Improving scientific knowledge
- gaps & successful approaches -

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vetmeduni vienna

Structure

1. What is driving migrations / nomadism
2. Public perception / awareness / policies
3. Ecosystem services
4. Barriers to migration
5. „MVP“ for migratory species
6. Mitigation & offsets
7. Re-establishing migration

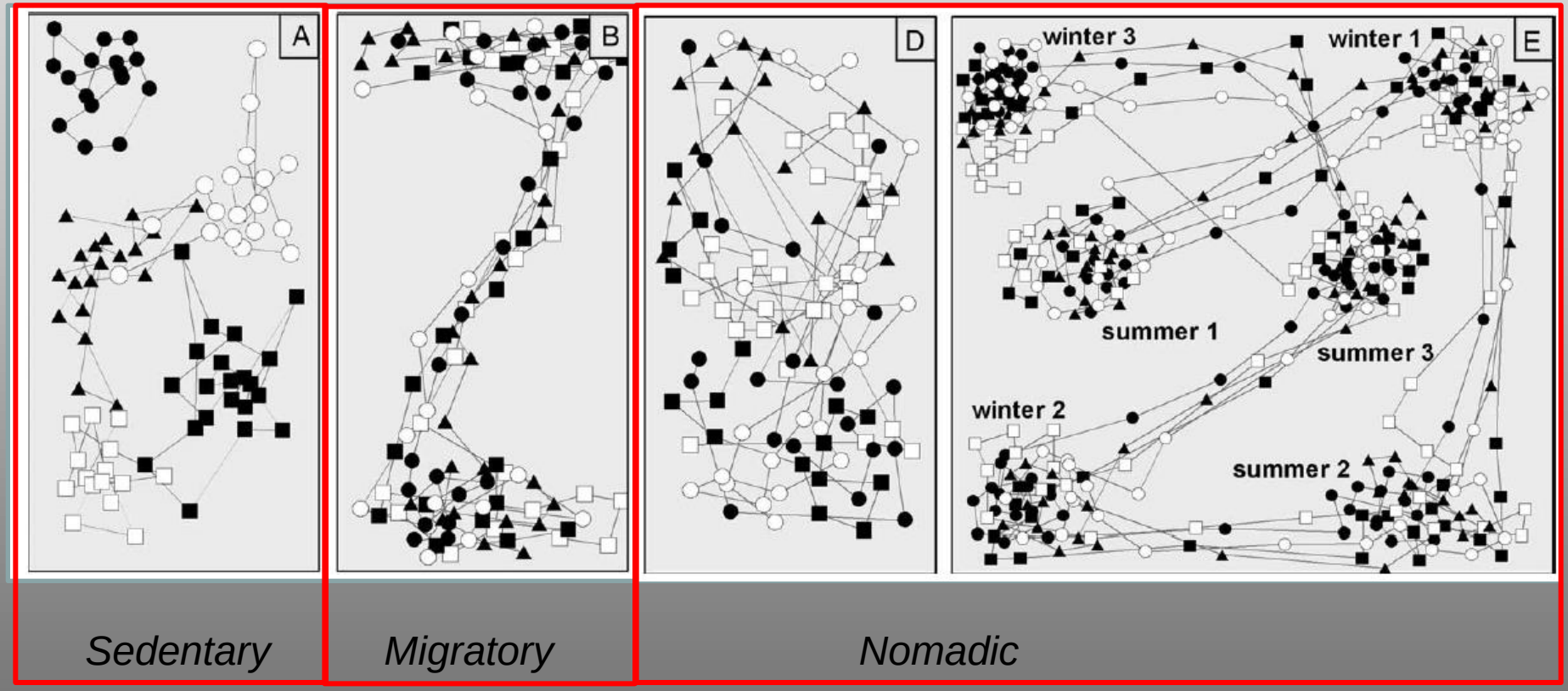
1. Drivers of migration

Table 1. Case studies of mammalian migration exemplifying specific hypothesis as described in the text.

Hypothetical benefit	Species	Migration type	References
Increase forage quantity	African and Amazonian manatee	Complete	Reeves et al. 1988; Arraut et al. 2010
	Frugivorous and insectivorous bats	Complete	Fleming and Eby 2003
	Humpback whale	Complete	Gaskin 1982; Rizzo and Schulte 2009
	Mexican long-nosed bat	Complete	Bernardo and Cockrum 1962; Moreno-Valdez et al. 2000
	Cheetah	Partial*	Durant et al. 1988
	Grey wolf	Partial	Parker 1973; Walton et al. 2001
	Lesser long-nosed bat	Partial	Rojas-Martínez et al. 1999
	Sperm whale	Partial*	Best 1969
	Spotted hyena	Partial	Hofer and East 1993
Increase forage quality	African elephant	Complete	Sikes 1971; Spinage 1994
	Caribou	Complete	Bergman et al. 2000
	Thomson's gazelle	Complete	Fryxell et al. 2004; Hopcraft 2010
	Wildebeest	Complete	Fryxell et al. 1988; Holdo et al. 2009
	Red deer	Partial	Bischof et al. 2012
Avoiding conspecific resource depletion	Thomson's gazelle	Complete	Hopcraft 2010
	Red deer	Partial	Mysterud et al. 2011
Thermoregulation	Humpback whale	Complete	Gaskin 1982; Rizzo and Schulte 2009
	Killer whale	Complete	Durban and Pitman 2012
	Schreiber's bat	Complete	Rodrigues and Palmeirim 2008
	Mexican free-tailed bat	Partial*	Bernardo and Cockrum 1962; Fleming and Eby 2003
	West Indian manatee	Partial*	Deutsch et al. 2003
Avoiding ectoparasitism	Reindeer	Complete	Folstad et al. 1991
Escape predation	Amazonian manatee	Complete	Arraut et al. 2010
	Zebra	Complete	Hopcraft 2010
	North American elk	Partial	Hebblewhite and Merrill 2007
Escape calf predation	Baleen whale (general)	Partial*	Corkeron and Connor 1999
	Bighorn sheep	Partial*	Festa-Bianchet 1988
	Caribou	Partial*	Bergerud et al. 1990; Heard et al. 1996
Mating	Bighorn sheep	Partial*	Bleich et al. 1997
	Bowhead whale	Partial*	Reeves et al. 1983
	Flying fox	Partial	Tidemann and Nelson 2004
	Harbor seal	Partial*	Parijs et al. 2000
	Harp seal	Partial*	Burns 1970
	Himalayan tahr	Partial*	Forsyth 1999
	North American elk	Partial*	Clutton-Brock et al. 1982
	Northern elephant seal	Partial*	Stewart and DeLong 1995; Van Den Hoff et al. 2002
	Sperm whale	Partial*	Best 1969
	Walrus	Partial*	Wiig et al. 1996

Avgar T, Street G, Fryxell JM (2014) On the adaptive benefits of mammal migration. *Canadian Journal of Zoology* **92**(6), 481-490.

Resource distribution & predictability



Mueller T, Fagan WF (2008) Search and navigation in dynamic environments behaviors to population distributions. *Oikos* **117**, 654-664.

Examples from Central Asia

- **Resource availability [NDVI]**

Mueller T, Olson KA, Fuller TK, Schaller GB, Murray MG, Leimgruber P (2008) In search of forage: predicting dynamic habitats of Mongolian gazelles using satellite-based estimates of vegetation productivity. *Journal of Applied Ecology* **45**(2), 649-658.

Ito TY, Tsuge M, Lhagvasuren B, Buuveibaatar B, Chimeddorj B, Takatsuki S, Tsunekawa A, Shinoda M (2013) Effects of interannual variations in environmental conditions on seasonal range selection by Mongolian gazelles. *Journal of Arid Environments* **91**, 61-68.

Singh NJ, Grachev IA, Bekenov AB, Milner-Gulland EJ (2010) Tracking greenery across a latitudinal gradient in central Asia - the migration of the saiga antelope. *Diversity and Distributions* **16**(4), 663-675.

- **Predation / disturbance**

Singh NJ, Grachev IA, Bekenov AB, Milner-Gulland EJ (2010) Saiga antelope calving site selection is increasingly driven by human disturbance. *Biological Conservation* **143**(7), 1770-1779.

Olson KA, Mueller T, Kerby JT, Bolortsetseg S, Leimgruber P, Nicolson CR, Fuller TK (2011) Death by a thousand huts? Effects of household presence on density and distribution of Mongolian gazelles. *Conservation Letters* **4**(4), 304-312.

Kaczensky P, Kuehn R, Lhagvasuren B, Pietsch S, Yang W, Walzer C (2011) Connectivity of the Asiatic wild ass population in the Mongolian Gobi. *Biol Conserv* **144**(2), 920-929.

Gaps

- Route, scale, general pattern
- Triggers, cues, timing
- Sensory ability (e.g. sensing rainfall over large distances)
- Memory & Information transfer

2. Public perception / awareness

Moving beyond science - *Pronghorn*

WILDLIFE

Pronghorns bound through snow in Wyoming's upper Green River Basin.

Losing Ground Pronghorn antelope run faster than any animal except the cheetah, and they make the longest migration—up to 350 miles round-trip—of any land mammal in the U.S. But they can't outpace human development. For millennia, pronghorns followed eight routes in Idaho, Montana, and Wyoming to their summer ranges in the Yellowstone and Teton highlands. Six of these routes are now blocked by roads, farms, reservoirs, and suburban sprawl.

