PLEISTOCENE PARK: RE-ESTABLISHMENT OF A FUNCTIONAL STEPPE ECOSYSTEM IN NORTHEAST SIBERIA

Sergei A. Zimov
North East Science Station
Sakha Republic, Yakutia
Cherskii, Russia
Tel: 23-013

(Temporary address same as Chapin)

F. Stuart Chapin, III and Melissa Chapin
Dept. of Integrative Biology
Univ. of California
Berkeley, CA 94720
Tel: (510) 642-1003
FAX: (510) 643-6264
fschapin@garnet.berkeley.edu

Summary

We propose to create a grassland ecosystem maintained by large northern herbivores similar to that which existed in Siberia 10,000-100,000 years ago during the late Pleistocene. Bison, horses, muskoxen, caribou, and moose will be introduced to 'Pleistocene Park', a scientific reserve in northeast Siberia. This region supported large herds of these animals and of mammoths during the Pleistocene. These animals were important in maintaining a steppe-grassland ecosystem, just as large grazers currently maintain African grasslands. The proposed project would re-establish a significant area of northern grassland, an ecosystem type that has disappeared but was formerly one of the world's most widespread biomes.

Background

During the Pleistocene, when glaciers covered much of North America and Europe, large expanses of northern Siberia, western Alaska, and the continental shelf connecting the two areas (which together were called Beringia) were ice-free and supported grassland vegetation and large herds of grazing mammals, including bison, mammoths, horses, muskoxen, caribou, and moose (Hopkins et al. 1982, Guthrie 1990, Zimov et al. 1995). Today all these animals except caribou and moose have disappeared from the region, and the vegetation has changed from grassland to tundra and forests dominated by mosses and shrubs except in floodplains where disturbance by flooding maintains grasslands. The reasons for the loss of this grassland biome from Berengia are uncertain. Climatic reconstructions using general circulation models suggest that today's climate in this region is warmer than during the Pleistocene but that precipitation and storm patterns may be similar (Manabe and Broccoli 1985, Kutzbach and Guetter 1986, Rind 1987 , Zimov et al. 1995). Grassland or steppe was widespread in northern Asia during the Pleistocene, despite large regional and temporal variation in climate. Some combination of climatic change and human hunting probably led to the extinction of the Pleistocene grazers and associated grassland vegetation (Martin and Klein 1984, Guthrie 1990, Zimov et al. 1995). However, there is no way to tell from the historical record whether a climate-induced change in vegetation caused extinction of the megafauna or whether loss of the megafauna from human hunting led to the change in vegetation. Recent research provides substantial support for the concept that the megafauna was critical to the maintenance of grassland vegetation during the Pleistocene (Zimov et al. 1995), just as African grazers currently maintain the savannas of Africa (Owen-Smith 1988). However, a true test of this hypothesis would require the

reintroduction of a grazing megafauna similar to that which existed during the Pleistocene. Detailed evidence for the role of megafauna in maintaining grassland in Siberia is given by Zimov et al. in the attached article (Zimov et al. 1995).

Objectives

We propose re-introducing the major elements of the Pleistocene megafauna to a 160 km^2 scientific reserve (Pleistocene Park) in northeast Siberia, where grassland was the predominant ecosystem type during the Pleistocene, and where grasslands are still a prominent component of the vegetation. We propose that bison be introduced from Canada and that horses be introduced from herds already present within 300 km of the reserve. Moose are already present in the reserve, and their density would be increased by local introductions. Wild reindeer graze near the reserve and could be readily transferred to the reserve. This paper is intended as background for a formal request for permission to reintroduce wood bison from northern Canada to northeast Siberia.

The animals

The bison (Bison priscus) that was present in Siberia during the Pleistocene was larger than the present bison, but generally similar in morphology. There was considerable morphological variation from western Siberia to western Alaska, but Guthrie considers it to be a single species. Although the details of bison taxonomy and phylogeny are debated, it seems clear that in the late Pleistocene and early Holocene, the body size of steppe bison declined, and all morphological features approached those of the present North American species (Bison bison). All of the morphological features of the late Pleistocene steppe bison are more similar to the northern wood bison (Bison bison athabascae) than to the southern plains bison (Bison bison bison) (Guthrie 1990). The wood bison with its large size, ability to deal with extreme cold and deep snow make it ecologically more appropriate than the European bison (Bison bonasus or wisent) for re-introduction into northern Siberia. Fossilized bones of the steppe bison are common in Pleistocene deposits near Cherskii, where we propose to establish a new bison population. In summary, the area near Cherskii formerly supported large herds of bison, a large-bodied bison that was morphologically similar to the present wood bison of northern Canada. There are scattered records (skulls and pictographs) suggesting that steppe bison survived in Yakutia into the Holocene, but there are no historical records of bison in the region during the 300 yr of European settlement.

