FIRES IN STEPPES AND SAVANNAS

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Summary

Steppe and savanna fires are a major category of landscape fire which may originate either spontaneously anthropogenically. During the evolution of most grasslands they became well adapted to the impact of fire. The adaptation of plants to persistent impact of natural fires was always in conjunction with their adaptations to the impacts of wild herbivores—rodents, ungulates and other grazing and browsing mammals. This is confirmed by the fact that prior to agricultural plowing of the Eurasian steppe it served as grazing land for large herds of ungulates including wild horses. In the absence of fire ecosystems accumulate litter, woody material and leaves, and grassland biodiversity is reduced as woody vegetation becomes more prominent.

Fire is one of the most important factors determining the composition, functioning and multi-year dynamics of the world's grasslands. They occupy about 20% of the land area and are represented by the prairies in North America, by the pampas, lianos, cerrado and campos in South America, by the steppes in Eurasia, by downlands in New Zealand and different types of savanna in subtropical and tropical Africa. Due to their structural and dynamic characteristics, secondary grasslands which replaced dry tropical forests in

Asia and Africa, and grasslands of the Mediterranean type which originated as a result of the impact of persistent periodic fire on broad-leaved trees, can also be regarded as grasslands. Another group of grasslands comprises mountain steppe and dry subalpine meadows. These resemble their analogues on the plains in respect of their structure and composition but they cannot be considered as pyrogenic formations as large grass fires are infrequent in such habitats.

Data on the affected area, severity and occurrence of fires in the world's grasslands is very poor and generally unreliable. Usually, in both national data and that from UN and FAO, grasslands are comprise only natural pastures and meadows, and primary and secondary grasslands are not distinguished.

Unlike forest fires, grassland fires do not transform the ecosystem. Erosion and ravine development are more intense after fire, so deliberate burning of steppe pastures is usually confined to the dryer spring season.

Before the appearance of human beings forests had occupied up to 90% of the land area of the Earth. Even deserts had been substantially covered with trees. The climatic conditions in steppes and other grasslands are normally suitable for forest growth but fire controls the spread of bushes and trees, and was a major reason for deforestation. The other main factor is lack of rainfall in summer, when grasses cease their development and reduce water consumption—something which trees are unable to do. Since the arrival of humans, intentional use of fire has been a more frequent cause of wild fires than lightning strikes. The period between fires has become so short that there is hardly time for grass regeneration. Establishment of trees was only possible in small patches and for limited periods of time. In the competition between trees and grasses, fire gave the advantage to the latter.

As an instrument in the control of grassland dynamics, fire goes back tens of thousands of years. Fire was used in hunting at a very early time in human history, and soon after this it became a means of improving grassland for grazing. In this way the use of fire became more subtle and experience of its use in different seasons and weather conditions was gradually gained. Burning itself was an input to traditional knowledge and land use.

Geographical aspects of fires in grasslands are discussed for the unforested areas of Australia, Africa (savannas, velds), North America (prairie and chapparal), southern Europe (Mediterranean grassland and shrub ecosystems), South America (cerrado, pampas, lianos, etc.), and Eurasia (steppes).

It is considered that savanna and steppe biomes have optimal conditions for productivity. Their contribution to the global carbon cycle is proportional to their area. In fact their total annual production is higher than that of tropical forests and only slightly less than overall global forest production (including boreal). The production of natural grasslands constitutes nearly 45% of the net global primary carbon production. Accordingly, steppe and savanna fires play an important role in global climate change and its consequences. Furthermore, along with forests and peat bogs, soils of the steppe biome represent major stores of global carbon.

1. Introduction

Steppe and savanna fires are types of landscape fires which originate naturally (normally from a lightning strike) or from anthropogenic causes (e.g. intentional vegetation burning for amelioration of pastures and expansion of arable land). Most natural and semi-natural grasslands, grass-scrub communities of the Mediterranean type, and open forest ecosystems of the subtropical and tropical zones (forest savanna) have developed in relation to periodic fires. The adaptation of plants to persistent impact of natural fires has always been in conjunction with their accommodation to the impact of wild phytophagous animals, including insects, rodents and large mammals. The latter factor played a vital role not only in sustaining the biological cycle and energy flow but also in reduction of above-ground herbage—potential combustible material. Grazing and browsing reduced the risk of fire outbreaks, and hence limited the impact of fire on biota. This was always an important natural factor, even in Eurasia where, prior to agricultural plowing, the steppes served as grazing land for large herds of ungulates, including wild horses. At present the African savanna is grazed by more than 70 ungulate species, including many antelopes. Their pressure on vegetation cover has been assessed as 100-300 kg per ha, which is equivalent to grazing of 1 to 2 cattle per ha of pasture.