Their only path south of the Tetons narrows to a few hundred feet, about a sixteenth of its average width. "The southern path is an artery for the lifeblood of Grand Teton National Park," says Steve Cain, a biologist with the National Park Service. "It's part of a predator-prey system unrivaled in the U.S. outside Alaska," sustaining coyotes, wolves, mountain lions, and grizzlies.

Cain and his colleagues are pushing for government protection of the remaining pronghorn routes. They also recommend that any natural gas fields be tapped diagonally from outside the route. "This is one of the last world-class examples of long-distance mammal migration," Cain says. "If we destroy it for the sake of human convenience, we'll regret it for sure." —Michael Klesius

Table 2. Chronology of conservation milestones that promoted protection of Path of the Pronghorn in the western United States.

Year	*Type*	*Description**
<2003	context	75% of GYE pronghorn migrations lost (Berger et al. 2006)
2003	context/ outreach	Is extinction acceptable in national parks? (Berger 2003)
2003–2004	science	GPS collar migration study (Supporting Information)
2004	media	*The New York Times*—Endangered Migration (Robbins 2004)
2006	science	Publication of POP migration research (Berger et al. 2006)
2006	science/ media	Informal digital distribution of migration route polygon
2006	outreach	First annual "Party for the Pronghorn" JHCA and local business
2006	support	Teton County Commission letter to WY governor to support migration corridor protection
2007	media	*The New York Times* commissioned editorial "Let the Antelope Roam" (Berger and Berger 2006)
2007	media	*Smithsonian* "End of the Road?" (Glick 2007)
2004–2007	outreach	WCS-led stakeholder (Table 1) workshops, meetings, presentations
2007	support	Western Governors Association Policy Resolution 07–01 to protect corridors
2008	support	Pledge of POP protection support by GTNP, NER, BTNF (GTNP, unpublished data)
2008	outreach	Migration waysides unveiled GTNP, WGFD, BTNF, NER
2008	policy change/protection	First federal protection of migration corridor in United States, POP through BTNF (BTNF 2008)
2008	protection	DOI pledges $1 million to help further protect POP
2008 to present	protection	Continued conservation work by NGOs and private land owners

**Abbreviations: POP, Path of the Pronghorn; JHCA, Jackson Hole Conservation Alliance; WCS, Wildlife Conservation Society; GTNP, Grand Teton National Park; NER, National Elk Refuge; BTNF, Bridger-Teton National Forest; WGFD, Wyoming Game and Fish Department; DOI, United States Department of Interior.*

Berger J, Cain SL (2014) Moving Beyond Science to Protect a Mammalian Migration Corridor. *Conserv Biol*.

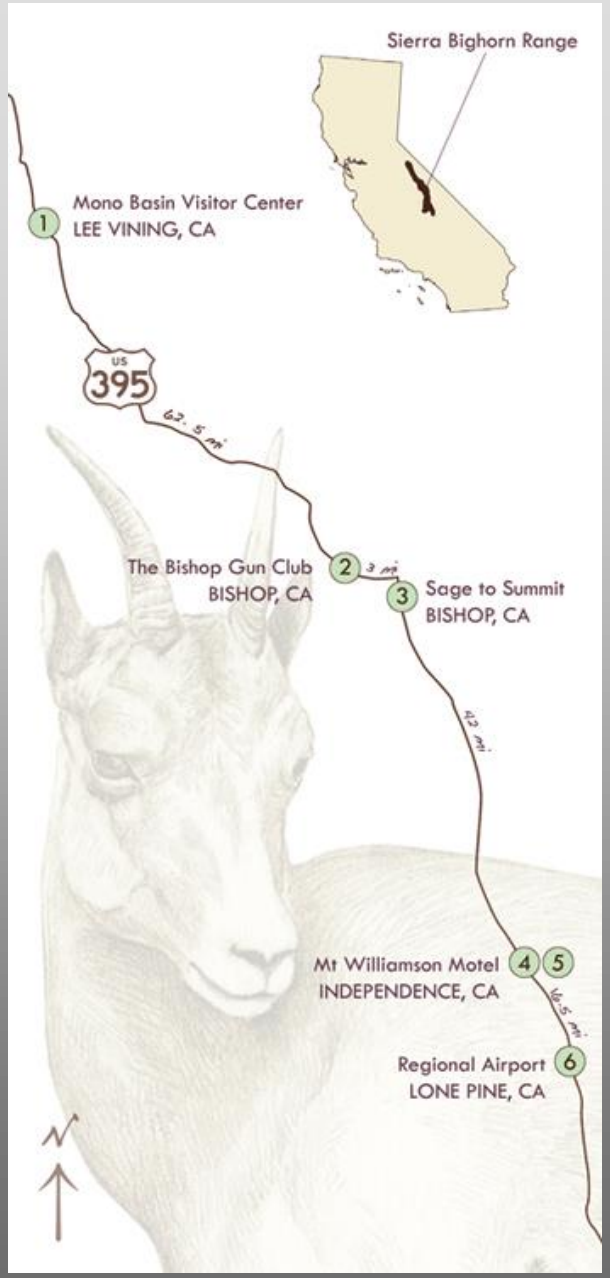
Moving beyond science

- Established legal framework
- Effective management institutions
- Excellent science institutions / wildlife professionals
- Science based policies
- Adaptive management approaches
- Stakeholder involvement / established communication channels
- Adequate funding

-> need for social & political science

THE MIGRATING MURAL goal is to bring attention to rare wildlife in an effort to drive support for endangered animals and public art.

The Sierra Nevada bighorn sheep is the subject of the first Migrating Mural, a series of six murals spanning 120 miles of California's Highway 395.



http://conservationmagazine.org/2014/03/migrating-murals/

http://ink-dwell.com/portfolio/migrating-mural-chapter-one-sierra-nevada-bighorn-sheep/

3. Ecosystem services

Benefits	Costs
Nutrient distribution / C storage	
Seed dispersal	Disease transmission, invasive species
Creating bird habitat	Trampling
Grazing facilitation / stimulating grass growth	Competition, overgrazing, crop raiding
Fire control	
Hunting / harvest (higher abundance of migratory versus resident populations)	
Tourism	
Cultural value	Human-wildlife conflicts
Intrinsic value – ecological phenomena	Opportunity costs

Management challenges:

- combining monetary and non-monetary values
- spatial mismatch of costs and benefits
- how to deal with non-ecosystem services such as extraction industries

Ecosystem service calculation

Annual spatial subsidy calculation for Chinook salmon. Negative values for the subsidy (Y) indicate the amount owed.

	River	Near shore	Ocean
V	$3,711,003.00	$0.00	$1,611,979.00
D	0.270555695	0.510635434	0.218808871
Mo	$436,130.10	$2,718,103.22	$812,000.38
Mi	$2,706,970.00	$0.00	$1,259,263.69
Y	−$2,270,839.91	$2,718,103.22	−$447,263.32

V = ecosystem services
D = species dependency on location
Mo = gross migration support provided to all other locations
Mi = gross migration support received from all other locations
Y = balance

Semmens DJ, Diffendorfer JE, López-Hoffman L, Shapiro CD (2011) Accounting for the ecosystem services of migratory species: Quantifying migration support and spatial subsidies. *Ecological Economics* **70**(12), 2236-2242.

