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COMMENTARY

Towards more meaningful scenarios of biodiversity responses to land-use change in Central Asia

Johannes Kamp[1] · Martin Freitag[1] · Norbert Hölzel[1]

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Abstract
We here respond to Nunez et al. (Reg Environ Chang 20:39, 2020), recently published in *Regional Environmental Change*. Nunez et al. project biodiversity responses to land-use and climate change in Central Asia. Their projections are based on scenarios of changing socio-economic and environmental conditions for the years 2040, 2070, and 2100. We suggest that the predicted magnitude of biodiversity loss might be biased high, due to four shortfalls in the data used and the methods employed. These are (i) the use of an inadequate measure of "biodiversity intactness," (ii) a failure to acknowledge for large spatial variation in land-use trends across the five considered Central Asian countries, (iii) the assumption of a strictly linear, negative relationship between livestock grazing intensity and the abundance of animals and plants, and (iv) the extrapolation of grazing-related biodiversity responses into areas of cropland. We conclude that future scenarios of biodiversity response to regional environmental change in Central Asia will benefit from using regional, not global, spatial data on livestock distribution and land-use patterns. The use of extra-regional data on the relationships between biodiversity and land-use or climate should be avoided.

Keywords Livestock · Grazing · Steppe · Fire · Saiga antelope · Post-Soviet

In a recently published paper in *Regional Environmental Change*, Nunez et al. (2020) develop scenarios of future land-use and climate change for Central Asia. They use these to project biodiversity responses to environmental change in the region in the years 2040, 2070, and 2100.

We welcome the study by Nunez et al. because regional environmental change, especially land-use change, is difficult to predict across Central Asia, and because few have attempted to project biodiversity responses across larger scales in this region. However, we are concerned that the published scenarios suffer from four shortcomings that compromise their usefulness for guiding regional and global policies.

First, a major aim of Nunez et al. is to project how Central Asian biodiversity will react to climate and land-use change, but their definition of biodiversity remains elusive. The only biodiversity metric employed is a measure of "intactness": the relative mean abundance (Alkemade et al. 2013) of all animal and plant species in pristine ecosystems in relation to their abundance in degraded states of that ecosystem. The index is based on a relationship that is considered globally universal, despite being established from a review of a mere 28 studies (three to eight studies each on plants, birds, mammals, insects, and reptiles, on average 17 species per study; Alkemade et al. 2013). Of these, 26 were conducted in Africa, the Americas, Australia, and Southern Europe. Sixteen are from wooded savannas and shrublands, i.e., ecosystems that structurally differ strongly from the Central Asian steppe grasslands. The only study from Central Asia does not contain any information on the degradation state of the surveyed habitats (Sánchez-Zapata et al. 2003). Nunez et al. realize that "Central Asia is a region with large information gaps of past and current biodiversity trends" and acknowledge that "global assessments inadequately depict (…) subtle changes in grasslands." Yet they scale a global indicator of intactness to a region where the "intact" state is not defined and the indicator not calibrated. We question that the employed index can be used to describe the intactness of biodiversity in Central Asia, due to the low sample size, the divergent geographic scope, and the large proportion of included studies from non-steppe habitats. It is surprising that no studies were considered that

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✉ Johannes Kamp
johannes.kamp@uni-muenster.de

[1] Institute of Landscape Ecology, University of Muenster, Heisenbergstr. 2, 48149 Muenster, Germany

describe relationships between species abundance and ecosystem degradation from Central Asia. Similarly, the authors used an indicator of climate change effects on biodiversity calculated from a meta-analysis of 89 studies—of which again none was from Central Asia or perhaps neighboring, similar Mongolian or Chinese grazing systems.