Yakutian horses are a hardy northern breed that is raised in northernYakutia. The nearest large herd is in Srednekolymsk about 300 km south of Pleistocene Park, where winters slightly colder but summers are warmer than in Pleistocene Park. These animals have long hair and a thick layer of subcutaneous fat, which provide winter insulation. In 1988, 25 yearling foals of Yakutian horses were established in an area near Pleistocene Park. They successfully acclimatized and are reproducing as a free-ranging herd without supplemental food or water (Zimov et al. 1995). There have been no problems with hunting or poaching of the horses. In areas where the activity of this reintroduced herd is concentrated, grasses increased in abundance, while mosses declined, consistent with our hypothesis that grazing mammals can generate grass-dominated vegetation. The success of horses on free range near Cherskii suggests that bison and other large mammals would thrive in this climate and vegetation. Horses are

important culturally to the Yakut people of northeast Russia, being used both for transport and for food.

Moose and wild reindeer are present locally so there should be no problem maintaining these animals in Pleistocene Park. We will attempt to increase the density of these animals by local introduction of individual animals to fenced areas of the reserve. Muskoxen are present on the Taimyr Peninsula of Siberia and on Nunivak Island in Alaska. We will consider introducing muskoxen to Pleistocene Park in the future after we have demonstrated that it is feasible to establish viable free-ranging populations of bison and horses.

Suitability of climate and habitat

Pleistocene Park is located near the town of Cherskii in the Kolyma-Pantileikha River river basin, 150 km south of the Arctic Ocean. Cherskii has a continental climate, with cold dry winters and mild summers. The snow-free season lasts about 120 days from 20 May until 20 September. Average January temperature is -33°C, and average July temperature is 12°C. Precipitation is 190 mm (90 in winter, 100 in summer). Winter snow depth is 35-40 cm (record high 60 cm) and is usually very loose and easy for animals to push aside for feeding.

Pleistocene Park is near the northern boundary of forest tundra, and is bordered on the east by lowlying hills 1,000 m in elevation. It includes a mosaic of habitats and many lakes of 0.5-l km in diameter. The northern half of the park is a Holocene floodplain including riparian sedge meadows dominated by Eriophorum angustifolium and Equisetum spp. (aboveground biomass 300-600 g m^{-2}), grasslands dominated by Calamagrostis purpurea and Arctagrostis langsdorfi, shrub savanna dominated by Salix spp and Betula middendorfi, wet sedge meadows dominated by Carex aquatilis and Eriophorum angustifolium, and dwarf shrub heath dominated by lichens, Empetrum nigrum, and Ledum palustre. The southern half of the territory is a Pleistocene terrace of hills and thermokarst lakes. This area was previously covered by thick Larix forest, 70% of which has burned over the last 30 years, leaving young forests or shrub communities. Although Pleistocene Park contains this entire range of vegetation types, productive grasslands and riparian sedge meadows of high forage quality are the major vegetation types (70% of the area). The area is described in more detail and is compared to the Mackenzie Bison Sanctuary in Table 3 of the proposal to reintroduce bison to Pleistocene Park.

Management plan

Pleistocene Park is a 160 km^2 scientific reserve, owned and administered by a non-profit corporation (Pleistocene Park Association) consisting of six ecologists from the Northeast Science Station in Cherskii and the Grassland Institute in Yakutsk. The reserve is surrounded by a 600 km^2 buffer zone that will be added to the park by the regional government, once animals have successfully established. The park is 30 km south of the town of Cherskii. This area is close enough to Cherskii to be supervised closely by the scientific director (S.A. Zimov) but far enough from town that the animals would rarely encounter people other than the caretaker who lives in the park. The bison and horses would initially be maintained in separate 10 km^2 fenced areas of

productive grassland and Salix shrubs and would be provided with supplemental food and water as necessary during the first winter until they acclimatize to local conditions. After acclimation, most individuals of each species would be moved to a single 10 km^2 fenced area containing a habitat mosaic typical of the park. The fences will be built in April 1997. When horses were introduced to the region in 1988, 1 km^2 provided enough forage for the long-term sustenance of 25 animals, so we are confident that the 10 km^2 fenced area would provide sufficient habitat for the initial megafauna ecosystem and that the 160 km^2 area (expandable to 750 km^2) would meet the long-term needs of even large herds. If the animals successfully establish, we envision 3 phases to the effort: Phase I--the initial introduction to Pleistocene Park; Phase II--expansion to the 750 km^2 reserve; Phase III--a free-ranging herd that could spread through the Indigirka lowland (500,000 km^2). See the bison reintroduction proposal for details.