4. Barriers to migration

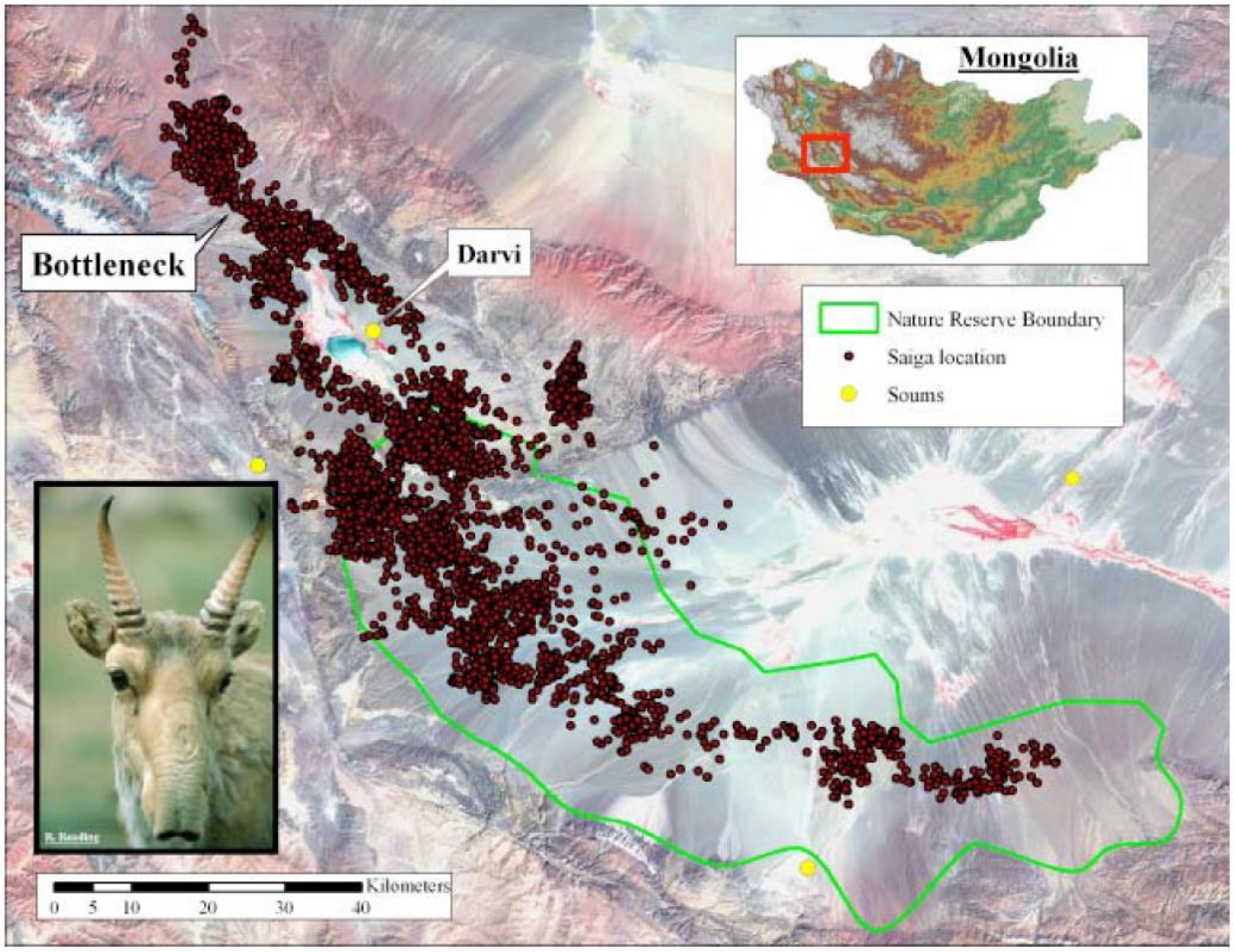


Fig. (1). GPS-locations from four female saiga near Darvi soum (town) in the Shargyn-Govi Nature Reserve, Mongolia (location indicated in map inset of Mongolia). Photo inset of male saiga, often hunted for their horns.

Berger J, Berger KM, Bergen S, Buuveibaatar B, Fine A, Lkhagvasuren B, Young JK, Zahler P (2008) Migration Bottlenecks, Climate, and the Conservation of Pleistocene Relicts in Central Asia *The Open Conservation Biology Journal* **2**, 9-10.

Barrier effect – *Mongolian gazelles / khulan*

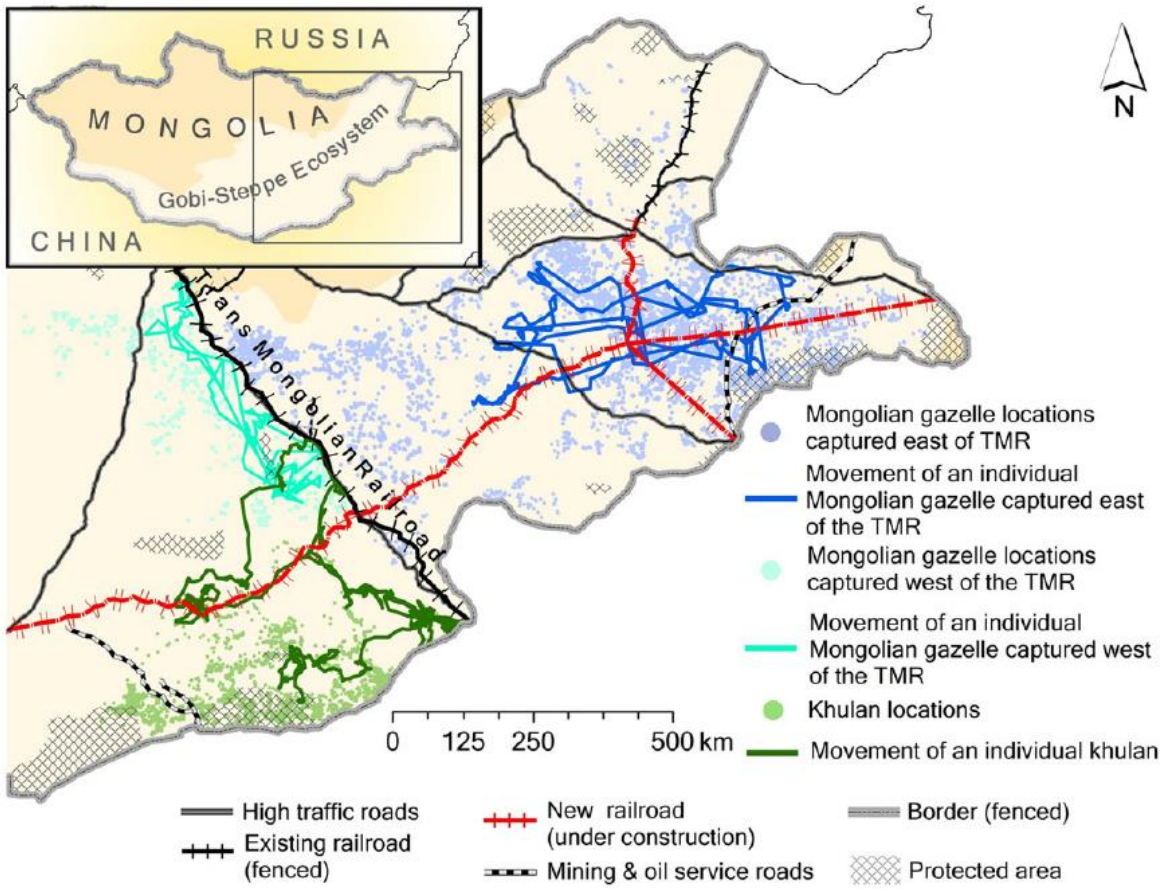
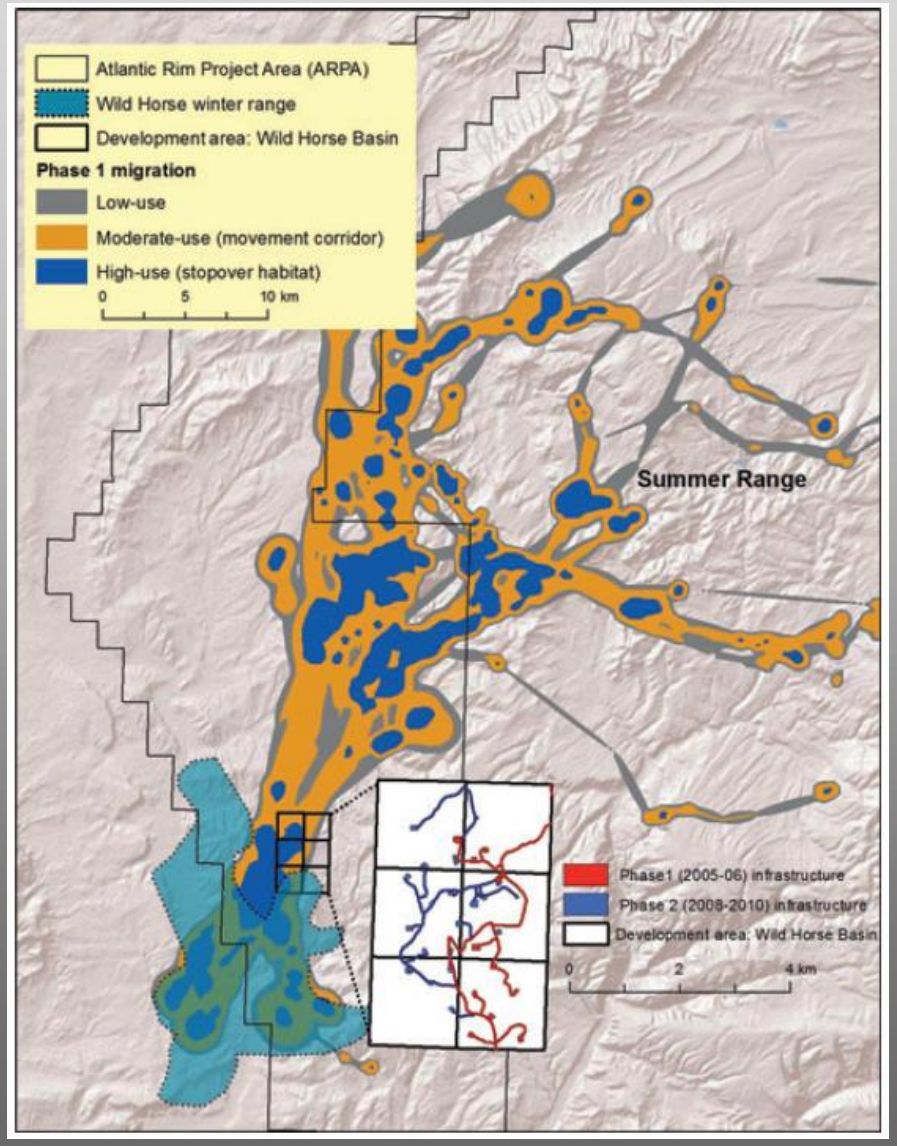


Figure 2. Locations of 61 Mongolian gazelles and 7 khulan (Kaczensky et al. 2011; Ito et al. 2013; Fleming et al. 2014) and movement pathways of 2 Mongolian gazelle and one khulan in the Gobi-Steppe Ecosystem.

Batsaikhan N, Buuveibaatar B, *et al.* (2014) Conserving the World's Finest Grassland Amidst Ambitious National Development. *Conserv Biol*.

Identifying barriers – *mule deer Wyoming*



Sawyer H, Kauffman MJ, Middleton AD, Morrison TA, Nielson RM, Wyckoff TB, Pettorelli N (2013) A framework for understanding semi-permeable barrier effects on migratory ungulates. *Journal of Applied Ecology* **50**(1), 68-78.

