data
- Number of spp. in detail
- Entire guild or family in detail
- Community-based, detailed

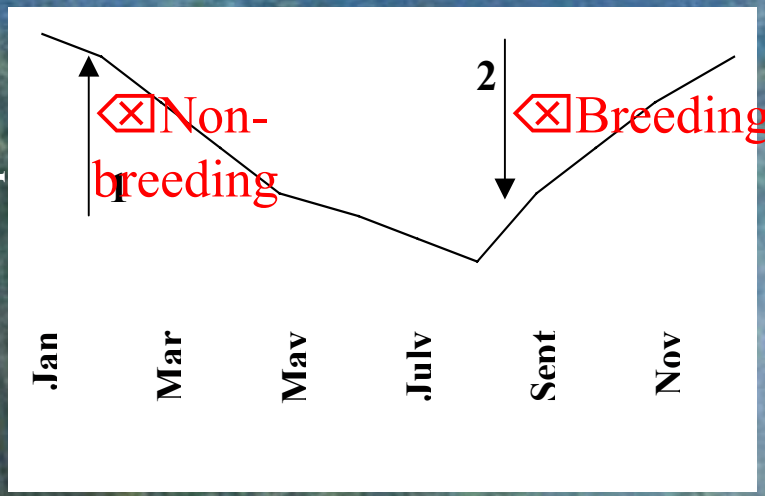
Direction and timing of altitudinal migration of Neotropical birds:

Direction:

- ➲ Outward migration in the majority downslope
- ➲ Return migration upslope

Timing: E.g., on eastern (Amazonian) slope of eastern Andes in Bolivia

Monomodal precipitation cycle:



After breeding -

1: outward (downslope) migration after breeding

Non-breeding season

2: return migration (upslope)