Science plan

The major purpose of Pleistocene Park is to increase our understanding of the ecological dynamics of a northern grassland and associated large grazers, similar to that which was widespread during the Pleistocene.

Pleistocene Park will encourage the international scientific community to participate in the study of the interaction between megafauna and their physical and biotic environment in northern Siberia. The Park will contain several experimental treatments worthy of study: (1) areas with each of the five animal species by itself, (2) areas with all major animal species together (maintained at the same total animal density as the single species areas), (3) an area that is physically disturbed to mimic the physical disturbance of large grazers, (4) an area that has nutrients added at a level similar to that annually added by grazers in feces and urine, and (5) a control area in which no animals are introduced (and from which local grazers and browsers are excluded. Additional small replicated controls (exclosures) would be fenced to exclude grazers within each treatment. These nine areas constitute the basic scientific research area of the park.

As populations expand, we will establish new fenced areas for the combined megafauna (same as treatment 2) to produce an extensive area that simulates the Pleistocene ecosystem.

Although plant species typical of Pleistocene grassland exist within the park, they are not widespread. We will reintroduce individuals of the major grassland steppe species into each treatment area to provide the possibility for expansion of plant species that were widespread during the Pleistocene but currently have a restricted range. If the animal grazing treatments alter vegetation to support the expansion of these plant species, as we expect, we will explore possibilities of local introduction of other Pleistocene fauna (e.g., beetles and ground squirrels) and of Pleistocene microflora, which is currently preserved in permafrost. All reintroduction efforts would be applied equally to each fenced area. The success with which these steppe elements become established would depend on ecological interactions within each treatment. Except for bison, muskoxen, and horses, all species would be introduced from biota that are present in the region but not locally abundant. Thus, we will not introduce exotic organisms that might escape from the park and greatly alter Russian forest or tundra.

We will establish a scientific steering committee of 5-10 people to provide guidance on the design and operation of experiments within Pleistocene Park. This steering committee will consist of experts in the ecology and nutrition of each of the introduced herbivores, the ecology of the extant vegetation, the ecology of Pleistocene animals and vegetation, and the ecology of other large grazing systems (e.g., Serengeti grasslands) where large mammals exert a strong effect on ecosystem processes. The Northeast Science Station in Cherskii already serves as a scientific center for numerous Russian and foreign scientists that study the current and Pleistocene ecology of the region. Thus, there is already a clientele of knowledgeable scientists interested in Pleistocene Park.

Disease considerations

Unintentional introduction of diseases are a potential threat to the success of any wildlife reintroduction program, so we will make major efforts to prevent any such disease introductions. The major diseases of concern for bison reintroduced to Siberia are bovine brucellosis (Brucella abortis) and tuberculosis. We hope to reintroduce wood bison from a diesase-free population in Canada, avoiding the possibility of disease introduction. Since there have never been domestic animals in Pleistocene Park other than dogs and chickens, we do not anticipate a local reservoir of disease to which bison or other species might be exposed. The closest cattle (8 cows in Cherskii 30 km away) are tested regularly and are free of bovine brucellosis and tuberculosis. The next closest cattle are in Srednekolymsk 300 km away. No new cattle have been transported into northern Yakutia since the 1970s. There is no record of sheep or goats having been brought to Cherskii or to other towns in the region. Domestic reindeer 90 km to the north are tested regularly for brucellosis suis type IV. This disease is present, although it is controlled. It is therefore likely that wild reindeer, which move through Pleistocene Park, have some (unknown) levels of this disease. There is currently no evidence that bison contract or are seriously affected by Brucella suis type IV. We will carefully test horses and muskoxen for diseases before introducing them to the Park.

Tentative Schedule and Logistics

We hope to reintroduce approximately 20 wood bison from northern Canada to Pleistocene Park in late winter 1997. If this initial reintroduction is successful, we would like to reintroduce an additional 100 animals to ensure the establishment of a viable population. The Mackenzie Bison Sanctuary supports a large, expanding herd of disease-free wood bison, which have been the source of animals for several recent re-introductions to other areas of North America. Biologists working with this herd are knowledgeable about the habitat of bison, the precautions needed in transport, and the procedures that promise the most effective acclimation of animals on arrival. We would hope to work closely with these biologists in all aspects of the bison reintroduction.

We hope to move approximately 50 Yakutian horses from Srednekolymsk to Pleistocene Park in summer 1997. These horses would be tested for diseases during late winter 1997 and transported by river in summer 1997.

