Long-Term Research on Biodiversity in West Khentey, Northern Mongolia

Michael Mühlenberg
Georg-August-Universität Göttingen, michael.muehlenberg@zentr.uni-goettingen.de

Erforsch. biol. Ress. Mongolei (Halle/Saale) 2012 (**12**): 27–37

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M. Mühlenberg

Abstract

Biodiversity is studied at ecosystem, community, and species level around Khonin Nuga, where the University Goettingen supports a research station since 15 years (established 1997 in cooperation with the National University of Mongolia). In that period 39 scientists have been involved and 67 students graduated with theses (7 PhD) about field work at that station. Inventories started at 1998 for several taxa and are now compiled in a book, which will be printed 2012 in Ulaanbaatar. It covers fungi, lichens, plants, several insect groups, spiders, crustaceans, and all vertebrate classes. For all taxa adequate experts proved the species lists. Because of both the high species richness in most taxa and the new threat by logging and frequent anthropogenic fires the area around Khonin Nuga has to be denoted a “hotspot of biodiversity” for Mongolia. The long-term ecological research led to an understanding of the dynamics of the different forest types: the old-growth forest with dominating *Pinus sibirica* shows a gap-dynamics in regeneration, whereas the *Larix sibirica – Betula platyphylla* forests are driven by frequent fire disturbances. The anthropogenic fires are destructive for the biodiversity in forests. The tree species *Betula platyphylla* proved as a key resource for many saproxylic organisms and hole-breeding birds. The south-facing slopes are covered naturally by dry-mountain-steppes where trees are beyond their limits. In the river valleys meadows can form stable communities even though the floodplains allow tree growth physiologically. At the community level we studied for more than 10 years the dynamics of small mammal populations. At the southern edge of the taiga there is no pattern of cycles. The dynamics (fluctuation with population crash) is mainly caused by adverse winter conditions, but the dynamics can also shift to intrinsic factors at high population densities and favorable winter weather. At the species level we studied the reproduction strategy of a social corvid, the Azure-winged magpie (*Cyanopica cyana*). In years with favorable conditions it breeds without helpers. In years with high nest predation we observed 10 % helpers, but in a year with a colony disaster by burning 64 % helpers improved significantly the breeding success. The southern boreal forest is an area of special interest for conservation, containing the most diverse assemblages of species within the boreal forest. Intact, contiguous boreal forest will be best able to keep up with rapidly changing climate conditions because of high connectivity, providing diverse habitats for wildlife by its heterogeneity, high potential for regeneration, maintaining the soil system, and moderating local climate. Contributions to the long-term studies came from Dulamsuren Ch., Oyunsanaa B., Gottschalk E., Sheftel B., Gantulga B. and others found in the references.

Key words: Southern taiga, forest dynamics, wildfires, species inventories, vegetation mapping, small mammal dynamics, Azure-winged magpie

Introduction

In the valley “Khonin Nuga” an ecological research station of the Georg-August-Universität Goettingen, Germany, was established in collaboration with the National University of Mongolia in 1997. This station is situated in the West Khentey Mountains at the geographical coordinates of N 49°05’17’’ and E 107°17’36’’, 930 m a.s.l. The location is in the buffer zone of the Strictly Protected Area of Khan Khentey where the two rivers Sharlan and Hong meet and create the river Eroo, the upper part of the watershed of the Lake Baikal. The Khentey Mountains of northern Mongolia, where the Siberian forest belt borders the steppe, represent a unique and greatly untouched ecosystem.

The main reason for this station is to facilitate ecological long-term studies and capacity building. As part of the university it hosts in the summer student courses beside smaller research groups for vegetation, forestry, river ecology, invertebrates (insects, spiders and Crustacea), ornithology and small mammals.

Species inventories

Species lists of certain taxa emerged from the interests of different experts and students visiting the station. Some taxa were collected during one season; other taxa were sampled repeatedly in consecutive years. For instance, birds were always observed and therefore the species list could be completed every year. Up to now we have species lists of the following taxa (table 1).

There are two main reasons for the high species richness in the Khentey: 1. In this region elements of boreal, temperate and Daurian origin meet each other, and 2. The low human impact has not seriously reduced abundances of most species neither led to local extinction, not yet. Examples of species numbers from selected taxa are given in table 2.

The number of butterfly species is comparable: in Germany with an area of 356.970 km^2 about 180 species are known from a wide range of different habitats.