Altitudinal intervals crossed

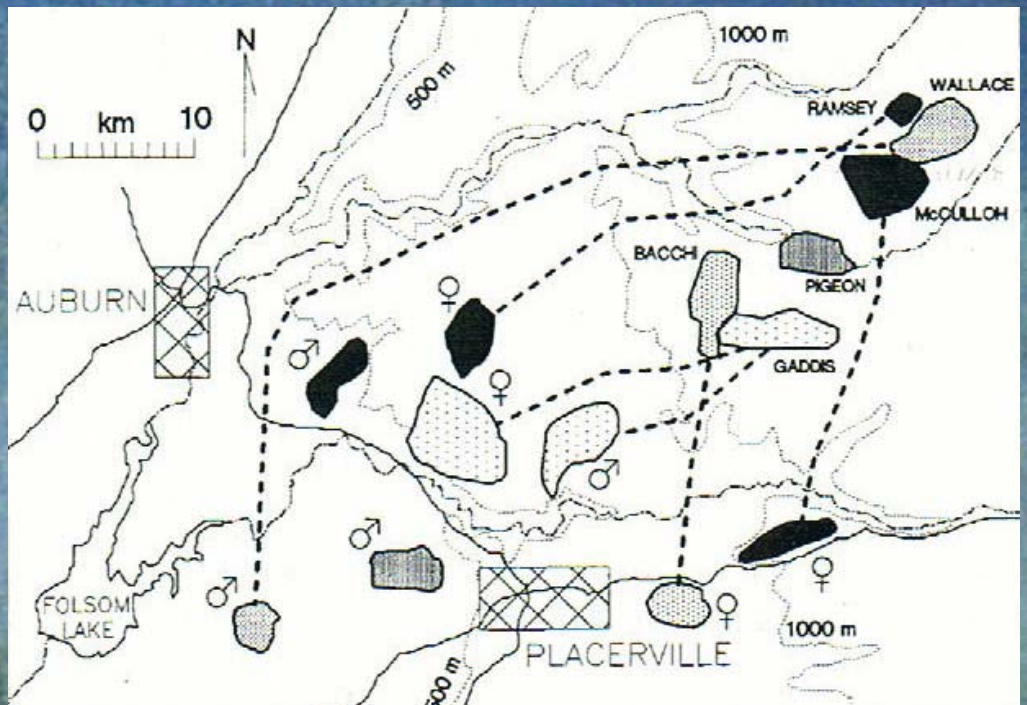
Species (Family)	Country, mountain range	Source
	altitudinal interval [x 100m]->	2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
Junco hyemalis (Emberizidae, New World sparrows)	North Carolina, Appalachians	Rabenold & Rabenold 1985
Tichodroma muraria (Tichodromidae, wallcreepers)	Slovakia, Carpathians	Saniga 1995
Elvira cupreiceps (Trochilidae, hummingbirds)	Costa Rica, Carribean slope	Stiles 1985
Lampornis hemileucus (Trochilidae, hummingbirds)	Costa Rica, Carribean slope	Stiles 1985
Hypsipetes madagascariensis (Pycnonotidae)	India, Western Ghats	Raman 199 - daily in high numbers!
Tersina viridis (Thraupidae, tanagers)	Venezuela, Coastal Range	Schaefer 1953
Nectarinia olivacea (Nectariidae, sunbirds)	Tanzania, Uzambara Mts.	Benson 1982
Corapipo leucorrhoa (Pipridae, manakins)	Costa Rica, Carribbean slope	Rosselli 1994
Muscisaxicola frontalis (Tyrannidae, New World flycatchers)	Chile, Pacific slope Andes	Cody 1970
M. flavinucha (Tyrannidae, New World flycatchers)	Chile, Pacific slope Andes	Cody 1970
M. albilora (Tyrannidae, New World flycatchers)	Chile, Pacific slope Andes	Cody 1970
M. maculirostris (Tyrannidae, New World flycatchers)	Chile, Pacific slope Andes	Cody 1970
Pharomachrus mocinno (Trogonidae, quetzals and trogons)	central Costa Rica	Powell & Bjork 1995
Turdus nigriceps (Turdidae, thrushes)	Peru, Andes	Robinson et al. 1988
Prunella collaris (Prunellidae, accentors)	Spain, Sierra Nevada	Martín-Vivaldi et al. 1995
Parus gambeli (Paridae, chickadees)	Utah, Rocky Mts.	Dixon & Gilbert 1964
Strix occidentalis (Strigidae, owls)	California, Sierra Nevada	Laymon 1989
Discosura conversii (Trochilidae, hummingbirds)	Costa Rica, Carribean slope	Stiles 1985
Colibri delphinae (Trochilidae, hummingbirds)	Costa Rica, Carribean slope	Stiles 1985
Pipra pipra (Pipridae, manakins)	Costa Rica, Carribean slope	Blake & Loiselle 2002
various spp.	Costa Rica, Carribean slope	Loiselle & Blake 1991
Junco phaenotus (Emberizidae, New World warblers)	Arizona, Rocky Mts.	Horvath & Sullivan 1988
Carduelis psaltria (Carduelidae, cardueline finches)	Honduras	Monroe 1968
various spp.	Italy, Alps	Géroudet 1972
Cossypha natalensis (Turdidae, thrushes)	South Africa	Oatley 1966
Pyrrhocorax graculus (Corvidae, crows)	France, Alps	Voisin 1995 - daily!
Plegadis ridgwayi (Threskiornithidae, ibises)	Peru, Pacific slope Andes	Pearson 1974
Larus serranus (Laridae, gulls)	Peru, Pacific slope Andes	Pearson 1974
Phoenicopterus chilensis (Phoenicopteridae, flamingos)	Peru, Pacific slope Andes	Hughes 1970
Vultur gryphus (Cathartidae, New World vultures)	Peru, Pacific slope Andes	Hughes 1970
Phacoboenus megalopterus (Falconidae, falcons)	Peru, Pacific slope Andes	Hughes 1970