Without the continuous impact of phytophagous animals on grass cover, or with only weak grazing pressure, accumulation of vegetation mass in grasslands exceeds the optimal stock and the consequent scale and severity of fires damages the upper soil layer, kills the grasses with a short root system and trees with a low crown, and causes animal casualties. If the absence of fire continues, the ecosystems accumulate litter, dead leaves and woody material, the diversity of grasses and other plants is reduced, and eventually the grassland is replaced by scrub or arboreal vegetation.

2. Grasslands and fire

Fires represent the most important factor determining the composition, functioning and multi-year dynamics of the world's grasslands. They occupy about 20% of the total land area, principally in the prairies of North America, the pampas, lianos, cerrado and campos of South America, the steppes of Eurasia (from Hungary across Ukraine and Russia to Mongolia and China), the downlands of New Zealand and the British Isles, and the different types of savanna in subtropical and tropical Africa. Secondary grasslands which replaced the dry tropical forests of Asia and Africa, and grasslands of the Mediterranean, both of which originated from persistent fire impact on broad-leaved trees, can be regarded as semi-natural grasslands, with largely natural structural and dynamic characteristics.

A special group comprises mountain steppe and dry subalpine meadows. These resemble their analogues on the plains, with respect to their composition and effect on the landscape. Comparatively large areas of mountain grassland communities can be found in the Andes, Cordilleras, and Apennines as well as in the Caucasus, Altai, Tien-Shan, Tibet, and the Himalayas. Their ultimate expression can be found in north-eastern Siberia, in Yakutia and Chukotka, where cold steppes are present on dry mountain slopes on the southern border of the tundra. In contrast to lowland grassland, mountain grasslands cannot be considered as pyrogenic formations, as large grass fires are infrequent. Consequently in our outline we shall concentrate on lowland ecosystems.

Data on the affected areas, severity and frequency of fires in the world's grasslands is very poor, and somewhat unreliable. In statistical reports of the UN and FAO, and also in national statistical reference books, grasslands include natural hay meadows and pasture; primary and secondary grasslands are not distinguished. The corresponding fire statistics are not collected, as no distinction is made between spontaneous and controlled fires. At the same time in the international system of global assessment projects on the contribution of fires to global climate change, the structure and dynamics of vegetation cover, including deforestation, steppe and savanna fires, are given greater prominence. For example output from the project TREES (Tropical Ecosystem Environmental Observation by Satellites, 1995) revealed the large scale trends of deforestation in Central Africa and replacement of tropical forest with secondary vegetation including grass and grass-thorn scrub savannas. Statistics on grass fires are compiled in the Global Vegetation Fire Information System (GVFIS), which is designed as a technological base for the Global Fire Monitoring Center (1998). At present this activity is integrated into a project known as the "Global Vegetation Fire Inventory", which also encompasses data on forest fires. Relatively complete statistics on fires have been compiled and presented by the European Economic Community (EEC), which collected data not only for European countries but also for USA and Canada (EEC\FAO, 1993). As regards size, the largest fires occur in African savannas, in the Mediterranean region and Russia. Statistical data on these regions is not adequate, and a satisfactory monitoring system has not yet been established.

Unlike forest fires, grassland fires have no transformation effect on the ecosystems. There is an opinion that in a rainy season after a fire, erosion and ravine development are intensified by the lack of vegetation. For this reason the timing of fire amelioration on steppe pastures is usually limited to the dry spring season, and the autumn season is avoided for deliberate burning.

In different parts of the world transformation of grassland is mainly attributable to plowing and other types of agricultural land use, and industrial and transportation development. In recent years the total area of grasslands in the world has been stabilized. The general trends of grasslands area change in selected countries of Europe, North America and Australia are presented in Table 1 which is based on data from OECD and FAO.

	1980	**1985**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Canada	300.1	256.1	261.0	263.3	263.3	263.3	263.3	263.3	268.8	268.8
Mexico	745.0	750.0	750.0	780.0	785.0	790.0	795.0	795.0	795.0	795.0
USA	2375	2416	2391	2391	2392	2392	2392	2392	2392	2392
Australia	4506	4398	4187	4171	4188	4138	4145	4145	4145	4145
New Zealand	141.6	138.8	134.9	135.1	135.2	134.5	133.8	133.1	132.4	131.7
Russia	942.7	932.4	879.6	878.7	879.2	874.1	873.7	875.8	881.4	881.4
UK	107.4	104.4	109.6	110.7	111.9	113.0	114.1	115.3	112.7	110.1
Greece	52.7	52.6	52.6	52.2	52.2	52.2	52.2	52.2	52.2	52.2
Italy	52.3	49.8	48.8	42.0	43.5	45.3	45.6	45.6	45.6	45.6

Spain	107.4	103.0	103.0	102.8	102.6	103.0	106.9	106.9	106.9	106.9
Turkey	101.0	106.0	120.0	123.8	123.8	123.8	123.8	123.8	123.8	123.8
France	146.9	139.5	130.1	128.1	126.8	123.0	121.2	123.8	122.4	120.8

Source: OECD Environmental Data (1999)

Table 1. Dynamics of grassland change in European, North American and Australian countries for the years 1980-1997

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Bibliography

Arianoutsou-Faraggitaki Margarita. Post fire successional recovery of a phryganic (East-Mediterranean) ecosystem. In: Acta oecologia plantarum, 1984, v. 5, #4, p. 387-394 [article on pirogenic successions of phryganic ecosystems; description of recovery vegetation processes after fires in Mediterranean ecosystems].