Classification of vegetation types

Biodiversity studies at the community level require a classification of the vegetation types. There are several approaches to describe different vegetation types. We compared two common approaches: the method of Braun-Blanket (DULAMSUREN 2004) and the stratified random sampling. To distinguish different forest types both methods led to similar results. In fig. 1 the data analysis of both methods are shown, for Braun-Blanket a ordination was done (DULAMSUREN et al. 2005a), for the stratified random sampling a clustering of the sample points led to the differentiation of four forest types (MÜHLENBERG et al. 2004).

We distinguished finally the following habitat types in table 3. In an surveyed area of around 400 km^2 the proportion of forests to grasslands to shrublands was 81 % : 12 % : 7 % respectively (SOLONGO 2005). DULAMSUREN et al. (2005a) configured the different vegetation types according to the natural distribution along the altitudinal belts and exposition (fig. 2).

The mountain dry steppe patches in the forest-steppe zone have been questioned of their naturalness. By planting experiments on these south-facing slopes DULAMSUREN et al. (2005b) proved the natural origin and the ecological conditions of these grasslands. The dry mountain steppe and the sharp forest margin above are natural vegetation due to ecologically restricted tree growth. A further proof of the natural origin of the steppe vegetation here in the forest-steppe zone was shown by pollen analyses (SCHLÜTZ et al. 2008).

Forest succession and forest dynamics

Long-term research is necessary to understand processes like succession and dynamics of the forest ecosystems. This natural boreal forest experiences natural disturbances, whereof wildfires have the greatest impact. They not only shape the landscape diversity and affect energy flows and bio-geo-chemical cycles (e.g. carbon release), but also influence forest age, structure, species composition and physiognomy (GOLDAMMER & FURYAEV 1996, GRABHERR 1997, SCHULZE et al. 2005, WIRTH 2005). Vegetation of the upper montane belt (1200 – 1600 m a.s.l.) is dominated by dark taiga forests *of Pinus sibirica, Abies sibirica, Picea obovata*. Dark taiga forests grow at the most humid sites with an annual precipitation of about 350 – 400 mm. In the lower montane belt (900 – 1200 m a.s.l.), *Larix sibirica* and *Betula platyphylla* dominate in the light taiga. It is still in discussion, if the light taiga forest represents a “climax”-forest because even in the *Larix-Betula* dominated forest stands dark conifer-species can settle and grow up if there is for longer no wildfire.

Table 1: List of the taxa which were sampled and identified to the species level by the corresponding experts (MÜHLENBERG et al. 2012)

Taxon	Expert who contributed to the species list
Fungi	A. Alexandrova, G. Kost, R. Sunjidmaa
Lichens	M. Hauck, A. Kemmling
Plants	Ch. Dulamsuren, B. Solongo, A. Alexandrova
Benthic insects	S. Purevdorj
Dragonflies	L. Seifert, C. Wesche
Grasshoppers and Bushcrickets	L. Nockemann, J. Munkhbat, E. Gottschalk
Ants	M. Woyciechowski, A.G. Radchenko, G.W. Elmes, B. Seifert
Bumble bees	M. Woyciechowski, P. Williams, S.A. Cameron, H. Hines
Hoverflies	L. Erdenetungalag, G. Merkel-Wallner
Longhorn Beetles and other saproxylic beetles	J. Müller, H. Bußler, B. Buyanjargal, A. Enkhmaa
Butterflies	C. Gantigmaa, M. Mühlenberg, M. Woyciechowski
Moths	C. Gantigmaa, J. Krause
Spiders	L. Erdenetungalag, Y. Marusik
Crustaceans	A. Poloczek
Fishes	Y. Dgebuadze, P. Melchert ł, R. Mendsaikhan, D. Krätz
Amphibians	B. Sheftel, B. Taivanjargal
Reptiles	B. Sheftel, D. Semenov
Birds	F. Wichmann, I. Pokrovskaya, B. Gantulga, H. Böhme, Z. Uuganbaatar, M. Mühlenberg
Mammals	B. Sheftel, D. Alexandrov, M. Tamir, P. Tserendawaa, R. Samjaa

Table 2: Species numbers of selected taxa recorded from the station Khonin Nuga. The data refer to an area of approximatively 200 km²

Taxon	Species number around Khonin Nuga	Percentage of known Mongolian flora or fauna
Plants (Angiospermae)	620	~22 %
Fungi (Macromycetes)	395	
Butterflies (Lepidoptera: Rhopalocera)	158	~60 %
Saproxylic beetles (Cerambycidae and others)	115	
Birds	211 (up to 144 breeding species)	~60 %
Mammals	57 (including species from steppe fauna)	