Journal of Animal Ecology

Journal of Animal Ecology 2014 doi: 10.1111/1365-2656.12275

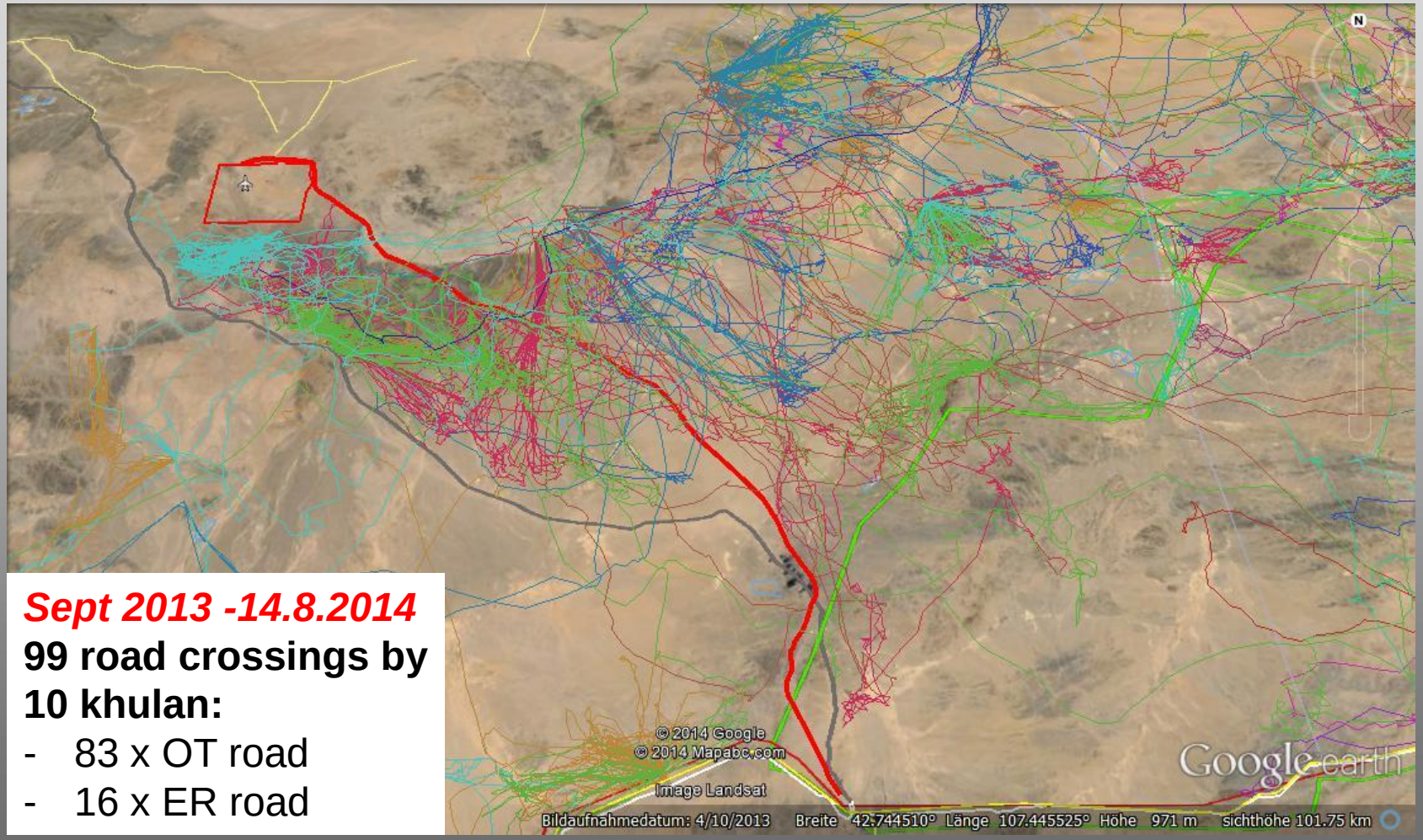
SPECIAL FEATURE: STUCK IN MOTION? RECONNECTING QUESTIONS AND TOOLS IN MOVEMENT ECOLOGY

'You shall not pass!': quantifying barrier permeability and proximity avoidance by animals

Hawthorne L. Beyer[1*], Eliezer Gurarie[2,3], Luca Börger[4], Manuela Panzacchi[5], Mathieu Basille[6], Ivar Herfindal[7], Bram Van Moorter[5], Subhash R. Lele[8] and Jason Matthiopoulos[9]

Challange: new tool not yet easily applicable to real world problems

Corridors? -khulan SE Gobi

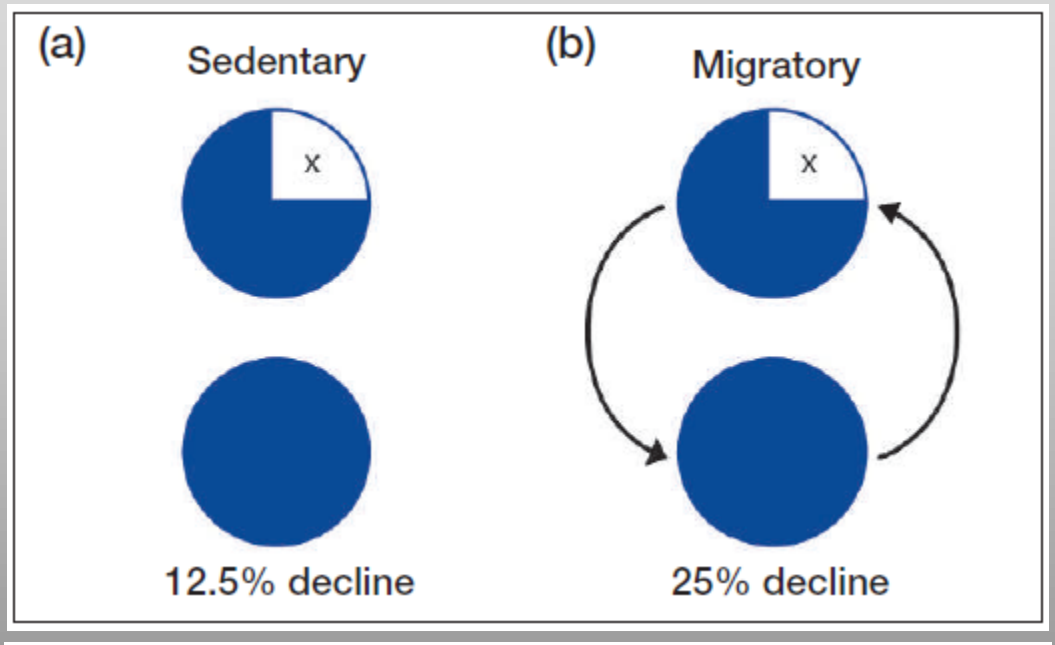


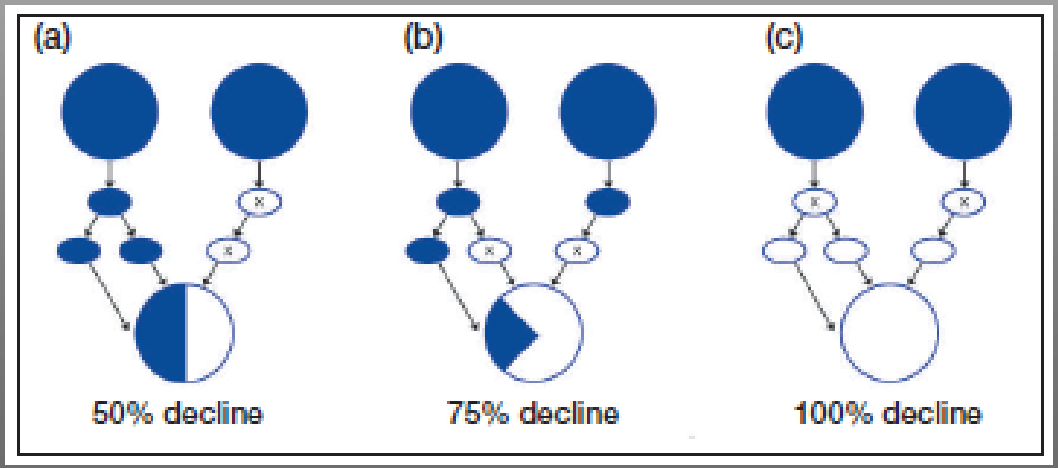
Sept 2013 -14.8.2014

99 road crossings by 10 khulan:

- 83 x OT road
- 16 x ER road

5. „MVP" for migratory species





Non-linear relationship between habitat size and population size

Runge CA, Martin TG, Possingham HP, Willis SG, Fuller RA (2014) Conserving mobile species. *Frontiers in Ecology and the Environment* **12**(7), 395-402**.**

