INTERNATIONAL CRANE FOUNDATION

EURASIAN CRANES AND CLIMATE CHANGE

Will short term gains be followed by long term loss?

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INTERNATIONAL CRANE FOUNDATION

1. Summary

The Eurasian Crane *(Grus grus)* is widely distributed through a variety of wetland habitats (for breeding and roosting) and agricultural landscapes (for foraging) across Eurasia and northern Africa. Its world population has grown dramatically in the recent decades and is now estimated to be about half a million birds.

This population growth has been due to the species' flexibility in choice of wetland nest sites, its readiness to forage in upland areas thus accessing vast food resources on agricultural landscapes, and its ability to shift behavior in response to human and natural factors.

In the near term, we expect the species to continue to increase in part because warming trends will make available new areas for breeding to the north and at higher elevations, extend the length of breeding seasons in many areas, allow birds to stage longer in rich agricultural areas before migration, and in some cases to undertake shorter migrations. Water availability, however, will decrease in some areas, or become less predictable, which is expected to reduce productivity and fitness of cranes.

In the mid and long term, changes in crop production and water availability will have both direct and indirect negative impacts on cranes, in particular as humans use land and water resources more intensively. The future for this species will depend on the extent of warming the world experiences and the extent to which societies embrace adaptation strategies to climate change that sustain the resources on which people and cranes depend. Thus the long-term future for this species is uncertain, although it appears less vulnerable than most other crane species.

Research and conservation activities related to Eurasian Cranes and their habitats should increasingly focus on current and future impacts of climate change on the species, including indirect impacts related to water supply and agricultural practice.

Protected areas should undertake assessment of their climate change vulnerabilities, particularly for wetlands, and identify adaptation measures to be incorporated into management plans and practice.

Evaluation of development project impacts and regulatory changes, especially those related to water and agriculture, should consider future impacts of climate change on cranes and other biodiversity and be responsive to current and predicted conservation needs.

Further research is needed to verify the climate change impacts already happening and that will occur in the future. For this species, there is a need to elucidate the different factors affecting crane numbers, distribution, and behavior including relative contributions of warmer conditions, greater variability in rainfall, more extreme weather events, changes in crop patterns unrelated to climate change, and an overall growing crane population.

The significance of climate change on short-term and long-term status of cranes should be communicated to wildlife and wetland managers and relevant policy makers, as well as media and the general public, so that relevant adaptive measures can be identified and implemented.

Assessment of climate change vulnerability and implementation of adaptive conservation measures are needed for other crane species, especially those that appear most threatened such as Whooping Crane (sea level rise), Blue Crane (changes in agricultural practice under warming and drying conditions), and White-naped Crane (reduced water availability).

2. Purpose of this fact sheet

The future course and impacts of climate change are complex and vary across the vast range of the Eurasian Crane, one of the most intensively studied of the world's cranes. This assessment of Eurasian Cranes and climate change has been developed by distributing a questionnaire widely among crane specialists familiar with the species, and then assembling information about changes that have already occurred and trends that may result in further change in the near or mid-term future. See Figure 1 for locations providing information for this assessment.