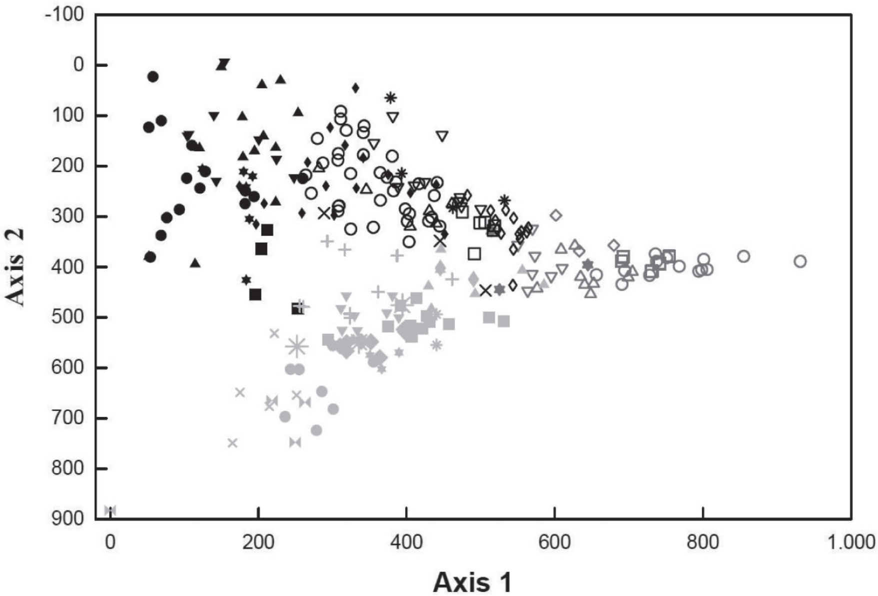


Fig. 1a: DCA ordination of 254 relevés. Habitat types: full black – dark taiga forests, open black – subtaiga forests, full grey – riverine shrubland (floodplains), open grey – steppe vegetation (southern slope vegetation), from DULAMSUREN et al. (2005a, b).

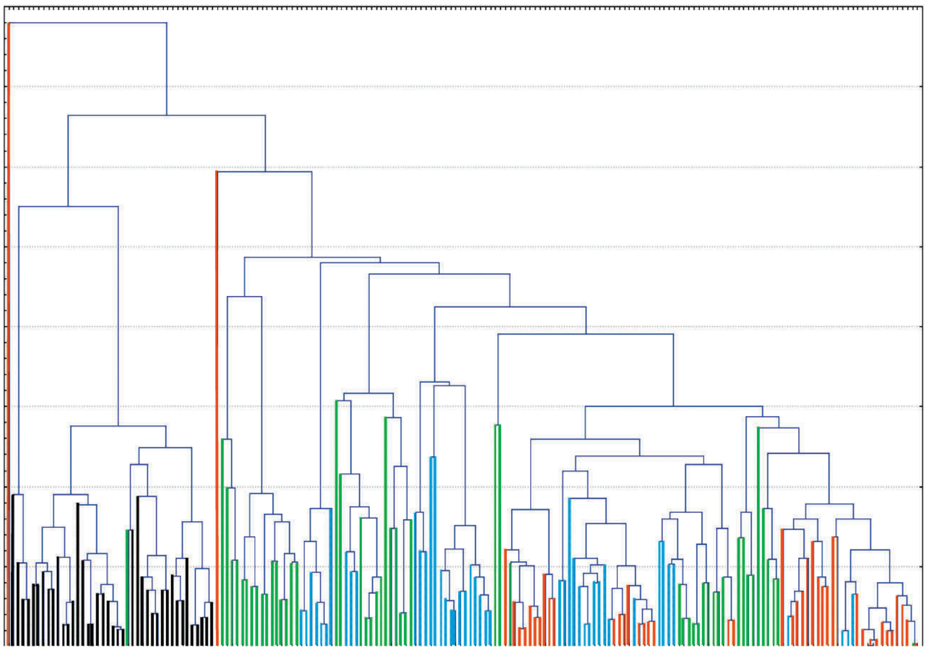


Fig. 1b: Clustering of 184 plots according to the basal area of the tree species in order to describe vege-tation types. Orange = *Betula-Larix* F., green = *Picea-Abies-Pinus* F., brown = *Pinus sibirica* F., blue = *Populus laurifolia* - Riparian F.; from MÜHLENBERG et al. (2004).