Second, Nunez et al. do not acknowledge strong differences in recent temporal livestock trends among the five Central Asian countries in their scenarios, despite mentioning them. Whereas livestock numbers in Uzbekistan, Turkmenistan, and Tajikistan have recovered quickly from declines that followed the break-up of the Soviet Union in 1991, this is not the case in other republics. In Kazakhstan (which makes up by far the largest share of the study region), sheep numbers dropped from 33 million animals in 1992 to 8.7 million in 1999 (FAO 2020; Fig. 1). Since then, numbers have begun to recover, but currently stagnate at less than 50% of the 1992 numbers. A similar pattern emerges for cattle, and for sheep and cattle in Kyrgyzstan (Fig. 1). Due to these declines in stocks, vast areas of the lowland grasslands in Central Asia have witnessed a strong *decrease* in grazing pressure since the collapse of the Soviet Union in 1991. The area of heavily grazed steppe decreased by 70% in Kazakhstan in the period 1988 to 2017 (Dara et al. 2020a), and huge restocking potentials exist (Hankerson et al. 2019). This in turn has caused vegetation change and homogenization due to more frequent and larger wildfires, which likely impact animals higher up the tropic chain (Brinkert et al. 2016; Dara et al. 2020a, b; Fig. 2). Ongoing climate change will result in an increasing fire return rates, whereas an increase in grazing pressure would consume biomass and thereby reduce fire return rates (Dubinin et al. 2011).

Nunez et al. therefore operate from regionally differing baselines, which dilutes the outcomes of the scenarios: Whereas in the three first-mentioned countries heavy grazing might indeed already affect biodiversity in a negative way, an increase in grazing pressure over large areas of Kazakhstan is likely to benefit biodiversity. Also, the scenarios were developed and refined in two stakeholder workshops, of which only one was conducted in Central Asia but the other one in Azerbaijan, in the Caucasus region. Basing conclusions on stakeholder opinions from the Caucasus and Central Asia will hardly yield drivers and magnitude estimates representative for Central Asia. A key assumption in the presented scenarios is that human population growth and economic growth will affect grazing intensity in a multiplicative way. In our opinion, this is questionable for Central Asia's livestock systems, which are based on semi-subsistence herding over vast areas: The higher the general living standard becomes with increasing GDP, the more herders will swap their rural existence for a comfortable city life (Hauck et al. 2016). A major current constraint to restore animal stocks is rural outmigration and the associated lack of shepherds in rangelands that are mostly very remote. We cannot see how these trends are considered in the presented scenarios, which suggests that the projections of intensification across vast, remote areas of Central Asia might be overly pessimistic. Furthermore, a multiplicative

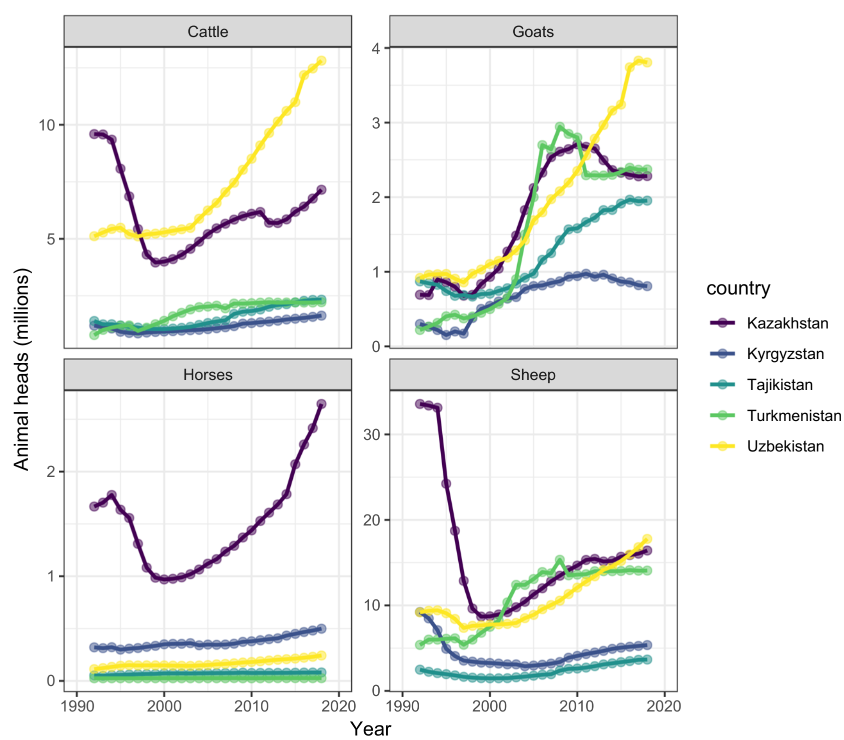

Fig. 1 Trends in livestock numbers in the period 1992 to 2018 for all five Central Asian countries considered in Nunez et al. (2020). Trends were largely positive in Tajikistan, Turkmenistan, and Uzbekistan over the period, but dropped steeply in the post-Soviet period in Kazakhstan (sheep and cattle) and Kyrgyzstan (sheep) and have not recovered since. Data source: FAO (2020)