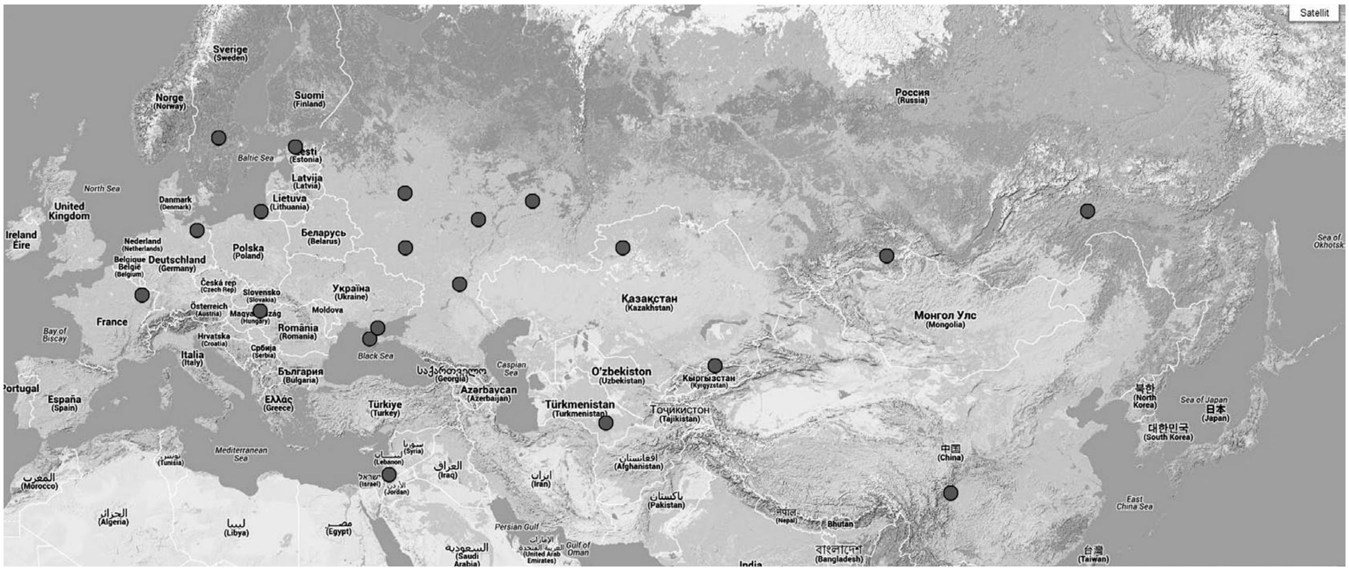

Figure 1: Sites of Eurasian Crane occurrence providing data used in this publication. Map source: Google Maps.

While some of the trends summarized in this fact sheet have been well documented through field studies, we have also drawn on expert opinion which presents a more complete characterization of changes that are rapidly occurring. Some changes are the result of direct impacts of climate change; some appear to be indirect impacts, for example through changes in agriculture or other land uses; and some appear to result from other factors that influence crane populations and interact with the effects of climate change. This fact sheet only provides brief mention of these other factors, but they are included to illustrate the diversity of influences that can interact and impact the cranes. In addition, short term climate cycles, in particular years of drought followed by wetter conditions on a multi-year cycle, interact with the impacts of long-term climate change that is the focus of this paper. With our present state of knowledge, we have not found it possible to separate out crane responses to these different temporal scales of change.

A primary goal of this compilation is to encourage field researchers and conservation practitioners to incorporate climate change concerns into their plans and activities. This survey of published and unpublished information highlights the need for carefully designed research that can further elucidate the processes underway and the factors responsible. We hope this publication will encourage such research for Eurasian Cranes as well as other crane species, some of them much more vulnerable to climate change than the abundant and adaptable Eurasian Crane. The information gathered through this publication reveals gaps in our knowledge that require further study, such as changes in disease patterns, and impacts of invasive species on wetlands and thus indirectly on the cranes. In this publication, we summarize what little information is available on these topics.

We hope this publication will inspire comments, corrections, and new information.

3. What do we know about Eurasian Cranes and climate change?

IUCN Red List category	Least Concern (assessed 2009)
Current estimated world population	491,200 – 503,200 (Wetlands International 2014)
Crane Action Plan estimated population	220,000 – >250,000 (Meine & Archibald 1996)

3.1 Species distribution and biology

The breeding range of the Eurasian Crane extends from northern and western Europe across Eurasia including northern China and eastern Siberia. During winter, the species is mostly found in the Mediterranean region, eastern Africa (Ethiopia, Sudan), the Middle East, India, and southern and eastern China. While some populations are decreasing, and others are stable or have unknown trends, the species as a whole has increased significantly in the past thirty years (Wetlands International 2012).

The species shows diverse migration strategies. Some birds breeding in Scandinavia migrate as far south as Ethiopia; others spend the winter only a couple of hundred kilometers away from their breeding grounds.

Cranes do not normally breed until 3-4 years of age, and lay clutches of two eggs. Eurasian Crane pairs regularly rear two chicks to fledging, although more often only one chick survives. Early losses of nests can lead to renesting.

3.2 Expected consequences of climate change (after Cox 2010)

Over the last half century, the Northern Hemisphere has been warmer than at any time during the past 1300 years. At the highest northern latitudes and also on the Iberian Peninsula, climatic warming is greatest compared to the global average; north of latitude 45°, the spring season is advancing, thus lengthening the growing season by 12 to 19 days compared to about 50 years ago. Satellite data have revealed that snow melt on the Arctic tundra has shifted 2.0 – 3.3 days earlier per decade since the 1960s, and spring greening in boreal Eurasia advanced 7.1 days between 1982 and 1999. Additionally, precipitation at high latitudes is increasing. These changes affect ecosystem dynamics. Numerous plant and non-migratory animal species have already started to adapt their phenology. Further, shrubs are invading the tundra, and several tree species have shifted into higher altitudes. Moreover, the potential breeding season for many migratory birds has become substantially longer.

Due to the earlier and longer summer seasons, average temperatures of freshwater systems are rising, thus enhancing evaporation and consequently leading to a reduction of wetland habitats, or a shortening of the periods when water is above the surface. Climatic warming is also melting permafrost. Between 1973 and 2004, about 11% of 10,000 large lakes in Russian Siberia either disappeared completely or shrank to very small areas. This change suggests that the underlying permafrost formerly prevented drainage into deep subsurface zones. Impacts of climate change vary tremendously, however, depending on local conditions and the ecosystems involved. In some areas in the north of Eastern Siberia, for example, lake sizes have been increasing due to permafrost melting and wave action over the last half century, with open water replacing breeding habitats for Siberian Cranes *(Leucogeranus leucogeranus)*.