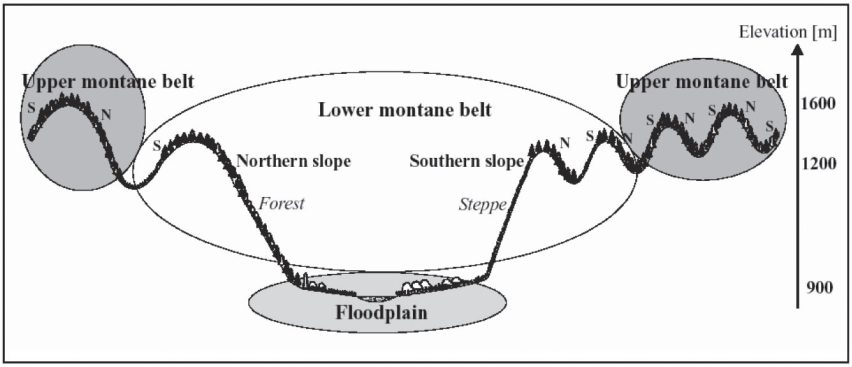
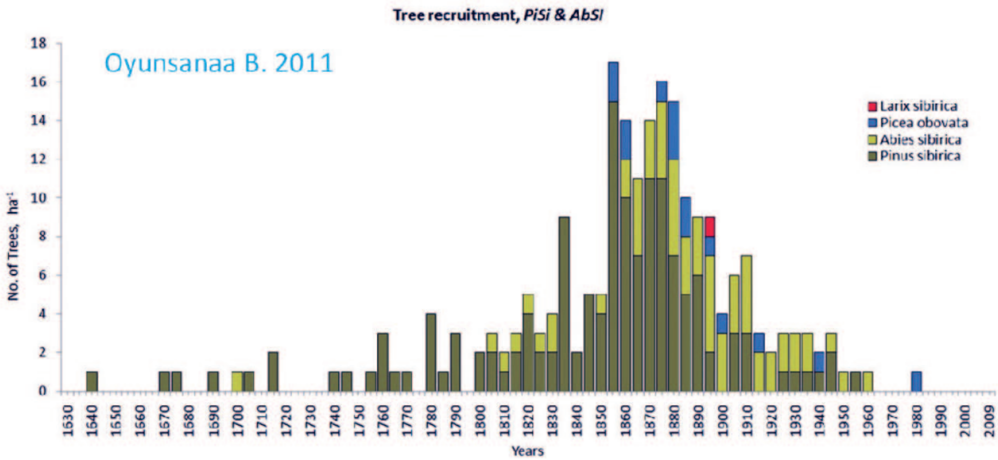


Fig. 2: Scheme of the altitudinal belts of the study area (DULAMSUREN et al. 2005a).

Table 3: Mapping of biotopes in the study area of West-Khentey: proportion, area and distribution (extracted from SOLONGO 2005)

Biotope Type (Label)	Proportion [%]*	Hectares	Number	Biotope Type Description
F1	37,4	14771	30	*Larix sibirica-Betula platyphylla* sub taiga forests
F2	15,7	6189	20	Mixed conifer dark taiga forests of the lower montane belt
F3	12,3	4859	68	*Pinus sylvestris* and *Populus tremula* sub taiga forests
F4	2,3	910	8	*Picea obovata-Abies sibirica* forests
F5	14,0	5510	2	Dark taiga forests of the upper montane belt with *Pinus sibirica*
G1	7,0	2773	211	Mountain steppes, meadow steppes and rock vegetation
G1/F1	0,7	275	2	Mosaic of meadow steppes and *Larix sibirica-Betula platyphylla* sub taiga forest
G1/F2	0,6	244	1	Meadow steppes on logged area with reserved trees of dark taiga forest
G2	0,4	168	5	Terrace meadows without shrub land
G3	0,4	165	2	Terrace meadows with *Padus asiatica* shrub land
G4	0,6	240	10	Floodplain meadows with *Salix* and *Betula fusca* shrub land
G4/G5	3,7	1442	11	Floodplain meadows and *Carex* moist meadows and swamps with *Salix* and *Betula fusca* shrub land
G5/G6	0,1	24	21	*Carex* moist meadows and swamps with ponds, including water plants and bank vegetation
G7	1,1	442	1	Rivers/tributaries with reeds and herb vegetation on gravel deposits
R1	1,3	507	42	*Betula fusca* shrub land in river valleys
R1/R4	0,6	221	8	*Betula fusca* shrub land with *Picea obovata* riverine forest
R1/R4/G5	0,2	93	5	*Betula fusca* shrub land with *Picea obovata* riverine forest and *Carex* moist meadows and swamps
R2	0,1	19	6	*Salix* riverine forests and *Salix* shrub land
R3	1,1	420	51	*Betula platyphylla* riverine forests
R4	0,1	27	2	*Picea obovata* riverine forests
R5	0,4	158	7	*Populus laurifolia* riverine forests