Movement model & population dynamics - *Serengeti*

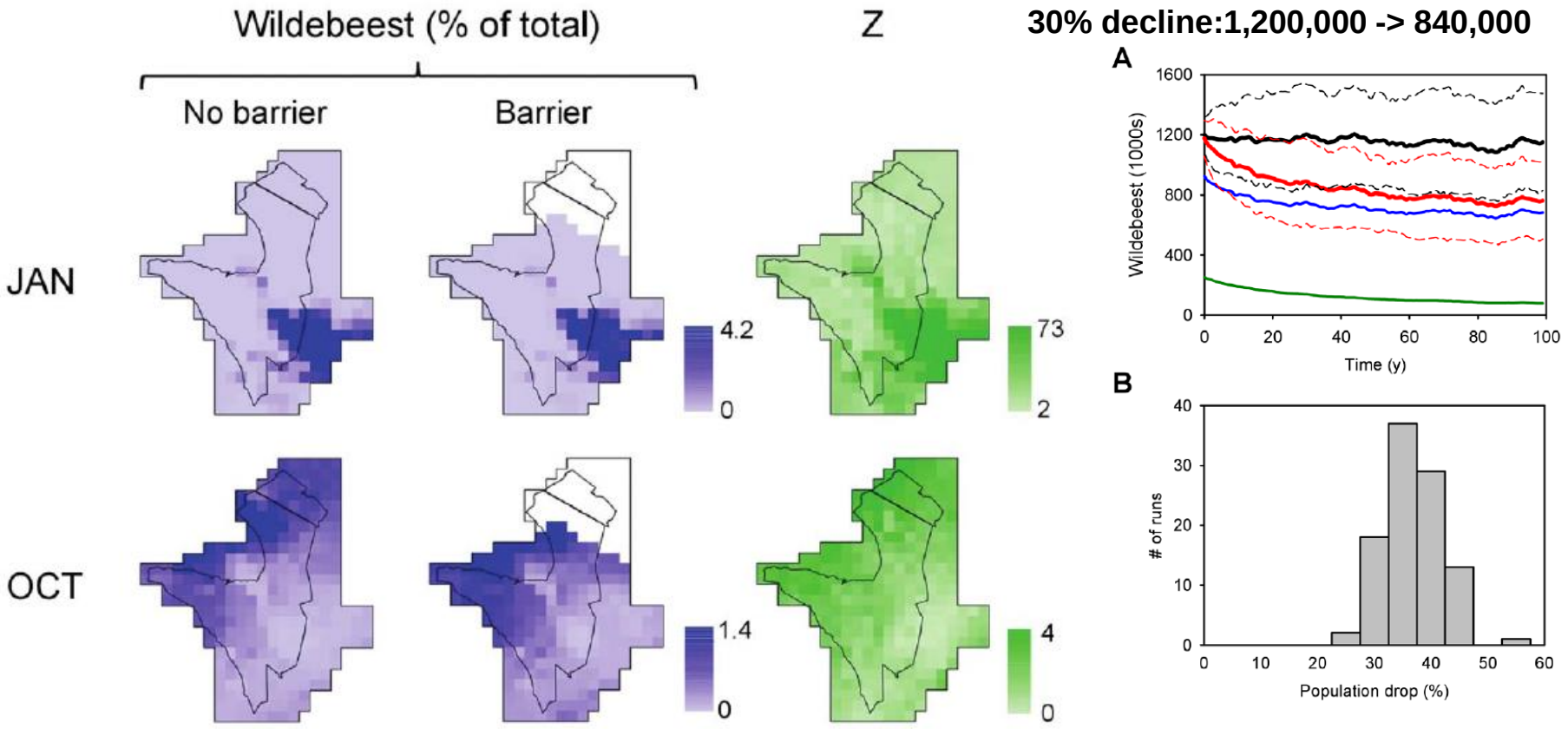
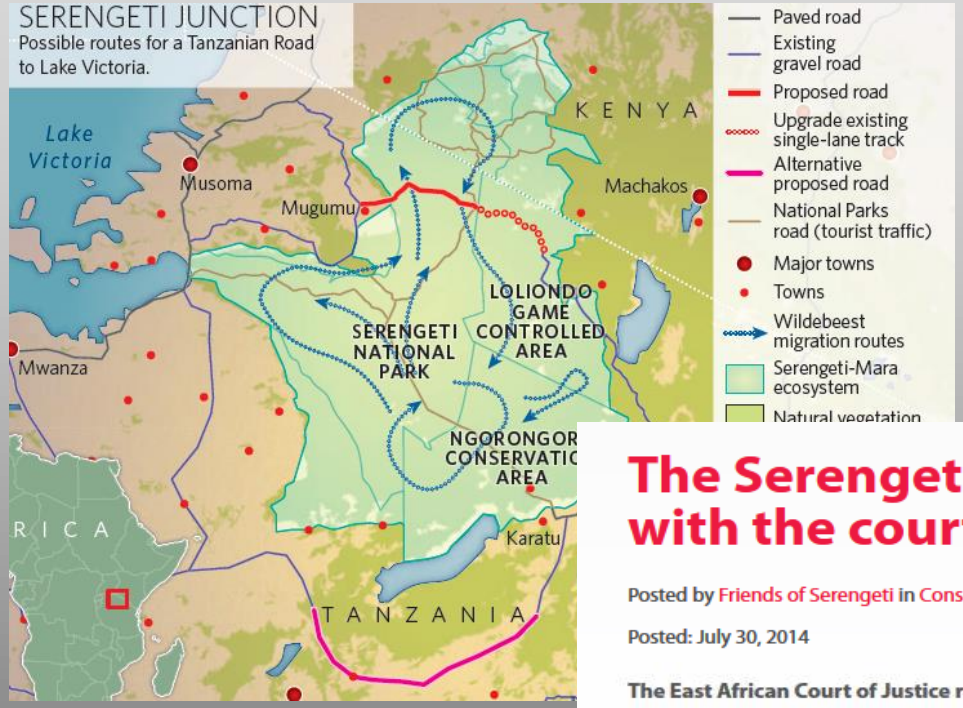


Figure 3. Simulated seasonal distributions of wildebeest and resources across the landscape. The wildebeest panels show the percentage of the total population that occupies each cell in the lattice (based on month-end counts) in the wet (January) and at the end of the dry (October) seasons for the no barrier and barrier scenarios. The resource panels show the mean daily values of Z (Eq. 1 in the text) across the landscape for the no barrier scenario.

Holdo RM, Fryxell JM, Sinclair ARE, Dobson A, Holt RD (2011) Predicted Impact of Barriers to Migration on the Serengeti Wildebeest Population. *PLoS ONE* **6**(1), e16370.

Road fragmentation - *Serengeti*



Dobson et al. 2010. Road will ruin Serengeti. NATURE

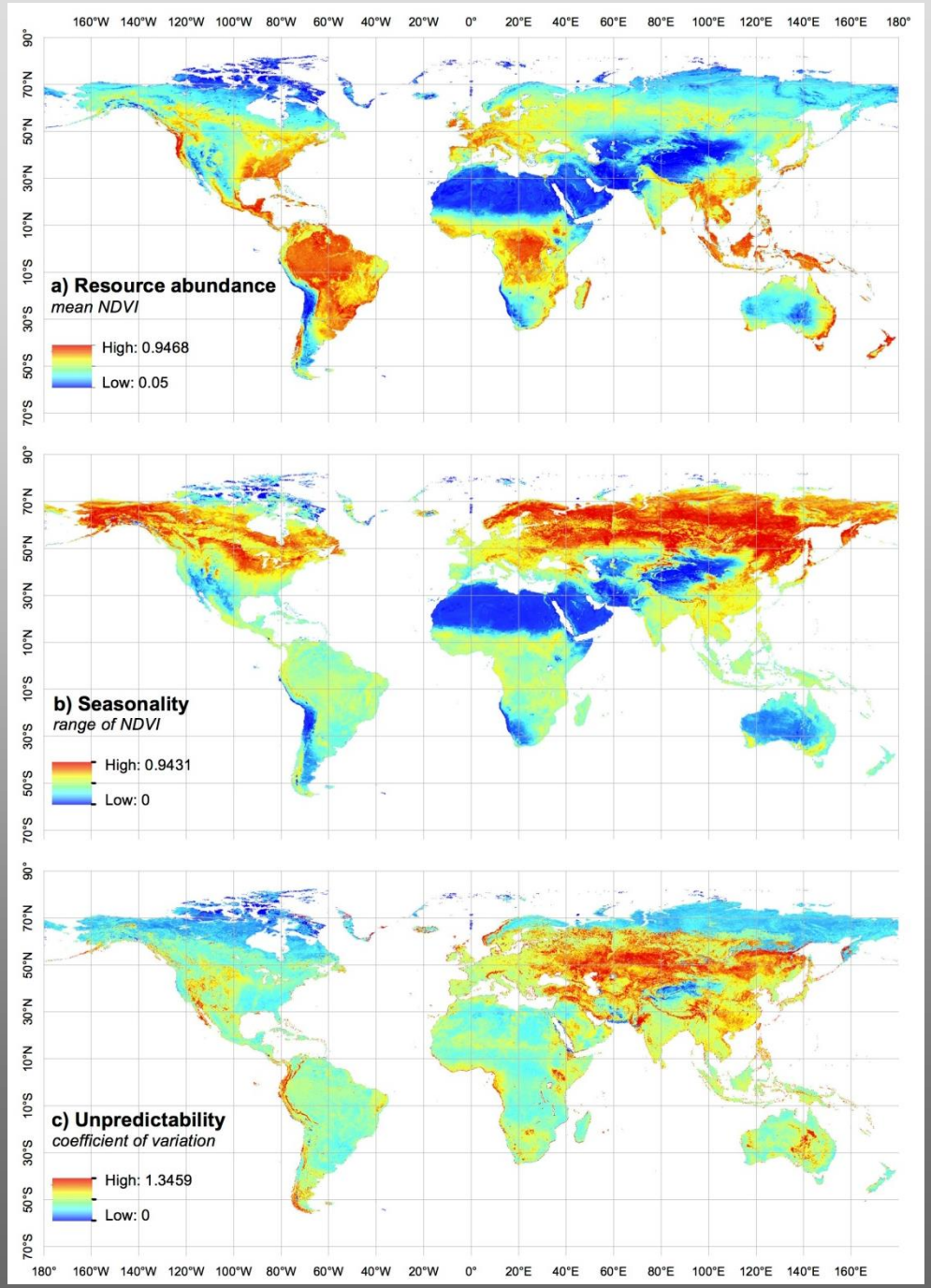
The Serengeti highway battle won, the war with the courts continues