The Mediterranean region is predicted to be the most vulnerable area of Europe to global climate change. As a consequence of climatic warming and changes in rainfall patterns, the seasonal distribution of food sources in this region will change considerably for both short and long distance migratory birds.

3.3 Summary from the Fifth IPCC Assessment Report (2014)

The Fifth Intergovernmental Panel on Climate Change (IPCC) Assessment Report states that impacts of climate-related extremes (e.g., droughts, floods, or wildfires) could be significant for some ecosystems that are vulnerable to alterations. The global annual average temperature has increased by 0.61°C from 1850-1900 compared to 1986-2005, negatively affecting crop yields of wheat and maize. The report identifies the loss of terrestrial and inland water ecosystems as potential future risks. Most likely, a large fraction of both terrestrial and freshwater species face increased extinction risks under projected climate change during and beyond the 21st century, especially as climate change interacts with other stressors, such as habitat modification, over-exploitation, pollution, and the expansion of invasive species.

The loss of biodiversity will likely also lead to the loss of various ecosystem goods, functions, and services that benefit human livelihoods. Also linked to warming, drought, flooding, and precipitation variability and extremes, there will be insufficient access to drinking and irrigation water for humans and thus reduced agricultural productivity. A breakdown of food systems is likely to be the consequence.

The report also states that "management actions, such as maintenance of genetic diversity, assisted species migration and dispersal, manipulation of disturbance regimes (e.g., fires, floods), and reduction of other stressors, can reduce, but not eliminate, risks of impacts to terrestrial and freshwater ecosystems."

4. How is climate change affecting Eurasian Cranes?

Climate change will have significant impact on quantities and distribution of rainfall, with a substantial proportion of the Eurasian Crane's range experiencing less precipitation and higher rates of evaporation due to rising temperatures. In addition, as climate events become more extreme, rainfall may be less evenly distributed through the year, with more frequent floods and droughts. Actually, there are already visible impacts of climate change at all stages of the annual cycle for the Eurasian Crane. Given the vast range of the species, and the varying distances of its migrations across different regions, climate change is affecting the species in diverse ways both positive and negative (see Figure 2).

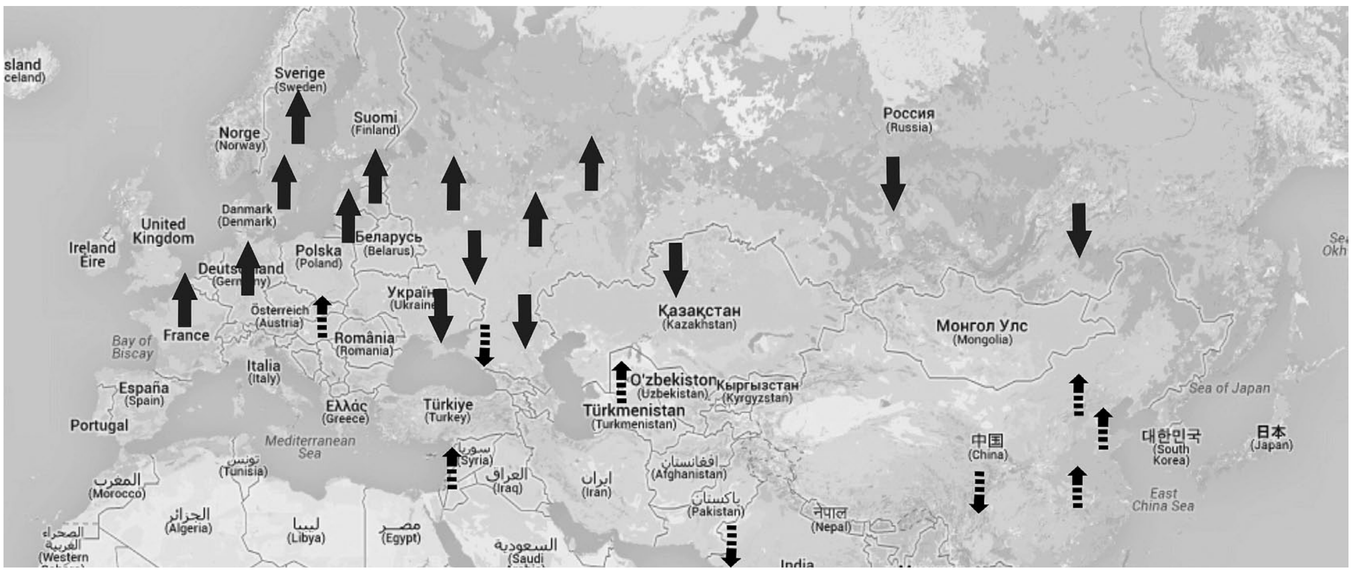

Figure 2: Increase and decrease of Eurasian Cranes *(Grus grus)* during the last decades. Full arrows demarcate breeding sites, dotted arrows indicate stop-over or wintering sites. Map source: Google Maps.