Whereas on the north-facing slopes light taiga forest grows in the submontane belt (see fig. 2), in the broad river valleys we find forest patches mixed with larger patches of grasslands. Grasslands on the south-facing slopes are ecologically explained by the constraints of tree growth. In the river valley the water availability is not as much limited as on the slopes. We should therefore expect an overall succession to forest in the valleys because there is no human impact by grazing livestock or tree cutting. Why grasslands are so stable in the river valleys although there is no regular flooding? Gottschalk investigated the tree growth in river valleys and concluded for the natural succession that both the tree mortality is much higher in the river valley compared to that on slopes and the germination of trees is impeded by the dense grass-layer (GOTTSCHALK & MÜHLENBERG, in prep.). Tree mortality is mainly caused by the attack of herbivore insects like gypsy moths (*Lymantria dispar*).



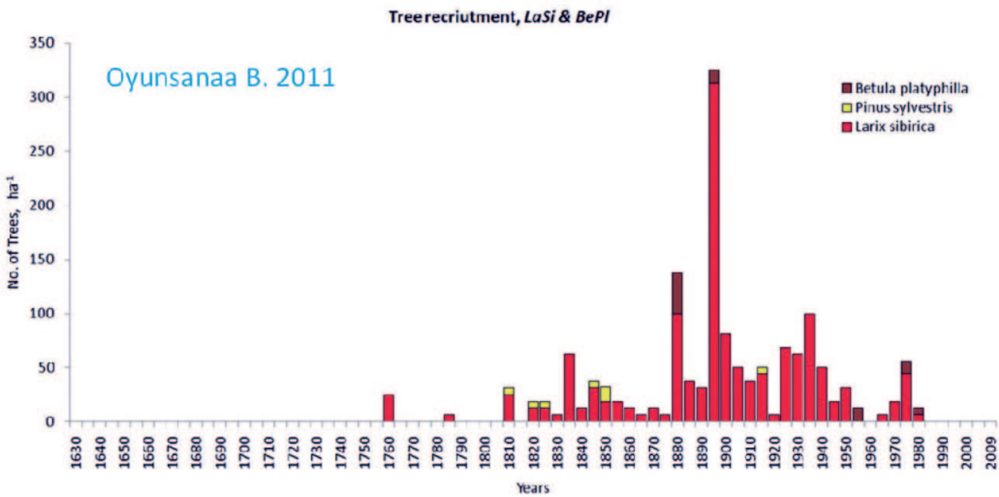


Fig. 3: Tree recruitment in a Pinus sibirica old-growth forest stand (above) and in a Larix-Betula forest stand (bottom) according to the analyses of tree cores. The light taiga forest of Larix-Betula shows regular major disturbances (e.g. 1870, 1920, 1960) which correspond to fire events; from OYUNSANAA (2011).

B. OYUNSANAA conducted tree coring in order to determine the composition of age-classes in different forest types. In addition he determined particularly with cut tree discs the history of fire events in a forest stand. He could estimate both the fire frequency typical of a forest type and the phase of recruitment (forest succession without disturbance). Old-growth dark taiga forest of *Pinus sibirica* showed a recruitment phase of more than 250 years without major disturbances. *Larix-Betula* forests, representing the light taiga, had a shorter recruitment phase without major disturbances, between 30 and 50 years (OYUNSANAA 2011).

Effects of wildfires

The natural disturbance regimes in boreal forests are wildfires. The frequency of wildfires in a forest stand plays the most important role in structuring the forest. But the effects of wildfire in a particular forest type depend on several factors: site factors are affected by the understorey vegetation, slope, aspect, elevation, time of the day and year. Stand composition is affected by tree species, age class, basal area, tree morphology, stand structure. The fire behavior itself varies due to fuel moisture, rate of spread, and intensity (ANGELSTAMM et al. 2005). First of all we proved that wildfires reduce forest structure and depress regeneration (table 4). Compared to larch-birch forests, basal area was on average 21 % lower on the burned areas and 84 % on the clear-cut.

