



Transforming **U**nsustainable
management of soils in key
agricultural systems in EU and China

Developing an **i**ntegrated platform of
alternatives to reverse soil degradation

Present status of land degradation in Bulgaria



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Introduction

The United Nations Conference on Environment and Development (UNCED, 1992), better known as the RIO Earth Summit, considered the fragile ecosystems in chapter 12 of Agenda 21. In this chapter, desertification was defined as 'land degradation in the arid, semi-arid and sub-humid areas resulting from various factors, including climatic variations and human activities'. Consequently, United Nations Convention to Combat Desertification defined land degradation as 'reduction or loss in arid, semi-arid and dry sub-humid areas of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range pasture forest and woodland resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical and biological or economic properties of soil; and (iii) long-term loss of natural vegetation'. Concomitant physical phenomena involve reduction in the vegetative cover, increased albedo, extensive soil erosion and salinization, deterioration of water resources, etc.

The United Nations Convention to Combat Desertification was adopted as a legally binding document in 1994 (CCD, 1994). The Convention comprises a framework of general principles and five annexes for Africa, Asia, Latin America, the Northern Mediterranean and Central and East Europe. The Convention entered into force in 1996 and the number of country parties to the convention is now reaching 180 including desertification affected and unaffected developing as well as affected and unaffected developed countries.

In January 2001 the National Assembly of the Republic of Bulgaria ratified the UN Convention to Combat Desertification and it entered into force for Bulgaria on 22.05.2001. The Ministry of Environment and Water has undertaken the responsibilities for its implementation as well as the functions of National co-coordinating institution. National seminar 'Land and soil degradation and combating desertification', which was organized in Sofia on 13-14 June 2002, aimed at reviewing the current state of the issue in Bulgaria and designating a body responsible for preparing the National action programme.

Driving forces of land degradation on the territory of Bulgaria

Landscape features

The territory of Bulgaria covers 111 007 km² of the eastern part of the Balkan Peninsula. The topographic characteristics (Fig. 1) show that the landscape features contribute substantially to the water erosion appearance: only 16 % of the territory are relatively flat

with slopes less than 3°, while about a half (49.1 %) of it is sloped 6–18°.

Climate

The country's territory, being a part of the Balkan Peninsula, is referred to two large climate regions – Temperate

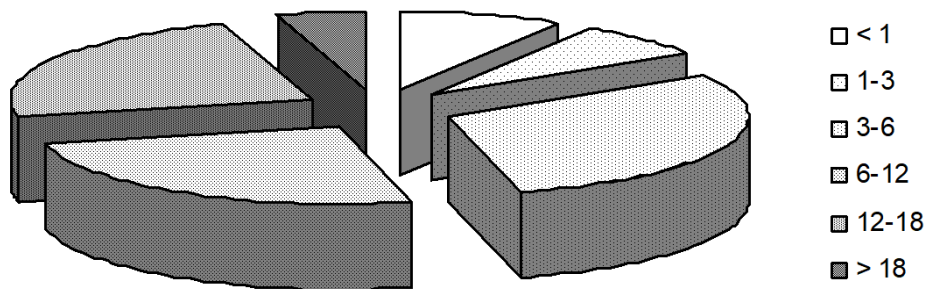


Fig. 1. Distribution of the territory according to the dominant slope gradient.

and Mediterranean ones. For both the topographical diversity and the transitory climate situation both the average annual rainfall amount and monthly distribution vary greatly over the country's territory. Results from recent studies on the annual fluctuations of the main meteorological elements for the potential vegetation period indicated a trend toward warming up accompanied by increase of the rainfall amount during the cold seasons and rainfall deficiency during the warm seasons (Alexandrov, 2002; Slavov, 2002).

The maximum 24-h rainfall amount ranges between 100 and 200 mm. About 97 % of the intensive rainfalls, which average annual number is 10-15, fall in the period May – September (Rousseva et al., 1992). Rousseva (2002) found that the average annual rainfall erosivity for 76 % of the territory exceeds 801 MJ mm/ha h.

Wind direction, velocity and frequency distribution depend on the season and the topography. There are 3-5 windy days with a predominating wind velocity of 5-10 m/s and 1-2 days with wind velocity of 11-15 m/s monthly during the spring. At the same time a strong spring dry spell set in every third year (Rousseva et al., 1992).