4.1 Spring migration

Positive

Advancement of the first arrival dates for Eurasian Cranes is reported from all spring staging areas, likely due to earlier warming in spring. In Estonia, studies revealed that the arrival date of cranes is significantly related to weather conditions in March; snow cover is a crucial factor, as was also reported from the Republic of Chuvasia (Russia). In Estonia, between 1948 and 1994 the beginning of spring migration has shifted earlier by 18 days, while the median date for migration has shifted earlier by only 3 days. In areas where the amount of spring precipitation (as rain) has increased (e.g., Crane Homeland, Russia), new wetlands have developed that can serve as roost sites.

Negative

Extreme events such as late snowfalls, unseasonable cold, storms, floods, and prolonged droughts may heighten mortality or reduce available habitat.

4.2 Breeding

Positive

A number of positive effects of climate change have been reported for the breeding populations of the Eurasian Crane. In most breeding areas birds tend to arrive earlier in spring with earlier first egg laying dates being reported from European breeding sites. In northeastern Germany for example, the average laying date for the first egg shifted back from April 2nd to March 21st between 1999 and 2009. This shift is related to a positive winter NAO (North Atlantic Oscillation, air pressure difference between the Azores and Iceland) index, which indicates warmer and more humid weather and a relatively higher monthly mean air temperature during winter months (averaged for December to March). Therefore, the potential breeding success has been increasing as there is more time for a second (replacement) clutch if the first clutch fails. In Sweden, a second breeding attempt was first recorded in the 1990s with the mean first arrival date shifting two to three weeks earlier compared to 30 years ago. In some areas (e.g., Crane Homeland, Russia), precipitation has increased considerably during the last decades. As a consequence more wetlands are available in these regions, and more breeding pairs were able to establish territories, which in turn enhances productivity of those populations. Nest sites in wetlands with sufficient water are better protected as they are more difficult to access by humans or mammalian predators.

Negative

Climate change often results in strongly fluctuating precipitation patterns. In some areas (e.g., northeast Germany or the Lipetsk Region in Russia) spring rain no longer occurs regularly. As a result, marshes and alder forests – e.g., in the floodplains of the Voronezh River (Lipetsk Region) – have gradually dried out and in very dry years (2002, 2010) some marshes even burned. Thus, the lack of spring rain might cause the retraction of breeding areas, or breeding cranes might be more frequently disturbed by humans and nest predators that can approach nest sites due to low water levels. Drought has become more severe in Ukraine during the last five to ten years. In the southern part of Ukraine, especially in July and August, wetland salinity has greatly increased and wetlands can completely dry out. Cranes traditionally used this area after the breeding season with their fledglings and during migration. Similarly in the Transbaikal Region of Russia, 98% of water bodies in the southern steppe zone dried out between 2000 and 2009; drought forced cranes to move further north into the forest-steppe zone. Overall, the number of suitable breeding sites - for Eurasian Cranes, White-naped Cranes *(Grus vipio),* Demoiselle Cranes *(Anthropoides virgo),* and Red-crowned Cranes *(Grus japonensis)* in Transbaikalia was substantially reduced. However, meteorological studies revealed for the Transbaikalian Region a regular alternation of dry and wet periods in cycles lasting approximately 30 years. As the last wet peak occurred during 1995-1998, and the last drought peak during 2000-2012, another wet period could be expected to begin in 2014.

4.3 Autumn staging and migration

Due to a) the overall increase of the crane population, b) changes in crop cultivation, and c) several restoration projects (e.g., water management in raised bogs), the number of individuals in most autumn staging areas has been increasing. However, overall, the distribution of crane staging sites in late summer and early autumn is proportional to agricultural land use, as agricultural practices increase or decrease food availability. But these landscapes must also provide suitable wetlands that serve as roost sites.

Positive

Increasing temperatures have led to a significant shift of the migration peak to later dates (e.g., in Hungary, Lipetsk Region (Russia), and Turkmenistan). At most staging sites, autumn migration generally takes place later than observed 15 years ago. Thus, cranes can spend more time feeding before making the journey south to the wintering grounds. Moreover, due to warmer temperatures, the cranes often now overwinter in former autumn staging areas. In some areas, as in the Moscow Region, the amount of precipitation has been increasing. Thus, new wetlands could form, especially in areas where anthropogenic influences had formerly changed the landscape (e.g., abandoned peat mines, deforested lands, abandoned agricultural fields), but also in floodplains of small rivers and in grasslands. These areas now serve as additional roosting and feeding sites for autumn pre-migratory crane congregations.