Table 4: Average number of diameter and height classes in the burned areas and the clear-cut in comparison to larch-birch forests (from MÜHLENBERG et al. 2012)

Forest type	**Growing stock** (diameter classes)	**Standing deadwood** (diameter classes)	**Regenerating trees** (height classes)
Larch-birch forests	4.7	1.7	4.9
Burned areas (means)	3.2	2.4	2.4
Clear-cut	1.8	0.4	1.4

There is a debate about the effects of wildfires on the local biodiversity. We compared the diversity of dead-wood fungi in forest stands which differ by age since last fire: Species number peaked about 5 years after fire and the similarity to reference forest becomes higher over the years (SUNJIDMAA 2009). The species diversity of spiders was higher in unburned areas compared to fire affected sites. But for ground spiders we found an increase in abundances after fire on the bare ground (ERDENETUNGALAG 2009, unpubl.). The influence of fire severity on bird species composition and density (grouped in ecological guilds) was studied by FISCHER (2010) in *Larix-Betula* forest stands: Aerial insectivores and foliage gleaners, cavity nesting birds as well as shrub and canopy nesters showed higher abundances in stands of low-intense fires. Bark and wood boring insectivores as well as ground insectivores, open and ground nesting species were more abundant in forest stands burned with high intensity. These findings underline the reduction in biodiversity in burned areas, in spite of the argument that wildfires support biodiversity ("Fire fueling biodiversity", Canadian Parks and Wilderness Society 2004). The importance of dead wood (coarse woody debris, CWD) is often stressed in nature conservation. A large proportion of the forest fauna depends on CWD (BOBIEC 2005). Whereas in the managed forests of Europe the old and dead trees matter for biodiversity, it is the birch tree (*Betula platyphylla*) which plays a key-stone species in the light taiga of natural forest ecosystems. Birches start to die without fires after an age of about 60 years. This predictable resource is most important for the amount of saproxylic beetles as food for woodpeckers. Birches are significantly preferred by cavity-nesting birds (BAI et al. 2003).

Small mammal dynamics

The small mammal community around the research station was studied by Boris Sheftel for more than 10 years. Standardized pitfall trapping in open and forested habitats resulted in a total of 743 captures of nine species. Sheftel examined the relative role of winter temperature (mean winter temperature, months with extremely high/ extremely low temperature) and snow cover (mean snow cover, months with extremely high/ extremely low snow cover). It could be proved that for most species hard winter conditions led to a decrease in numbers of animals (SHEFTEL et al., in prep.). Harsh winter conditions occur at the southern edge of the taiga like the Khentey Mountains more often than in Central Siberia (Sheftel 1989). But there was also a population crash after moderate winter conditions. This was explained by a shift of fluctuating population dynamics in response to harsh winter conditions to cyclic dynamics regulated by internal factors (SHEFTEL et al., in prep.). Food storage of some species could moderate unfavourable weather conditions significantly. The impact of weather conditions varied with biotope (open or forested area) (SHEFTEL et al., in prep.).

Adaptive breeding behavior in a social bird

The breeding performance of an isolated colony of Azure-winged magpies (*Cyanopica cyanus*) was studied in Northern Mongolia over four breeding seasons (GANTULGA et al., in prep.). There was high nest predation in one season and a major forest fire during another. Our study colony mobilized all the reserves against major forest fire, predation and food deficiency which was caused by fire. Nesting in clusters seemed to be a strategy against nest predation. This bird showed a facultative cooperative breeding behavior. Helping behavior was immediately observed following the forest fire when pairs with helpers had higher breeding success than those without. Most helpers were yearlings who helped their parents. Our study showed that helpers improved the breeding success of Azure-winged magpies, at least when shortage of food happened after forest fires (table 5).

Table 5: Comparison of breeding parameters in nests with and without helpers in 2009; from GANTULGA et al. in prep.

nest	hatching success	n	fledgling success	n	breeding success	n	clutch size	n	brood size	n	fledglings	n
with helpers	69 %	35	96 %	24	66 %	23	5.0 ± 0.31	7	4.8 ± 0.37	5	4.6 ± 0.24	5
without helpers	37 %	41	0 %	15	0 %	--	5.8 ± 0.70	7	5.0 ± 1.52	3	0.0	3
P value	*0.32*		*0.018*		*0.009*		*0.29*		*0.64*		*0.01*	

It could be shown that there was no difference on the number of fledglings per nest between last three breeding seasons due to helping behavior at ecological stress.