Soil cover

The structure of the soil cover of Bulgaria is very complicated and often inadequate to the present climate and vegetation conditions. The soil map of Bulgaria shows a mosaic pattern of great variability of soils and more than 20 soil groups, identified in the soil map of the World, can be found. The country's territory is referred to the following four soil regions:

1. Cambisol-Podzol-Leptosol Region with Luvisols;
2. Chernozem-Kastanozem-Phaeozem Region with Luvisols;
3. Luvisol Region with Leptosols and Planosols;
4. Vertisol Region of central Bulgaria

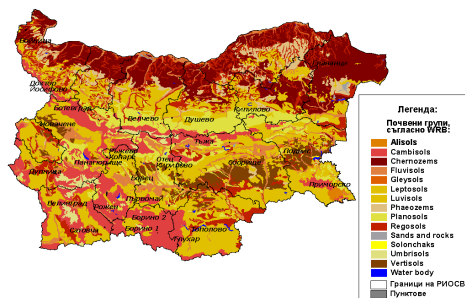


Fig. 2. Soil Map of Bulgaria by Classification WRB.

Social and economic forces

The social and economic relations that were established in Bulgaria after the World War II became shortly afterwards a driving force for land degradation. Accelerated processes of soil erosion by water and wind, soil compaction, soil acidification and decline in organic matter resulted from (i) the large cultivation fields, formed irrespectively on the landscape features; (ii) the use of uniform heavy agricultural machinery and crop-growing technologies, not suitable for the specific natural conditions, and not taking into account the soil degradation factors; (iii) disinterestedness of the agricultural managers and farmers in applying erosion control measures and practical impossibility of application of crop rotations to control soil erosion and (iv) indiscriminated use of fertilizers and pesticides. For the time being, different industrial enterprises have caused 'hot spots' of land and soil pollution with (i) heavy metals around mines, ore-dressing factories and smelters and away from them through air emissions of lead, zinc and copper and precipitations containing lead, zinc, copper, arsenic, cadmium, selenium, antimony and others elements; (ii) oil products as a result of accidents; (iii) radioactive nuclides from the uranium industry and (iv) organic pollutants.

Eroded lands

Mine industry is a major factor for land degradation. The degree of its impact depends on the applied extracting technology and the type of ore processing. The latest is based on the following methods:

1. Classical open-cast method – includes building of pits and mines.



Eroded lands

2. Classical underground method – it can be divided into two types:
 - a) Construction of vertical shafts to the ore's level and then mining by underground horizontal galleries;
 - b) The mining is done by construction of horizontal shafts.
3. Geo-technological method – installation of acidifying drills up to the ore level. Then the ores are treated with sulfur acid and the enriched solution is removed to the surface.
4. Construction of tailing-ponds for gathering the waste materials from the ore processing.

The classical open-cast method is accompanied with building of spoils. For the time being, they have covered huge areas and have totally changed the landscape of mine territories. Spoils are usually formed of geological materials characterized with low content of nutrients and unfavorable physical properties. In some cases spoils are



toxic for plants and their utilization requires application of different melioration activities.

For instance, the geological materials formed over the copper ores layers contain pyrite, which oxidizes by drain rainwater. This process results in acidification of lands, surface and underground waters and their contamination with heavy metals of high concentrations. The copper mines are usually situated in mountains where the possibilities for reclamation of disturbed lands are strongly limited. Therefore the ecological activities have to be based on an advanced detailed survey.

The classical underground method of ore extraction does not disturb directly entirely the land, except of small areas serving for the purpose of mine entrances (shafts) or ends of horizontal galleries. The anthropogenic impact in this case is realized by the accumulation of geological materials on the soil surface. The materials resulting of ore remnants are also unsuitable for biological

reclamation and endanger the environment components.

Extremely high infringement and changes of environment and soil cover result from the geotechnical method of ore exploitation since on one hand, soils are mechanically disturbed by sounding and detonating activities, constructing of sorption installations, disposing of different technological equipment etc., and on the other hand, working solutions chemically affected soils.

Processing of ores produces a high amount of waste materials, which are put aside in tailing-ponds. They are also problematic and might impede their restoration, reclamation and further usage. Tailing-ponds, for instance, built for storing the burnt coals (they are indivisible part of heating plants) form a number of ecological conflicts - they are built on arable lands or nearly to dense inhabited regions, they may cause diseases, like silicosis, because of high content of SiO_2 , etc.

Driving forces of land degradation on the territory of Bulgaria

Soil erosion

Soil erosion is the most serious degradation process for the territory of Bulgaria. Three types of soil erosion are identified on the country's territory depending on the driving force – water, wind and irrigation.

Water erosion

The arable land on slopes exceeding 6 % is a subject of water erosion risk, corresponding to about 3 million ha (72 % of the area of arable land). Since 1989 the area of cropped land dropped significantly and the area of abandoned cropland increased. The significant reduction of the cropped area resulted in respective decrease of both the average annual rates and the net soil lost by total sheet erosion from agricultural land compared to 1980. Nevertheless, it should be recognized that the increase of the area of abandoned cropland is a subject of accelerated rill erosion and raises the risk of gully development.