Negative

In some areas, however, roost habitat decreased substantially since the late 1990s due to insufficient autumn precipitation (e.g., in Krasnodar and Lipetsk Regions, Russia). Because dry floodplains are easier to access and will likely experience greater general disturbance as well as habitat degradation (e.g., use as cattle pastures), a consequence of a drier climate may be decreased staging habitat. In Europe (e.g., Hungary, Estonia, and Germany), cranes are extending the staging period with the milder climate and conflicts with farmers over the freshly seeded winter crops start to become challenging.

4.4 Wintering

Positive

As food availability is increasing – often related to reduced or absent snow cover – migration distances between breeding and wintering grounds have decreased. In France, wintering of cranes was rare until 1975. Since then the wintering population has been increasing, and in 2010/11 about 100,000 cranes spent the winter at three different sites. In Israel, continuous growth of the wintering population has been observed with an increase from a few hundreds in the 1990s to 35,000 in 2009. The shorter migration distance, combined with optimal food availability in the wintering areas, enhances the survival of cranes, and probably their overall fitness so that their chances for breeding success the next spring may also increase. A study with banded cranes from Germany showed that the median migration distance decreased from 2,088 km to 320 km between 1997 and 2007.

Negative

In Ethiopia, there is a clear trend that numbers of wetlands suitable for roosting are decreasing significantly. In India, changes in the monsoon patterns have been increasing and several years of droughts have influenced wetlands as well as agricultural practices. Though there are years with strong monsoons, habitat and food for cranes that mainly winter in the northern part of India more frequently become scarce.

5. Impacts of changing water availability related to human actions

Cranes and their habitats are not only influenced directly by climatic change, but often by other changes in land use and in agricultural practice that affect breeding, and especially staging and wintering grounds. These factors interact in complex ways. For example, climate change may lead to less predictable agricultural productivity or changes in crops selected for planting due to increased variability of rainfall and increased frequency of extreme climatic events. The frequent construction of dams or the installation of irrigation facilities can strongly modify water occurrence and availability over large areas.

Positive

In northeast China, Jilin Provincial Government has recognized the role of wetlands in evening out water flows, in particular holding back water that can help ameliorate length and frequency of drought. The province has set up a fund to provide water with a priority on wetlands of high biodiversity value. In the south of Turkmenistan, cranes have only been wintering since 1997. In addition to warmer temperature, this change probably occurred because cotton (the main agricultural crop during Soviet times) has increasingly been replaced by wheat and barley, providing good food resources for cranes during winter. Moreover, irrigation systems are being built in desert regions (e.g., in the area of Gulistan, south-western Tallymerjen-Kelif-Zeyit Region). Thus, more land is successively turned into agricultural fields that provide more feeding opportunities for cranes. Due to economic depression in the Moscow Region (Russia), drainage and irrigation systems usually are not restored and the land remains fallow. Thus, the spatial distribution of feeding areas and roost sites has changed. Cranes feed in areas where there is still (or newly) well developed agriculture and sometimes roost in former agricultural lands that have turned into wetlands.

Negative

As precipitation patterns shifted in the area around Volgograd, initially some wetlands provided better conditions for cranes. However, many artesian wells were created and water was transported from the river floodplains of the Middle Don to the surrounding towns. As a result many wetlands became much drier and the cranes lost breeding habitat. In the Transbaikal Region, the substantial decrease in water and remaining wetlands led to an increasing concentration of water pollutants (e.g., the Argun River is generally heavily polluted). Furthermore, cattle congregated at the few remaining wetlands and disturbed and destroyed breeding habitat and nests of cranes. Due to a channel constructed in 2009 in China water is transferred from the trans-boundary Khailar-Argun River to Dalai Lake, hence desiccating the river floodplains and affecting crane breeding habitat (also affecting Red-crowned Cranes and White-naped Cranes). In Ethiopia, the pressure on wetlands has dramatically increased: on one hand, rainfall has become much more variable, and on the other hand water demands by humans are fast growing (for crop and cut flower irrigation as well as for a growing number of cattle). Further, changes in crop cultivation as a result of climatic change are expected and may diminish foraging habitat of cranes (including Eurasian Crane, Wattled Crane *(Bugeranus carunculatus),* and also Black Crowned Crane *(Balearica pavonina).* Additionally, dam projects have been initiated in Ethiopia that already cause shifts in water availability.