Distances traveled:

pecies (Family)	Country, mountain range	Source
haromachrus mocinno (Trogonidae, quetzals and trogons)	central Costa Rica	Powell & Bjork 1995
unco phaenotus (Emberizidae, New World warblers)	Arizona, Rocky Mts.	Horvath & Sullivan 1988
ficrochera albocoronata (Trochilidae, hummingbirds)	Costa Rica, Carribean slope	Stiles & Clark 1989
arious spp.	Costa Rica, Carribean slope	Loiselle & Blake 1991
trix occidentalis (Strigidae, owls)	California, Sierra Nevada	Laymon 1989
axicola torquata (Turdidae, thrushes)	southern Africa	Benson 1982
tenostira scita (Sylviidae, Old World warblers)	southern Africa	Benson 1982
nthus novaeseelandiae (Motacillidae, pipits)	southern Africa	Benson 1982
lectarinia cuprea (Nectariniidae, sunbirds)	southern Africa	Benson 1982
ogonocichla stellata (Turdidae, thrushes)	Malawi, Zambia	Dowsett (1988)
		distance traveled [km]->

Strix occidentalis
- Spotted owl

Laymon 1989



Altitudinal migration on the community level:

Chesser (1997) **Bolivian Andes** **Tyrannidae (New World flycatchers)** **n=57**	**15 probable altitudinal migrants**	**26%**
Stiles (1988) **Caribbean slope** **“Resident” forest birds** **n=345**	**69 seasonal migrants** **19 daily movers** **17 movers of uncertain status**	**20%** **6%** **5%**
Hilty (1997) **Colombia, Pacific slope western Andes** **Cloud-forest birds** **n=271**	**57 altitudinal migrants**	**21%**
Thiollay (1980) **Nepal, Himalaya** **Montane breeding birds** **n=340**	**173 altitudinal movers**	**51%!**

Trophic guilds:

High coincidence in studies about feeding guilds amongst altitudinal migrants of tropical humid forest (by order of importance):

1. Nectarivores
2. Frugivores

Daily movers:

Strong-flying birds of prey, aerial insectivores

Habitat preference:

Most Neotropical altitudinal migrant birds are forest-based.

Altitudinal migration on the population level:

- Subspecies or populations may differ in their behaviour with respect to altitudinal migration (e.g., Chesser 1997).

- There are partially migratory as well as totally migratory populations, but partial migration seems to be more common (e.g., Loiselle & Blake 1991).

- Cases of differential altitudinal migration are known, but underinvestigated (Ketterson & Nolan 1976).

- Particularly after the breeding season, young birds are frequently expulsed from the most favourable distributional core area or leave to find their own territory (dispersion). They stay in the periphery (e.g., Diamond 1973, own observations).

Proximate factors influencing altitudinal movements:

-> adverse weather events (heavy rains, snow storms)
- semi-predictable

-> catastrophic events (hurricanes, natural fires)
- semi-stochastic

-> Phenologies of food resources (arthropods, fruits, vertebrate prey etc.) - ~predictable

-> Competition (intra- and interspecific)
- ~predictable

Important differences between altitudinal migration and longi-latitudinal migration: Geometry rules...

Other than in longi-latitudinal migration...

..breeding areas ~restricted by *~conical shape of mountains*.

...especially breeding (but also non-breeding) *areas ~linear*.

....*distribution ~restricted*.

... in many cases especially breeding *areas disjunct*.

... extreme *broad-front migration*.

... breeding and non-breeding *areas ~visually connected*.

... *weather events ~the same* at breeding and non-breeding areas.

...limits of breeding area often defined ~by *interspecific competition*.

Some important implications for conservation:

- ! New calculations of actual distributional areas required
- ! Complementary, year-round protection necessary, in both breeding and non-breeding area
- ! Migration corridors
- ! Hunting, capture for pet market (e.g., cage bird traders in southeast Brazil!)
- ! Nectarivores and frugivores important mobile links (Gilbert 1980): maintain populations of plants and their distributional limits
- ! Climate change: (altitudinal) migrants depend on multiple areas with independent phenological rhythms; rapid change may lead to a miscoordination between the breeding- and non-breeding areas

Altitudinal migration and the CMS:

"Significant proportion" criterion

✓ Varying percentage of altitudinal migrant individuals within a species

✓ But include daily movers and escapers!