Water erosion



Wind erosion | Photo by Scythian at Wikimedia Commons

Wind erosion

Wind erosion appears in flat plains and deforested regions. The area of lands with wind erosion risk is assessed to 1,657,386 ha (29 % of cultivated lands) and the resulting estimated annual soil loss can vary from 30 to 60 MT/y.

Irrigation erosion

Irrigation erosion risk has been negligible as far as it impacts the irrigated arable land sloped over 3°, most of which has been abandoned since 1989.

Decline in organic matter

The data for organic contents measured in virgin and arable lands, representative for the main soils distributed on the country's territory show that compared to the virgin soil, the decline in organic matter in the arable lands ranges from 10 to 40 % for most soils but can reach as much as 220–230 %.

Soil structural degradation

Soil structural degradation has been estimated using the data of soil bulk density, aggregate stability and available

water capacity measured in virgin and arable lands. Analyses of those data show that the increase of topsoil bulk density in the arable lands ranges from 1 to 23 % of the bulk density of virgin soils depending on the soil type. Soil compaction is associated with respective reductions of soil aggregate stability, ranging from 40 to 80 % and available water capacity, varying from 1 to 29 %. The aggregate stability of more than 60 % of the Bulgarian soils at virgin conditions can be qualified as good and that of only 3 % - as poor. The anthropogenic load resulted in deteriorated soil aggregate stability of the agricultural soils, which is predominantly poor.

Intensive spring and summer rainfalls followed by long dry periods are the most common cause of crusting of the structurally degraded Bulgarian soils. The surface crust affects the soil properties directly and indirectly. The direct effects

are associated with inhibition of the seeding emergence, root and plant growth. The indirect effects include decrease of the profile water permeability, which increases both the soil erosion risk and the soil penetration resistance. Soil crusting is a widely recognized agronomical problem in the region of the Distric Planosols, covering 12 % of the arable lands of the country.

Soil acidification

Analyses of soil survey data showed that the area occupied by soils with $\text{pH} < 7.0$ is about 6.5 million ha. Significant part (4.3 million ha) of those soils is highly vulnerable to acidification ($\text{pH} < 5.0$), a half of which is affected by acidification but only 0.45 million ha belong to the area of arable land.

Soil salinization

The total area of land affected by salinization processes in Bulgaria is estimated at 35,000 ha distributed in 8 administrative districts:



Saline soils

Pleven, Veliko Tarnovo, Varna, Burgas, Yambol, Sliven, Stara Zagora and Plovdiv.

Chemical pollution

There are four types of chemical pollution identified and studied on the country's territory, namely pollution with *heavy metals and metalloids*, radioactive nuclides, oil products and organic pollutants. Land polluted with heavy metals and metalloids is over 43,660 ha, 61.3 % of which is located in area surrounding industrial enterprises and can be classified as 'hot spots'. Land polluted with *radioactive nuclides* is 1,049 ha covering more than 40 'hot spots'. In 1993 the area polluted with radioactive elements resulting from uranium mining was 1,913 ha, of which 1,387 ha – arable land. The reduction is due to the legislative acts of Bulgarian Government, which stopped the extraction of uranium in 1992. *Pollution with oil products* occurs mostly on small spots as a result of accidents (oil refinery and oil transport pipe lines).

Ore-extraction sites

The total area of lands deteriorated by extraction and primary processing of ores and minerals is around 27,778 ha. The rate of reclamation of those lands is considerably lower than the rate of the land deterioration. The total area of re-cultivated lands deteriorated by extraction and primary processing of ores and minerals is 8,252.9 ha.

The highest Bulgarian tailing-pond is situated at "Maritza-Iztok" mine district. In the ends of exploitation period it will took an area of 600 ha but the thickness of ashes will be 15 m. It is necessary to note that the height of tailing-pond might exceed the planned one, which makes additional complications in an emergency.

In physical aspect, the ash represents a non-structural, strong dusty aggregation, which is an inexhaustible source of environment contamination. Studying of the ash shows



Tailings dam Lyulyakovitsa, Asarel-Medet AD | Photo by Edal Anton Lefterov at Wikimedia Commons

that it has light mechanical composition, low relative weight, high porosity and low water-fixing capacity.

It was found that if the speed of wind is 8-10 m/s the content of dust in the air is 690 mg/m³ nearby tailing-ponds and 102-180 mg/m³ in 200 m distance. The high concentration of dust in the air infringes the normal growth of plants but specially impedes breathing and assimilation - therefore the untimely drying of plants proceeds. The low content of nutrients, except potassium was established. PH factor is neutral.

All mentioned changes and deterioration of the environmental factors caused by mine industry need right and exact planning of reclamation and restoration activities including the recommendation for status of land utilization. This is a complex and long-lasting process, which begins with detailed survey of territories, affected by mine industry. Reclamation is the most fundamental method for restoration and improvement of land properties aimed to retrieve disturbed lands to arable landed fund. The principle scheme for reclamation of disturbed lands in Bulgaria includes two methods: coverage of the reclaimed lands (formed by geological or waste materials) with a layer of 40 cm depth of soil humus horizon or direct restoration of lands formed by geological or waste materials.