6. Effects of agricultural change

The continuing growth of the world's human population and the resulting increases in food demands are leading to increased pressures to make land available to grow crops, graze livestock, and produce biofuels which are being supported as an important contributor to meeting growing energy needs - in general and especially under conditions of climate change. Further, biofuels are promoted as tools for mitigating climate change, but peer-reviewed research indicates that the use of biofuels can result in extensive greenhouse gas emissions through the conversion of forests and grasslands to croplands thus accommodating biofuel production. Accordingly, the intensified use of existing agricultural land and the conversion of extensive areas for agriculture that currently serve other purposes will affect both natural habitats and biodiversity.

Ukraine provides a good example of a process that has happened in a number of countries once belonging to the former USSR, and thus covering a large part of the breeding area of the Eurasian Crane. In the 1980s, during the Perestroika Period, a program on the "Intensification of Agriculture" was established, and areas with moderately extensive agriculture became highly developed. Large areas were turned into highly productive fields. During the 1990s with the collapse of the USSR and an economic crisis, the well-established agricultural system was abandoned, and huge areas of arable land turned into waste and fallow fields. Additionally, human disturbance decreased significantly. Cranes (re)discovered these areas for breeding and staging. However, foraging habitat significantly decreased. Moreover, the risk of fire increased, affecting crane breeding grounds in some areas. Then, at the beginning of this century, Ukraine experienced an economic revival and the agricultural system became re-established, with continuing intensity. However, grasslands, rice, and corn fields – all providing foraging habitat for cranes – decreased. During the same period, the areas planted in sunflowers, rape, and soybeans have increased. The most recent five to ten years have seen severe drought. Thus, considering the last ten years, conditions for cranes have worsened again as the availability of breeding and foraging habitat fell substantially.

Negative

Selection of wintering sites depends largely on food availability. While in some areas in France the number of individuals has increased during winter, in other areas such as Lorraine (northeastern France) crane numbers have dramatically decreased because maize was widely replaced by colza for the production of biofuel. There is a similar situation in Gujarat (India) as the increased cultivation of cash crops (e.g., cotton) causes declining numbers of Eurasian Cranes in the area, and at Cao Hai in Guizhou Province (southwestern China), corn fields that were important foraging grounds for cranes are now used for growing vegetables or have been converted to tree plantations. In the Hula Valley (Israel) on the other hand, the wintering population is greatly increasing not only due to climate change, but due to additional factors such as changes in land-use practices (nutritious crops and newly created wetlands). Crane numbers are already very high and dense as the valley comprises only 6,000 ha, but the situation might deteriorate as the cranes are feeding not only on waste grain but on young, newly sown winter crops. Thus far, a joint stakeholder crane management program has successfully minimized crop damage. However, growing crane numbers may soon become unmanageable, which could have serious impacts on the cranes using this flyway.

7. Other factors affecting Eurasian Cranes

Until recent decades, this species underwent dramatic declines across much of its range from Europe through Central Asia to China. Major causes included destruction of wetland habitats, degradation and human disturbance in wetlands, and hunting. With increasingly effective protection from hunting and (in some areas) disturbance, Eurasian Cranes have experienced an equally dramatic recovery. Wetland restoration and favorable foraging conditions on agriculture lands, as already noted, have brought significant benefits as well.

Yet threats are still significant in some areas.

In the Taman Peninsula (Krasnodar Region, Russia), recreation (e.g., creation of new Cossack villages, meetings of bikers, rock-musicians, auto bikers, and auto tourism) have become a major threat, as disturbance prevents migrating cranes from using the wetlands as roosts. Similarly, in China human disturbance prevents cranes from using otherwise suitable wetlands. In some parts of Russia (e.g., Kaliningrad Region or Kaluga and Vladimir Regions), farmers have developed a negative attitude towards cranes as numbers of staging cranes and extent of crop damage increase. Moreover, the attitude towards nature conservation has generally been worsening; hence farmers are proposing to include the crane in the list of game species. In some Russian areas, as well as in Ukraine, hunters are shooting cranes illegally at several stop over sites. Further, eggs and chicks are being taken and sold for keeping in private breeding centers, while cranes in the floodplains of Udmurtia (Russia) are disturbed by fishermen and growing tourism activities. In the Indian state of Gujarat possible causes of declining numbers of Eurasian Cranes - in addition to climate change and hunting (which seems to be an issue along the whole flyway from Siberia to India) - is the poisoning of birds feeding on agricultural lands.

Due to the poor reproduction on the breeding grounds (see the section on Krasnoyarsk Region or Transbaikalia Region), the wintering population at Cao Hai in China has greatly decreased from roughly 2,200 in the 1980s to about 500 individuals in 2005. Additionally, interspecific competition between Eurasian Cranes and Black-necked Cranes *(Grus nigricollis)* has been observed. Numbers of the latter species have almost tripled over the past two decades and appear to be limiting the access to shallow water habitats for the Eurasian Cranes. Loss of wetlands due to drainage, dams and human disturbance across much of southwestern China has intensified this conflict over remaining habitat.