"Cycle" criterion

"Predictability" criterion

✓? Semi-stochastic/-predictable events not included

x? But consider, e.g., Nepal/India, Guatemala/Belize, Switzerland/ Italy, France, Zimbabwe/Moçambique

"Border-crossing" criterion

"100 km" criterion (applied only by GROMS):

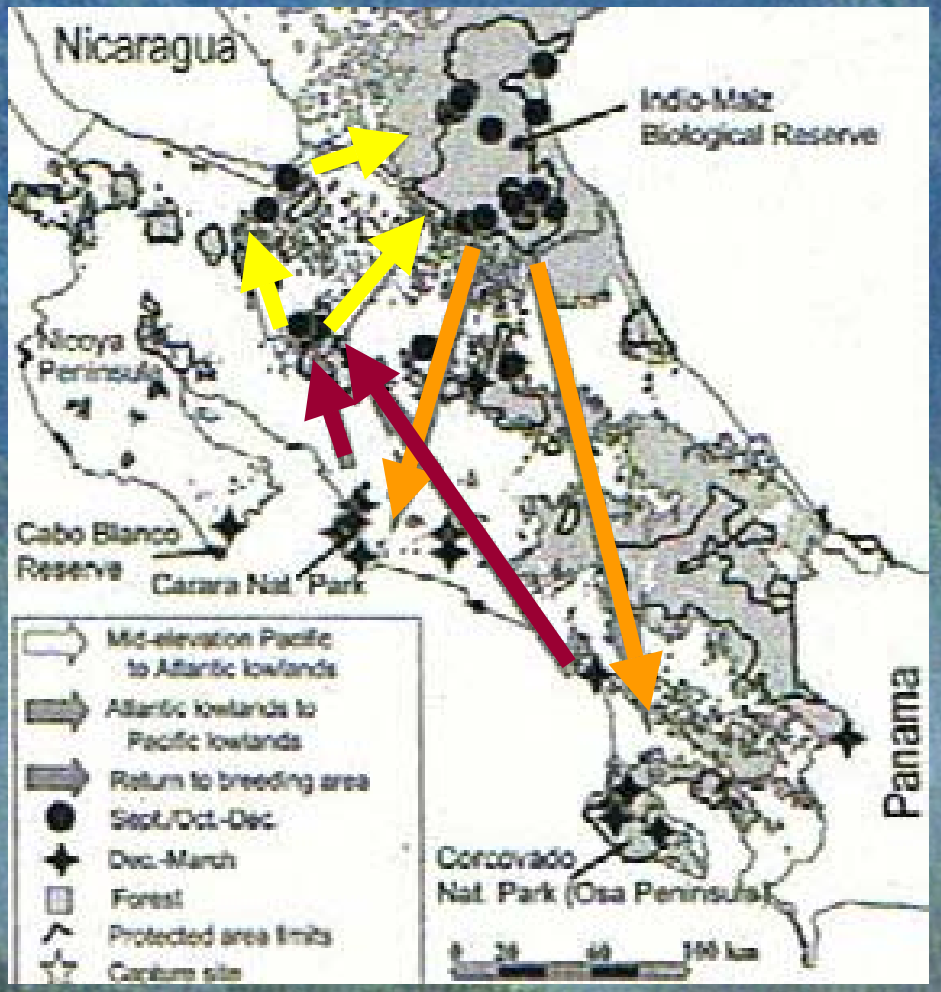
X (✓) some altitudinal migrants travel as far as 100 km, but the majority only short distances

Altitudinal migration represents a widespread and ecologically important migratory behaviour.

=> Convincing argument for the need for altitudinal conservation corridors!

CMS may look for synergisms with local/regional activities for conservation of altitudinal as well as "CMS migrants"!

Altitudinal and long-distance migration linked: the case of the Three-wattled Bellbird (*Procnias tricarunculata*)



Powell & Bjork (2004)

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