Fig. 2 Moderately grazed steppe (above) and ungrazed steppe subject to frequent (near-annual) fires. Plant species richness is high in the grazed steppe, whereas two or three grass species dominate vast areas in ungrazed regions. This is because where grazing is absent, biomass accumulates and provides fuel for frequent and large wildfires. These promote grasses over herbs and shrubs, which then accumulate more biomass—a feedback loop leading to impoverished stands. Grazing would stop this feedback loop and increase floral biodiversity. Lowland steppe, Stepnyak, Kostanay Province, Kazakhstan, May 2016 (pictures: Johannes Kamp)

relationship of the management factor (which is defined as the actual yield as a proportion of the maximum potential yield) and GDP seems counterintuitive, as the authors state that the management factor "depends on the regional GDP."

Third, Nunez et al. assume a linear negative relationship between relative mean species abundance and grazing intensity, suggesting that overall species abundance will, as a rule, decline when grazing intensity increases. Increases in grazing intensity can only have negative or indifferent effects on mean species abundance, because the indicator is truncated such that grazed sites are not allowed to exceed the mean species abundance of "intact" grassland. However, relationships between grazing intensity and species abundance are often hump-shaped, including in the grasslands of Central Asia (Kamp et al. 2012). The Central Asian steppes have been grazed since the last glaciation by wild ungulates, such as the Saiga antelope (*Saiga tatarica*). Nomadic pastoralism developed around 3200 BP (Hanks 2010). This means, that Central Asia's grasslands contain a large number of species that have evolved in the context of various, spatio-temporally variable levels of grazing. This includes globally threatened, synanthropic species that are now heavily dependent on intensive grazing (e.g., Kamp et al. 2009). Consequently, a moderate increase in grazing pressure over vast areas especially in Kazakhstan, as in some of Nunez et al.'s scenarios, will not only lead to abundance declines in plants and animals but also gains. Due to the way in which the mean species abundance indicator was derived and the assumption of a linear negative correlation between grazing pressure and biodiversity intactness, future impacts of grazing intensification on biodiversity are negative by definition and likely overestimated in Nunez et al.'s scenarios.

Fourth, the employed scenarios consider only livestock grazing as land-use, but surprisingly, spatial projections are made for large areas of active cropland (cf. Lesiv et al. 2018), especially in north and northeast Kazakhstan. We suggest that it is important to extend any biodiversity scenarios in Central Asia to changes in cropland use. This is because on average, 13% of the agricultural land of the five considered Central Asian countries were cropland in 2017, amounting to 38 million ha across the region (FAO 2020). Cropland use in the region has also been highly dynamic: In Kazakhstan alone, over 15 million ha of cropland has been abandoned since the collapse of the Soviet Union (Lesiv et al. 2018). Not all of these abandoned croplands will be recultivated due to socio-economic and environmental constraints (Meyfroidt et al. 2016). Therefore, future biodiversity trends in Central Asia will also be driven by the amount of cropland recultivated, the intensity of cropland use characterized by the degree of mechanization, pesticide and fertilizer use (Kamp et al. 2015), and the amount of abandoned cropland transferred to grazing systems. Interestingly, Nunez et al. include feedlot-based systems that are coupled with intensive hay and crop production on arable land as the final step of grazing system intensification, thereby acknowledging that the use of grasslands and croplands will have to be considered in an integrated framework.

Nunez et al. suggest that the "abundance of original occurring species [will decrease] to less than 70% in half of the total grassland area" by 2040 in all scenarios. In the light of the points discussed here, this figure seems high, especially since none of these species were included in the establishment of empirical relationships between land-use intensity and species abundance. Future scenarios of biodiversity responses to environmental change in Central Asia will likely benefit from the use of regional, not global, spatial data on livestock and grassland/cropland distribution. It might be preferable to base scenarios on regional studies that examine the relationship between land-use intensity and species richness and abundance.

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