In areas where growing beaver populations create new swamps and thus provide good breeding habitat for cranes, number of cranes may increase as was the case in Udmurtia (Russia).

Invasive predatory species (e.g., raccoons and raccoon dogs in Germany and Sweden) constitute an increasing risk especially for eggs and crane chicks.

Additional research might document additional processes where climate change interacts with negative trends. For example, in northern Sweden, a decrease in rodent numbers was observed due to milder climate. It is presumed that in winter rodent numbers will further decline. As a consequence, predators such as foxes may be forced to prey more often on birds. As foxes are the main predators of crane chicks, with decreasing rodent populations crane breeding success could be expected to decrease.

8. Future outlook: Can Eurasian Cranes adapt to climate change?

Success of this species in recent decades has been due to its flexibility in choice of wetland nest sites, its readiness to forage in upland areas thus accessing vast food resources on agricultural landscapes, and its ability to shift behavior in response to human and natural factors. In the near term, we expect the species to continue to increase in part because warming trends will make available new areas for breeding to the north and at higher elevations, extend the length of breeding seasons in many areas, allow birds to stage longer in rich agricultural areas before migration, and in some cases to undertake shorter migrations. Water availability, however, will decrease in some areas, or become less predictable, which is expected to reduce productivity and fitness of cranes. In the mid and long term, changes in crop production and water availability will have both direct and indirect negative impacts on cranes, in particular as humans use land and water resources more intensively. The future for this species will depend on the extent of warming the world experiences and upon the extent to which societies embrace adaptation strategies to climate change that sustain the resources on which people and cranes depend.

The outlook for the species varies among portions of its range.

8.1 Middle and Northern Europe

In the western part of its distribution, the Eurasian Crane appears to be benefiting from global warming (Fig. 2) by:

a) increased survival rates during winter due to decreasing migration distances and enhanced food supplies in the staging and wintering grounds;

b) increased breeding success due to earlier spring arrivals at the breeding grounds and thus chances of a second clutch if the first failed; and

c) expansion of the breeding area northwards and towards higher altitudes that allows more pairs to make breeding attempts. Based on the majority of the existing climate scenarios for the next 20 years, a northward shift of the breeding as well as the wintering range will continue in the next decades.

At some point, however, a saturation of breeding populations, as well as growing conflicts with farmers, increasing recreation due to warming conditions, and other human outdoor activities – especially at the autumn stop over sites – might lead to a halt in population growth. A further decrease of wetland habitat quality (not necessarily related to climate change) due to increased human activities and changes in land use is predicted. It is hypothesized that these factors will eventually lead to declining meta-populations for the mid-term.

Due to milder temperatures and less snow cover, migration distances have been decreasing leading to earlier spring arrivals, and thus to improved reproductive success. Further, the period Eurasian Cranes are spending at the autumn stop-over sites has been extending, and an increasing number of cranes will eventually overwinter in former autumn staging areas. So, the overall winter range will be enlarged towards the north, which could potentially lead to greater dispersal of cranes and reduced impacts in specific localities.

In some European countries (e.g., Germany), wetland restoration projects have been implemented to mitigate climate change as degraded wetlands, with peat or other organic soils exposed to oxidation, emit large amounts of greenhouse gases. Thus, there is a secondary effect, for cranes, as more breeding habitat becomes available.

8.2 Mediterranean region / Africa

Based on the majority of climate scenarios for the next decades, the conditions in the more southern areas (e.g., Africa, Middle East, Spain) that serve as wintering sites for Eurasian Cranes will become much drier. Roosting habitat will decrease significantly. Further, changes in crop cultivation as a result of limited water supply and other climate change issues are expected and may diminish foraging habitat.

8.3 Asia

In the eastern part of the range, availability of surface water will greatly influence crane distribution. In many areas hydrological systems are being constructed in the desert, projects which lead eventually to increased food availability for cranes. However, where wetlands are affected by water diversions for human water use, crane breeding success probably will decrease. Future wintering areas will be determined by the availability of food and roost sites. If winters become milder there might be more food available; however, where winters grow drier, water and hence roost sites will become a strong limiting factor. Further, in some parts of Asia political unrest and hunting may combine with the negative effects of climate change to lower crane populations.

9. Recommendations

This paper documents the changes already affecting Eurasian Cranes, directly and indirectly through their habitats and food supply. These changes will continue as human activity (e.g., manipulation of water resources and land use change) is the main factor which impacts crane status. For more precise determination of the impact of climate change on cranes it is necessary to analyze more data including phenology and the changes in crane numbers and breeding success.