Posted by Friends of Serengeti in Conservation, Events, News, Wildlife — 9 Comments ↓

Posted: July 30, 2014

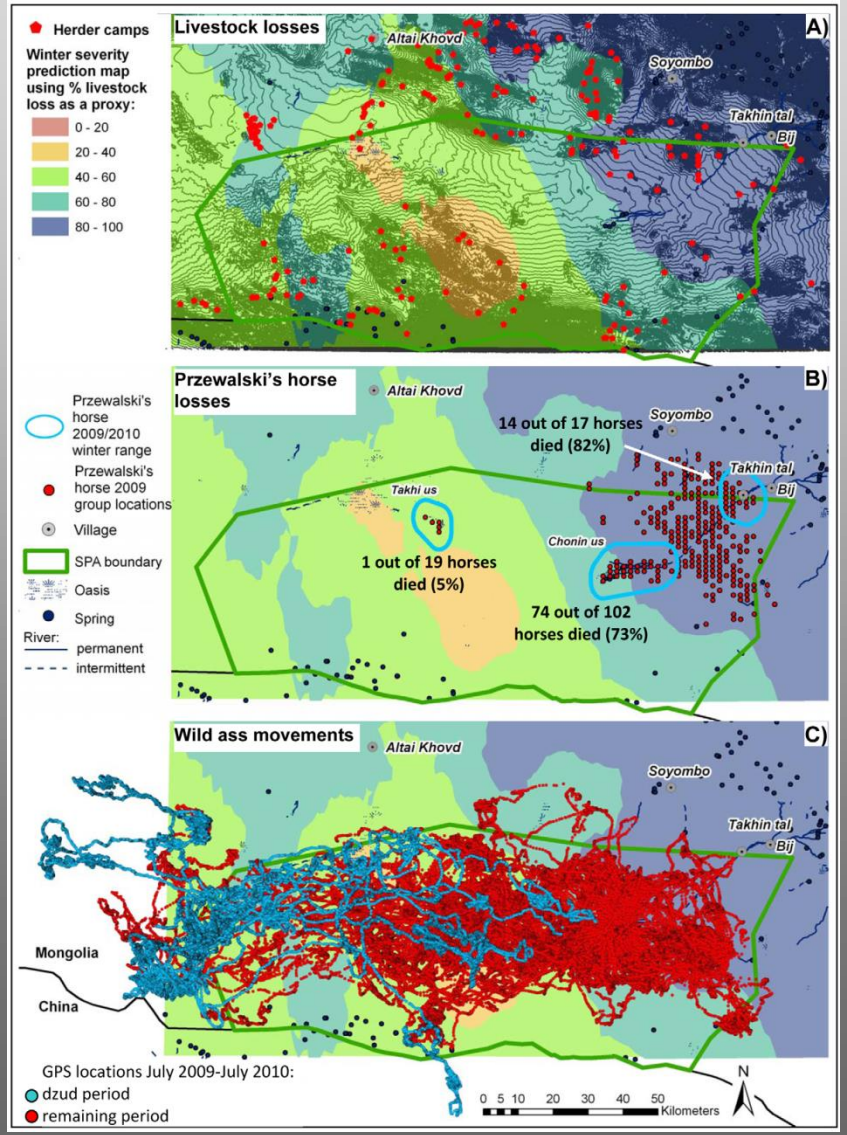
The East African Court of Justice ruled against a paved commercial highway through Serengeti National Park in Tanzania. Although a great victory, the ruling contains 'potholes.'

Landscape dynamics - *NDVI*



Dresslers MSc thesis

Catastrophic events - *khulan*



67% loss of livestock

60% loss of resident Przewalski‘s horses

0% loss of collared khulan
-10 of 14 collars retrieved
- Very few carcasses encountered

Kaczensky P, Ganbataar O, Altansukh N, Enkhsaikhan N, Stauffer C, Walzer C (2011) The danger of having all your eggs in one basket--winter crash of the re-introduced Przewalski's horses in the Mongolian Gobi. *PLoS ONE* **6**(12), e28057.

Climate change - *Przewalski's gazelle*

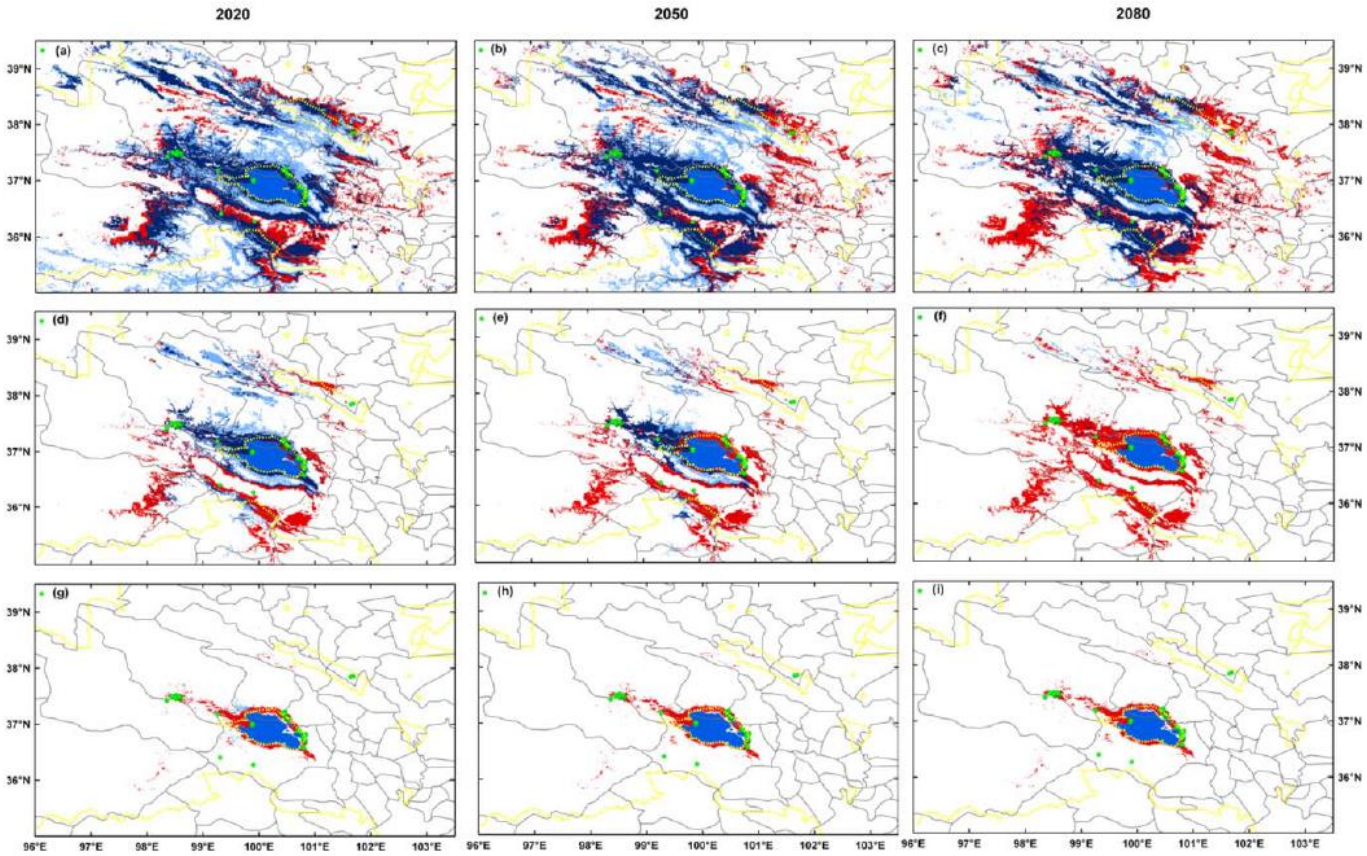


Figure 3. Close-up of predicted distribution of *Procapra przewalskii* for three time slices: 2020, 2050 and 2080. Models are obtained with an ensemble-forecast approach across the three general circulation models (CCCMA, CSIRO and HADCM3) and the two climate change scenarios (A2a and B2a). Suitable ranges are selected by the thresholds of 0.54, 0.80 and 0.95 (panels a–c; d–f; g–i, respectively) for current and future predictions. For all panels, red indicates the current suitable habitats predicted to be unsuitable in the future; yogo blue indicates the current nonsuitable habitats predicted to be suitable in the future and blue indicates current suitable habitats predicted to stay suitable in the future. The gray solid lines represent county boundaries and yellow dotted lines, the boundaries of protected areas. The lapis lazuli area indicates the Qinghai Lake.
doi:10.1371/journal.pone.0022873.g003

Hu J, Jiang Z (2011) Climate Change Hastens the Conservation Urgency of an Endangered Ungulate. *PLoS ONE*.