Long-term research as a base of future management

We are faced to climate change. Therefore we search for an adaptive management strategy to preserve the biodiversity best (Nicole & Heller 2009). Modeling the ecosystems is difficult because the data base considers in most cases only little interdependence. We have to go down to the species level. The model in Fig. 4 shows the interactions between abiotic factors and many species and ecological guilds. Only by precise information of the fluctuations of the involved taxa a prediction how the ecosystem will shift is possible to assess.

Therefore the best strategy in combating climate change is the protection of boreal forests. Intact, contiguous boreal forest will be best able to keep up with rapidly changing climate conditions because of high connectivity and abundant propagule production. Intact forests provide the corridors necessary for migration of many species. One example of this is the southern flying squirrel which has migrated north only through the more contiguous forests of south-eastern Ontario. Around the station Khonin Nuga we have a related species to the American one, the Siberian Flying Squirrel (*Pteromys volans*) which could serve as an indicator species. In addition, the slowed rate of change [by moderating local climate and by providing alternate habitats] is expected to aid in the adaptation of boreal wildlife to climatic shifts (NELSON 2010).

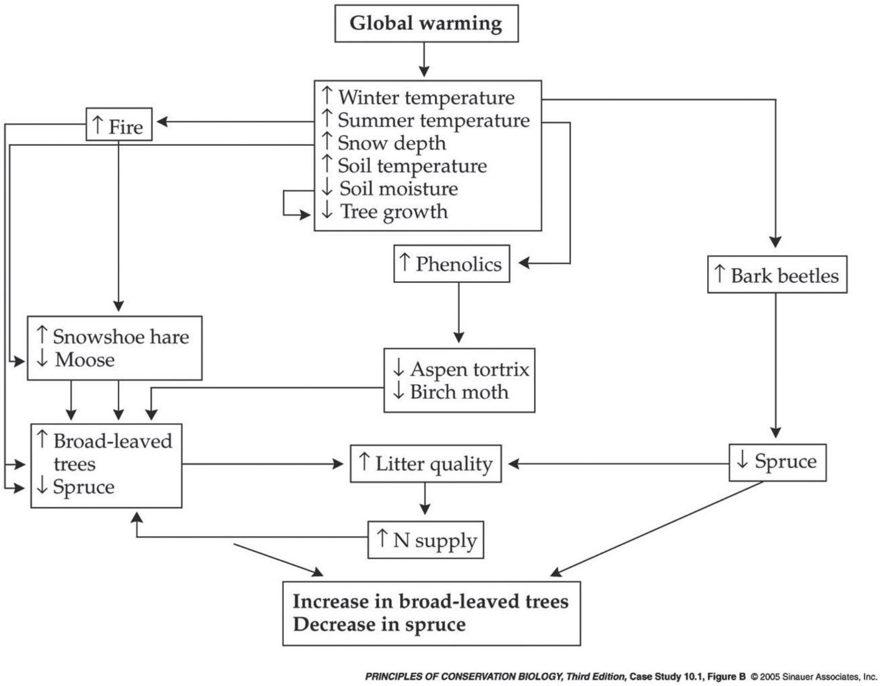


Fig. 4: Effects of Global Warming in boreal forests for interior Alaska, from GROOM et al. (2006, chapt. 10).

In summary, all long-term studies around Khonin Nuga underline the high nature value of the Strictly Protected Area of Khan Khentey. The high biodiversity still indicates a healthy ecosystem. This region should be well protected in the core zone to mitigate best against climate change.