Bazilivich N.I., Grebentchikov O.I., Tishkov A.A. Geographical regularities of ecosystem structure and functioning. Ed.: Isakov Yu. A. Moscow, Nauka, 1986, 297 p. [monograph about different geographical aspects of productivity, biological turnover and distribution of zonal ecosystems in former of USSR].

Coutinho L.M. Ecological effects of fire in brazilian cerrado. In: Ecology of Tropical Savannas , Berlin e.a., 1982, p.273-291.[article about ecological post effect grassland fires in Brasilia – for plants, animals, ecosystems].

Edwards D. Fire regimes in the biomes of South Africa. In: Ecological effect of fire in South African ecosystems. Berlin e.a., 1984, p.19-37. [article on fire rotation and changes of bush-grass ecosystems of South Africa].

Huntley B.J. Characteristics of South African Biomes. In: Ecological effect of fire in South African ecosystems. Berlin e.a. ,1984, p.1-17 [short review of nature peculiarities of South Africa in grassland fires].

Lacey C.J., Walker J., Noble I.R. Fire in australian tropical savannas. In: Ecology of Tropical Savannas, Berlin e.a., 1982, p.246-272.[large review on ecological effect of fires in eucalipted savannas in tropical zone of Australia].

Lamotte M. Consumption and decomposition in tropical grassland ecosystems at Lamto, Ivory Coast. In: Ecology of Tropical Savannas , Berlin e.a., 1982, p.415-432.[investigation results of role phytophagous and saprophagous organisms in tropical grassland].

Mordkovich V.G., Gilarov A.M., Tishkov A.A., C.A. Balandin. The future of steppes. Novosibirsk: Mangazeja, 1997, 208 p. [monograph about history, structure, dynamic and anthropogenic transformation of grassland ecosystems in World, North Eurasia and Russia].

Menaut Jean-Claud. The vegetation of African savannas. In: Tropical savannas, Amsterdam e.a., 1983, p. 109-149.[review on vegetation of African savannas in grassland fires context].

Tishkov A.A. Grassland ecological restoration in Russia. In: Grassland and society, Wagenningen, 1994, c.309-312.[results of first experiments on ecological restoration of grasslands in Russia].

Trollope W.S.W. Ecological effects of fire in south african savannas. In: Ecology of Tropical Savannas, Berlin e.a., 1982, p.292-306.[short review results of after effects of grass-bush fires in South Africa].

Biographical Sketch

Arkady Alexanrovich. Tishkov (born in 1950) is one of the leaders of modern biogeography and nature conservation in Moscow. In 1973, he graduated from the biological faculty of Moscow State University and since then he has been working in the Institute of Geography, Russian Academy of Sciences. Since 1990 he has been Head of Laboratory and a Professor at the International Independent University of Ecology and Politology.

In 1979 he obtained a scientific degree for his thesis entitled is “Bryophyte Communities in Tundra and Taiga Ecosystems”, and in 1994 he was awarded Doctor of Sciences and Professor of Geography (his second thesis was entitled “Geographical Regularities of Natural and Anthropogenic Successions”.

He has participated in many expeditions, e.g. the Taimyr peninsula, Magadan region, Kola peninsula, Spitsbergen (Norway), Uzbekistan, Ukraine, Hymalayas (China), and other regions.

He is scientific secretary of the editorial office of "Proceeding of Russian Academy of Sciences: Geographical Series", editor of “Problems of Regional Ecology”, secretary of the section "Flora and Fauna Conservation" in the Higher Ecological Council under the State Parliament of Russia, a member of the Nature Protected Areas Commission of the Russian Academy of Sciences, a member of the Biogeography Commission of the International Geographical Union, and coordinator and Deputy Chief Editor of “First National Report: Biodiversity Conservation in Russia”.

In recent years, he has supervised 12 PhD students in geography and published over 350 research papers and monographs including: *Geographical regularities of structure and functioning of ecosystems* (1986); *Geographical regularities of ecosystem dynamics* (1986); *The basis of modern biogeography* (1993,1995); *Ecological restoration of disturbed areas in the North* (1996); and *The future of steppes* (1997). His research interests are geography of biodiversity, succession, ecological restoration, and biodiversity conservation.

Current research projects for which he is acting as leader include: climatic fluctuations and successions of zonal vegetation (1993-1994), changes of biodiversity after invasions of exotic species (1993-1995), small watershed vegetation dynamics in southern taiga (1993-1994), biogeographical effects of alien species invasions (1995-1997), and biodiversity conservation, a GEF Project (1996-2001).