6. Mitigation & offsets

Table 1. Examples of biodiversity offset schemes that affect migratory species

No-net-loss target	*Biodiversity offset objective*	*Example*	*Challenges for mobile/migratory species*
Habitat	Any habitat degraded or lost through development is replaced with created/ restored habitat (indirect species conservation is assumed).	EU Natura 2000 sites (McKenney and Kiesecker 2010)	Species are not explicitly targeted or conserved, so it cannot be assumed they will be conserved along with their habitat.
Habitat used by migratory species	Any area of habitat used by a migratory species that is degraded or lost through development is replaced with created/ restored habitat that is also used by that migratory species.	Pronghorn antelope (Kiesecker *et al.* 2009)	Habitat type/condition may change with time (eg degrade due to climate change). Migratory species may change preference to a different site.
Species' migration route	Any negative impacts of development upon the migration route of a species are offset by actions that preserve that migration route.	Saiga antelope (UNDP 2010)	Species may change migration route. Species migration might stop entirely.
Migratory/mobile species (direct)	Any negative impacts of development upon a population of migratory species are offset by actions that conserve that population.	White-tailed sea eagle (Cole 2010)	Species may begin to be impacted by factors that are outside the scope of the offset scheme. The proportion of the population migrating may change.
Migratory/mobile species (indirect)	Any negative impacts of development upon a population of migratory species are offset by actions that conserve that species elsewhere in its range/life cycle.	Seabirds (Wilcox and Donlan 2007)	Species may begin to be impacted by factors that are outside the scope of the offset scheme. Difficult to demonstrate equivalence between different stages of a species' life cycle.
Ecosystem function	Any loss of functional value provided by a habitat and associated migratory species following development is restored, via the provision of that habitat/species or similar habitat/ species elsewhere.	US wetlands (McKenney and Kiesecker 2010)	Habitat/species may cease providing function. Habitat/species may provide function somewhere else.
Combination of the above	Any losses of habitat, species, or ecosystem function following development are compensated for in-kind.		Relationship between species/habitat/ ecosystem function might change such that offset goals become incompatible (eg different species might develop conflicting spatial conservation requirements).

Notes: Table contents appear (from top to bottom) roughly in order of increasing consideration given to the mobile nature of migratory species.

Bull JW, Suttle KB, Singh NJ, Milner-Gulland EJ (2013) Conservation when nothing stands still: moving targets and biodiversity offsets. *Frontiers in Ecology and the Environment* **11**(4), 203-210.

in kind

out of kind

Challange:

- Currency
- Indicators
- Cummulative effects

Off-sets – *Saiga Uzbekistan*

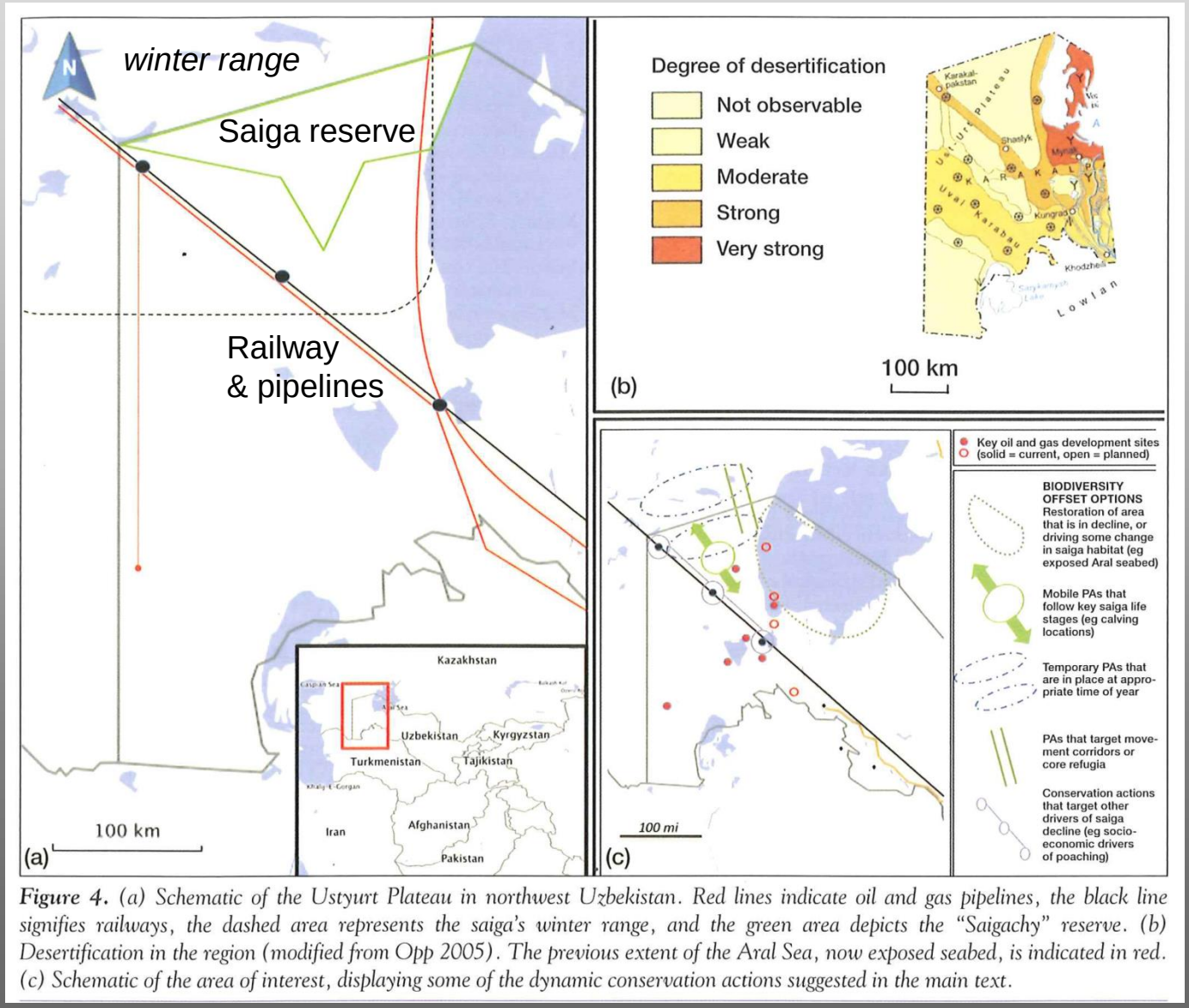
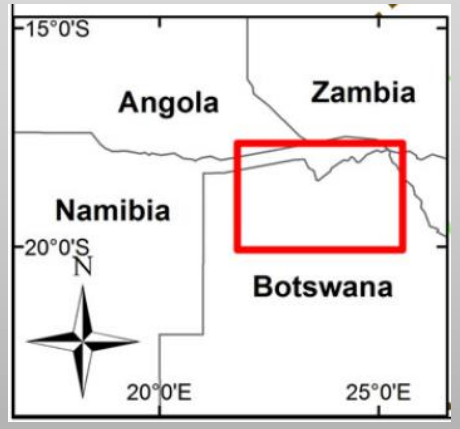
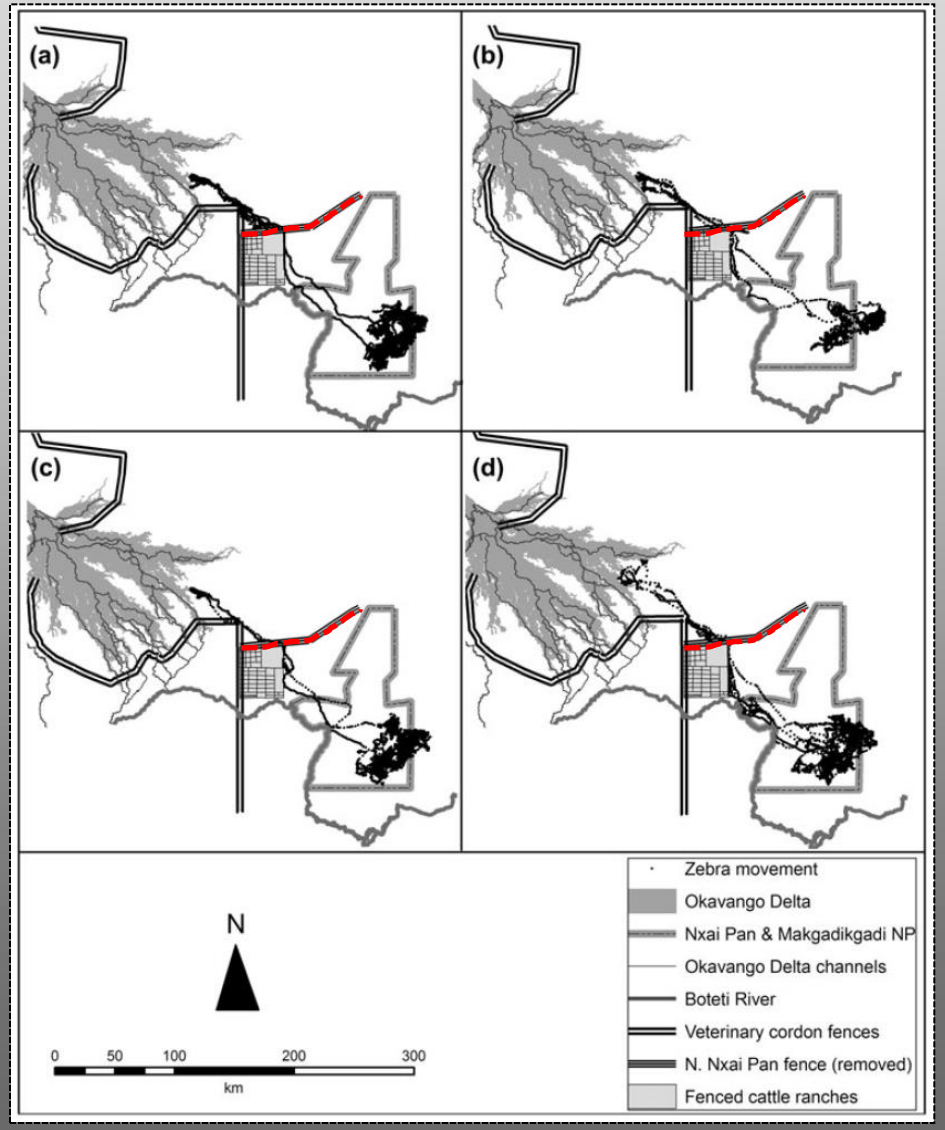