Pleistocene Park Association is a legally constituted non-profit corporation in the Republic of Sakha-Yakutia (the administrative region of Russia in which Pleistocene Park is located). The Republic of Sakha-Yakutia has permanently deeded the 160 km^2

area for the park to the Pleistocene Park Association and has promised $1,000,000 (U.S. equivalent dollars) in initial financial support for 1996-2001. These funds will be used for in-country expenses such as transport of bison within Russia, purchase and installation of fences, purchase and transport of horses, purchase and transport of supplementary food, veterinary services, and the construction of buildings in Pleistocene Park to house scientists and conduct research. The Pleistocene Park Association has already established the Park, has purchased the initial fences and fertilizer to enhance the forage quality of adjacent vegetation. The Northeast Science Station, directed by Zimov, is located in Cherskii, 30 km south of Pleistocene Park. This station can provide off-site housing and laboratory facilities for scientists doing research at Pleistocene Park.

The regional and local governments have guarenteed tax-free status for Pleistocene Park and have guarenteed that they will facilitate the importation of bison from North America (i.e., will speed the movement of animals through customs on arrival in Russia and will not impose import duties). Thus, we have a strong commitment of regional governmental support for the facilitation and establishment of Pleistocene Park and its first five years of operation.

We have inititated discussions with several transportation companies (Sakha Aviation, Alaska Airlines, Russian Air Services) to ship the bison by plane from Canada to Cherskii and have discussed details with personnel in these companies that are familiar with transportation between Alaska and Russia (Alaska Airlines and Russian Air Services) and who have experience in caging and transporting large animals by air within Russia (Eric Vercesi at Russian Air Services). A small team of biologists and transportation experts would preceed the animals to Russia by a few days to ensure that all local arrangements have been made for customs and transfer of animals. We are confident that, if we obtain Canadian permission to reintroduce bison and obtain funds for transport of animals from Canada to Russia, the local and regional governments will do everything possible to facilitate the transport and establishment of herds at Pleistocene Park.

Governmental permits and agreements are a major potential hurdle to establishment of Pleistocene Park. No permits are required to purchase and transport horses. The Russian governmental agencies that must approve the importation of the bison (Ministry of External Relations of the Sakha Republic, Department of Visas and Passports, and Federal Safety Service) have already given their written approval. Copies of these letters are attached to this proposal.

Funds required

If the Canadian government approves the release of bison for reintroduction to Pleistocene Park, the major cost of moving the animals will be the airplane charter (including landing fees and fuel) and salary for a veterinarian experienced in bison reintroductions, who would travel with the animals from Canada to Cherskii and would remain at Pleistocene Park during the first 2-4 weeks of the reintroduction to provide advice on handling of animals, to treat any animals that show signs of stress, and to advise local veterinarians on the long term care of bison. In addition, we would plan to hire a Russian (from Russian funds) and a North American (from North American funds) postdoctoral scientist for one year to study the physiology and

nutrition of animals during the initial acclimation phase. We estimate the costs for reintroduction and for the North American postdoc to be approximately $100,000. Once a source of bison has been approved, we will approach private foundations for this financial support.

Significance of Pleistocene Park

The Pleistocene grassland was circumpolar in distribution 10,000-100,000 years ago and was one of the most widespread biomes at the time. The proposed park would bring together most of the elements of this formerly widespread biome. Re-establishment of grassland-grazing ecosystems is globally important because grasslands have been more strongly impacted by anthropogenic change throughout the world than any other ecosystem type, both by conversion to agriculture and by over-hunting of native fauna. The Russian Far North is perhaps the only large area where the reconstruction of grassland-grazing ecosystems might be attempted (Zimov et al. 1995). Here, fragments of grassland and steppe vegetation occur on south-facing slopes (Yurtsev 1982, Murray et al. 1983) and in areas disturbed by human activities (Zimov et al. 1995), and meadows of sedges and grasses occur along rivers and thermokarst depressions (alasses). These species provide the genetic basis of Beringian grassland vegetation and might expand into other environments, if competition from mosses and other typical-tundra species were controlled by mammalian grazers. The research proposed here would test the concept that a grassland ecosystem could be re-established and maintained. Predators, such as the tiger, were also essential components of the Pleistocene ecosystem (Vereshchagin 1988). The Amur tiger in the Russian Far East formerly extended into cold regions of central Yakutia. This tiger is presently an endangered species due to lack of suitable prey. Large cats have been important components of all grazing ecosystems. If large herds are successfully established in the park, the tiger could be introduced to provide a viable habitat for this species. This is an example of secondary species that might become established after re-introduction of grazers and vegetation.