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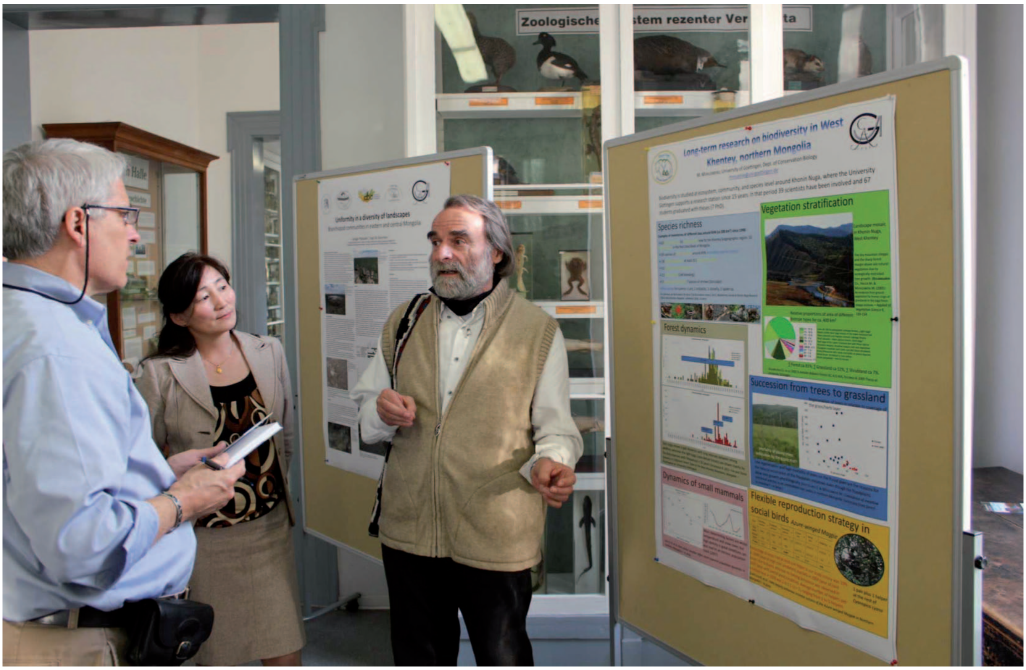
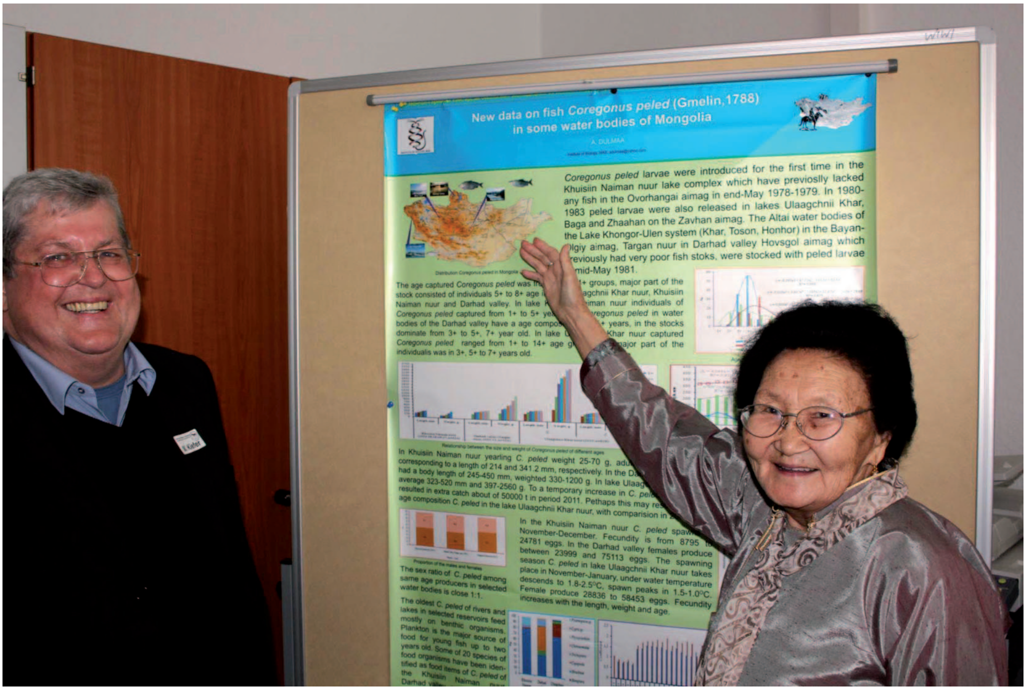
Address:

Michael Mühlenberg
Georg-August-Universität Göttingen
Dept. for Conservation Biology
Bürgerstraße 50
D-37073 Göttingen

e-mail: Michael.Muehlenberg@zentr.uni-goettingen.de



Poster discussion during the international symposium in Halle/Saale, March 2012. From left: Prof. Dr. Scott Lyell Gardner (University of Nebraska, Lincoln), A. Enkhmaa (National University of Mongolia, Ulaanbaatar), Prof. Dr. Michael Mühlenberg (Georg-August-University Goettingen).



Dr. Matthias Kiefer (München) and Prof. Dr. A. Dulmaa (Ulaanbaatar) during the poster session.

Left: in front – Dr. Margarita Erbaeva (RAS Ulan-Ude), above – Dr. Alexey V. Surov (RAS, Severtsov Institute Moscow). Right: M. Khishigjargal (GAU Goettingen), Ts. Munkhzul (MAS, Institute of Biology), Dr. Fedora I. Khenzykhenova (RAS Ulan-Ude), Dr. Renate Angermann (Dresden).