We make the following recommendations for action in response to known and unknown changes underway:

Assessment of climate change vulnerabilities and identification of adaptation measures should be incorporated into management plans and practice for Eurasian Cranes and the protected areas and other locations on which the cranes depend. See Glick et al. (2011), Walk et al. (2011), Young et al. (2011), and Gardali et al. (2012) for guidance and examples of vulnerability assessments, and see National Fish, Wildlife and Plants Climate Adaptation Partnership (2012) for adaptation planning.

Evaluation of development project impacts and regulatory changes, particularly related to water and agriculture, should consider future impacts of climate change on cranes and other biodiversity and be responsive to current and predicted conservation needs.

Further research is needed, perhaps using already existing data, to elucidate the different factors affecting crane numbers, distribution, and behavior including relative contributions of warmer conditions, changes in crop patterns unrelated to climate change, and an overall growing crane population.

While the global population of Eurasian Cranes is increasing, studies are needed of smaller populations, in particular those inhabiting highly vulnerable areas such as mountains and arid regions, to determine population trends, contributions of climate change, and effective conservation responses.

Long-term inter-disciplinary research is needed to distinguish short and mid-term climate cycles from long-term global climate change, especially for areas such as Dauria (Russia) with highly variable precipitation.
Better documentation is needed of crane migration patterns, distribution, population trends and their causes, and conservation needs in East Asia.

Areas with long-term historic data sets on cranes have special value and such monitoring should continue, with careful consideration of collecting additional data relevant to cranes and climate change.

Research is needed to determine what impacts favorable and unfavorable conditions during winter and migration have on breeding productivity.

The significance of climate change on short-term and long-term status of cranes should be communicated to wildlife and wetland managers and relevant policy makers, as well as media and the general public, so that relevant adaptive measures can be implemented.

Assessment of climate change vulnerability and implementation of adaptive conservation measures are needed for other crane species, particularly those that appear most threatened such as Whooping Crane *(Grus americana)* (sea level rise), Blue Crane *(Anthropoides paradisea)* (changes in agricultural practice under warming and drying conditions), and White-naped Crane (reduced water availability).

Data contributors

NAME	COUNTRY / AREA	TYPE OF CRANE SITE
Andryuschenko Y.	Ukraine / Crimea Peninsula	stop over
Belik V.	Russia / Volgograd and Rostov regions	breeding
Bragin E.	Kazakhstan / North Turgai (Kostanai Region)	breeding & stop over
Gavrilenko V. & Listopadskiy M.	Ukraine / Askania-Nova Nature Reserve (Kherson Region)	stop over
Glushenkov O.	Russia / Republic of Chuvashia	stop over
Goroshko O.	Russia / Transbaikalia Region	breeding & stop over
Grinchenko O. & Sviridova T. & Volkov S.	Russia / Crane Homeland Wildlife Refuge (Moscow Region)	breeding & stop over
Grishanov G.	Russia / Kaliningrad Region	breeding & stop over
Leito A. & Ojaste I.	Estonia	breeding & stop over
Li F.	China / Cao Hai (Guizhou Province)	wintering
Lokhman Y.	Russia / West Transcaucasia (Krasnodar Region)	stop over
Lundgren S.	Sweden	breeding & stop over
Menshikov A.	Russia / Republic of Udmurtia	breeding & stop over
Nowald G.	Germany / Mecklenburg-West Pomerania	breeding & wintering
Rustamov E.	Turkmenistan / Valleys of Amudaria, Murgaba, Tejen Rivers & Kopetdag Mountains, Tallymerjen & Kelif-Zeyit	stop over & wintering
Salvi A.	France / Lorraine	breeding & stop over & wintering
Sarychev V.	Russia / Lipetsk Region	breeding & stop over
Shanni I. & Labinger Z. & Alon D.	Israel / Hula Valley	stop over & wintering
Suprankova N.	Russia / Usinsk Hollow (Us River Valley Verkheusinskoey, Ermak District, Krasnoyarsk Region)	breeding
Toropova V.	Kyrgyzstan	stop over
Végvári Z. & Hansbauer M.	Hungary	stop over
Voloshina O.	Russia / Moscow & Vladimir Region	breeding & stop over

Note – citations, many of them in Russian language, have been provided by the contributors who also considered unpublished data in the information they provided. The compilers have not been able to review all of the literature referenced by the contributors and listed in this paper. For further information about specific regions, we suggest contacting the contributors listed above.

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APPENDICES

For the online version of this publication, we append a set of graphs summarizing selected areas that illustrate the influence of different factors on the Eurasian Crane. Visit **www.savingcranes.org/eurasian-cranes-and-climate-change.html** to find the online version with appended graphs.

Front cover: A flock of Eurasian Cranes (Grus grus) *feeding in a field in Sweden, September 2005.*
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