Figure 4. *(a) Schematic of the Ustyurt Plateau in northwest Uzbekistan. Red lines indicate oil and gas pipelines, the black line signifies railways, the dashed area represents the saiga's winter range, and the green area depicts the "Saigachy" reserve. (b) Desertification in the region (modified from Opp 2005). The previous extent of the Aral Sea, now exposed seabed, is indicated in red. (c) Schematic of the area of interest, displaying some of the dynamic conservation actions suggested in the main text.*

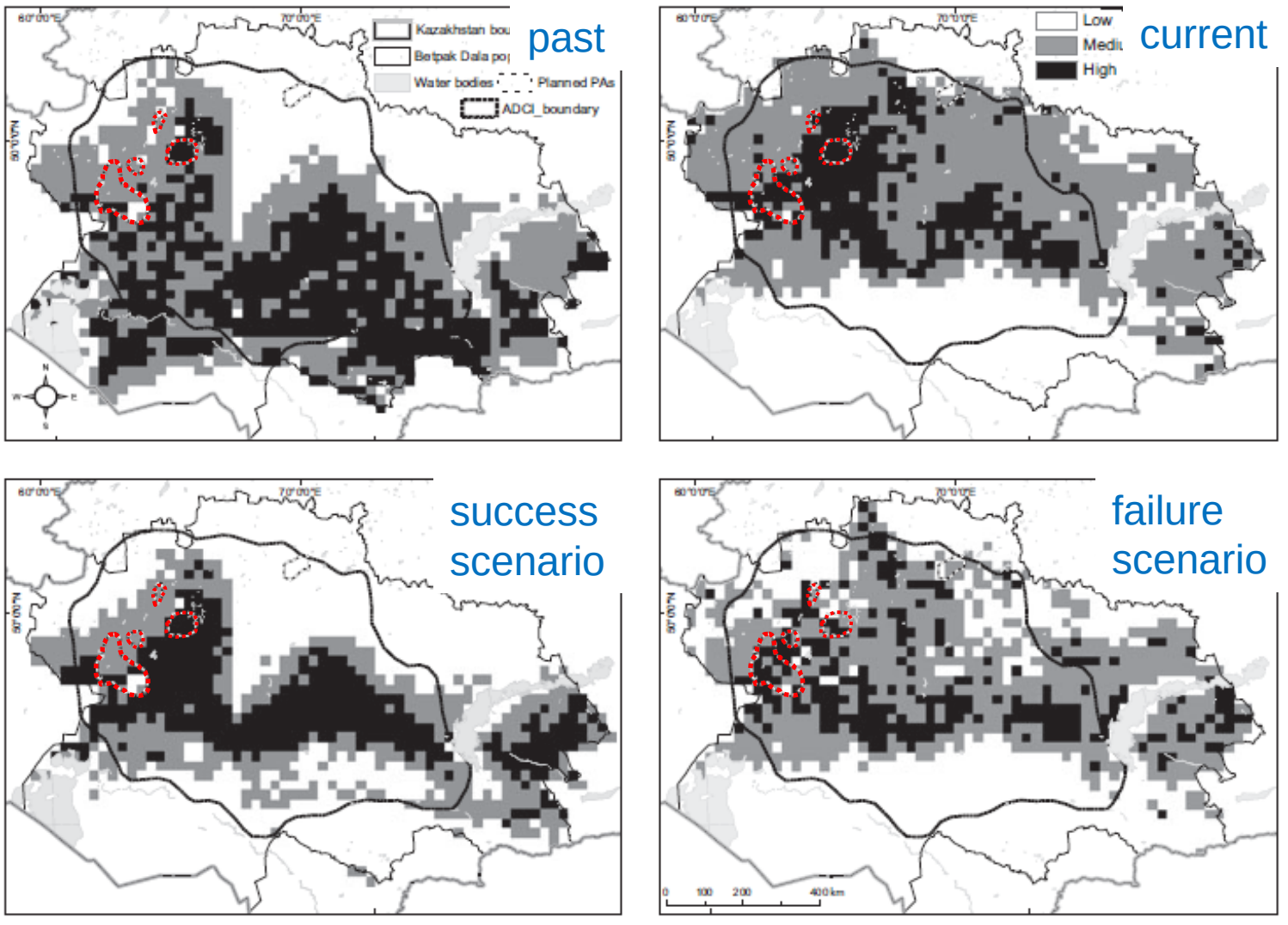
7. Re-establishing migration





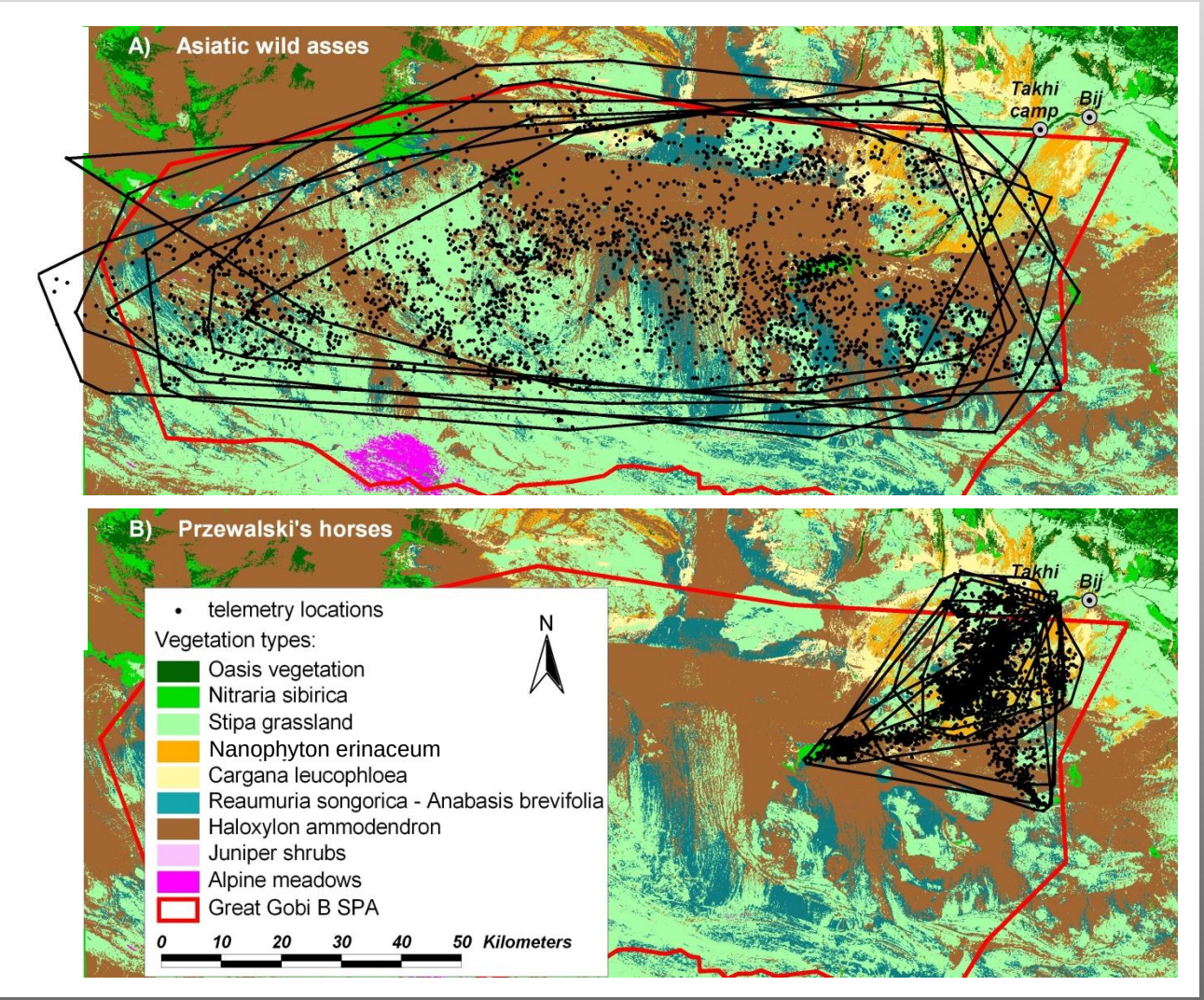
Bartlam-Brooks HLA, Bonyongo MC, Harris S (2011) Will reconnecting ecosystems allow long-distance mammal migrations to resume? A case study of a zebra *Equus burchelli* migration in Botswana. *Oryx* **45**(2), 210–216.

Conservation planning - *Saiga*



Singh NJ, Milner-Gulland EJ (2011) Conserving a moving target: planning protection for a migratory species as its distribution changes. *Journal of Applied Ecology* **48**(1), 35-46.

Reintroduction – *Przewalski horse*



Kaczensky P, Ganbaatar O, von Wehrden H, Walzer C (2008) Resource selection by sympatric wild equids in the Mongolian Gobi. *Journal of Applied Ecology* **45**, 1662-1769.

Reintroduction – *learning?*

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Thank you for your attention!