Grassland reconstruction has important implications for current ecological and social problems. Northern moss and forest communities are sensitive to human disturbance (Kriuchkov 1973), and Northern Siberia is currently a region of widespread human disturbance (Zimov 1990). Because grasses and other grassland species are less sensitive to disturbances such as human activity (Chapin and Shaver 1981), it may be easier to convert some highly disturbed tundra areas to grassland than to restore the original tundra. If grassland reconstruction were widely successful, grazing mammals could provide a sustainable food source for northern peoples and could provide a model for reconstruction of grazing ecosystems throughout the world.

Feasibility

The large mammals we propose to re-introduce have already been successfully reintroduced to other regions of the north: musk-oxen to northern Siberia and northern Alaska (Klein 1988), bison to the mountains of central Alaska (Guthrie 1990), and horses to northern Russia (Zimov et al. 1995). These re-introductions demonstrate that large mammalian grazers can withstand current climatic conditions and successfully exploit

tundra vegetation. However, in no place have multiple elements of the Pleistocene megafauna been re-introduced.

Although the concept of Pleistocene Park might initially seem like a science-fiction story, the establishment of such a park is quite feasible with relatively modest resources, and such a park, once established, should maintain itself without large additional external financial inputs. The feasibility of such a project depends on well established scientific evidence that such large grazers coexisted with one another as an intact ecosystem in the past and that such animals can be reintroduced to northern environments. A suitable habitat has been acquired and dedicated to such a reserve, and local governments have agreed to the establishment and long-term continuation of such a park. A process has been established so that fences and facilities for initial receipt of animals are available.

References

Chapin, F. S., III, and G. R. Shaver. 1981. Changes in soil properties and vegetation following disturbance in Alaskan arctic tundra. Journal of Applied Ecology 18:605-617.

Guthrie, R. D. 1990. Frozen fauna of the mammoth steppe: the story of Blue Babe. University of Chicago Press, Chicago.

Hopkins, D. M., J. Matthews J.V., C. E. Schweger, and S. B. Young, editors. 1982. Paleoecology of Beringia. Academic Press, New York.

Klein, D. R. 1988. The establishment of muskox populations by translocation. Pages 298-317 in L. Nielsen, and R. D. Brown, editors. Translocation of Wild Animals. Wisconsin Humane Society, Milwaukee.

Kriuchkov, V. V. 1973. Krainii Sever: problemy ratsional'nogo ispol'zovaniia prirodnykh resursov. Mysl', Moscow.

Kutzbach, J. E., and P. J. Guetter. 1986. The influence of changing orbital parameters and surface boundary conditions on climate simulations for the past 18000 years. Journal of Atmospheric Sciences 43:1726-1759.

Manabe, S., and A. J. Broccoli. 1985. The influence of continental ice sheets on the climate of an ice age. Journal of Geophysical Research 90D:2167-2190.

Martin, P. S., and R. G. Klein, editors. 1984. Quaternary extinctions. A prehistoric revolution. University of Arizona Press, Tucson.

Murray, D. F., B. M. Murray, B. A. Yurtsev, and R. Howenstein. 1983. Biogeographic significance of steppe vegetation in subarctic Alaska. Permafrost: Fourth International Conference, Proceedings 4:883-888.

Owen-Smith, R. N. 1988. Megaherbivores: the influence of very large body size on ecology. Cambridge University Press, Cambridge.

Rind, D. 1987. Components of the ice age circulation. Journal of Geophysical Research 92D:4241-4281.

Vereshchagin, N. K. 1988. Paleogeografia i paleoekologiia zverei mamontovoi fauny v chetvertichnom periode Severnoi Evrasii. Pages 20-32 in A. G. Voronov, editors. Obshchaia i regional'naia teriografiia. Nauka, Moscow.

Yurtsev, B. A. 1982. Relics of the xerophyte vegetation of Beringia in northeastern Asia. Pages 157-177 in D. M. Hopkins, J. V. Matthews Jr., C. E. Schweger, and S. B. Young, editors. Paleoecology of Beringia. Academic Press, New York.

Zimov, S. A. 1990. Chelovek i priroda Severa: garmoniia protivopolozhnostei. Vestnik Akademii Nauk SSSR 2:118-133.

Zimov, S. A., V. I. Chuprynin, A. P. Oreshko, F. S. Chapin III, J. F. Reynolds, and M. C. Chapin. 1995. Steppe-tundra transition: An herbivore-driven biome shift at the end of the Pleistocene. American Naturalist 146:765-794.