The first method is more effective than the second one since the fertility of the lands rapidly restores and ensures a high productivity level. Humus horizon conditions a good sustainability of yields. This method substantially improves physical, chemical and biological properties of reclaimed



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lands. Humus content positively regulates the aeration of substrata and makes them structural. Thus facilitates their tillage and guarantees a normal growth and nourishment of plants.

In some specific cases humus layer might be replaced with substance of organic and inorganic components, which possess definite analytic features and bio productive capacity. Method applies mostly in cases of agricultural utilization of lands.

In short supply of humus one should apply the second method of reclamation - that frequently imposes to do in mine regions of Bulgaria. That is how the estimation of suitability of various geological materials (which will form reclaimed lands) for reclamation has a prime mining. The estimation is based on data on morphological composition; particle- and micro-aggregate-size distribution; content of organic matter (humus); contents of total and available forms of N, P and K; pH; content of carbonates; adsorption capacity and exchangeable cations; chemical composition; content of microelements; particle density; bulk density.

The estimation, in principle, shows the possibilities for selective discovering and stratification of geological materials in order to achieve fast and stable restoration of lands. The selective manner of building the reclaimed lands represents a possibility for improving their features and properties together with to decrease expenses for reclamation.

Biological reclamation of lands includes planting of suitable or special vegetation, fertilizing with precisely evaluated norms,

conventional and unconventional tilling, etc. Contamination of lands with heavy metals, organic and inorganic matters sometimes exceeds the limited-admissible concentrations and assumes essential meaning during the biological stage of reclamation.

Surface sealing

Analysis of the statistical data shows that the area affected by surface sealing has increased with an average annual rate of about 7000 ha/y.



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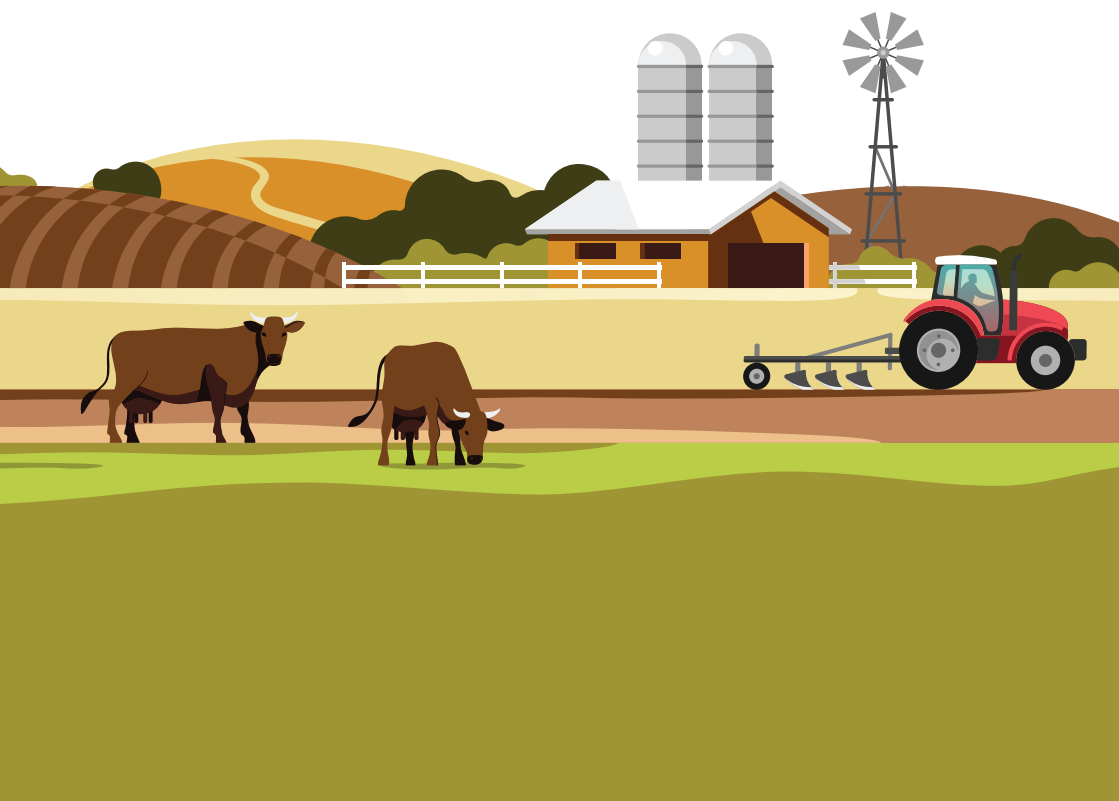
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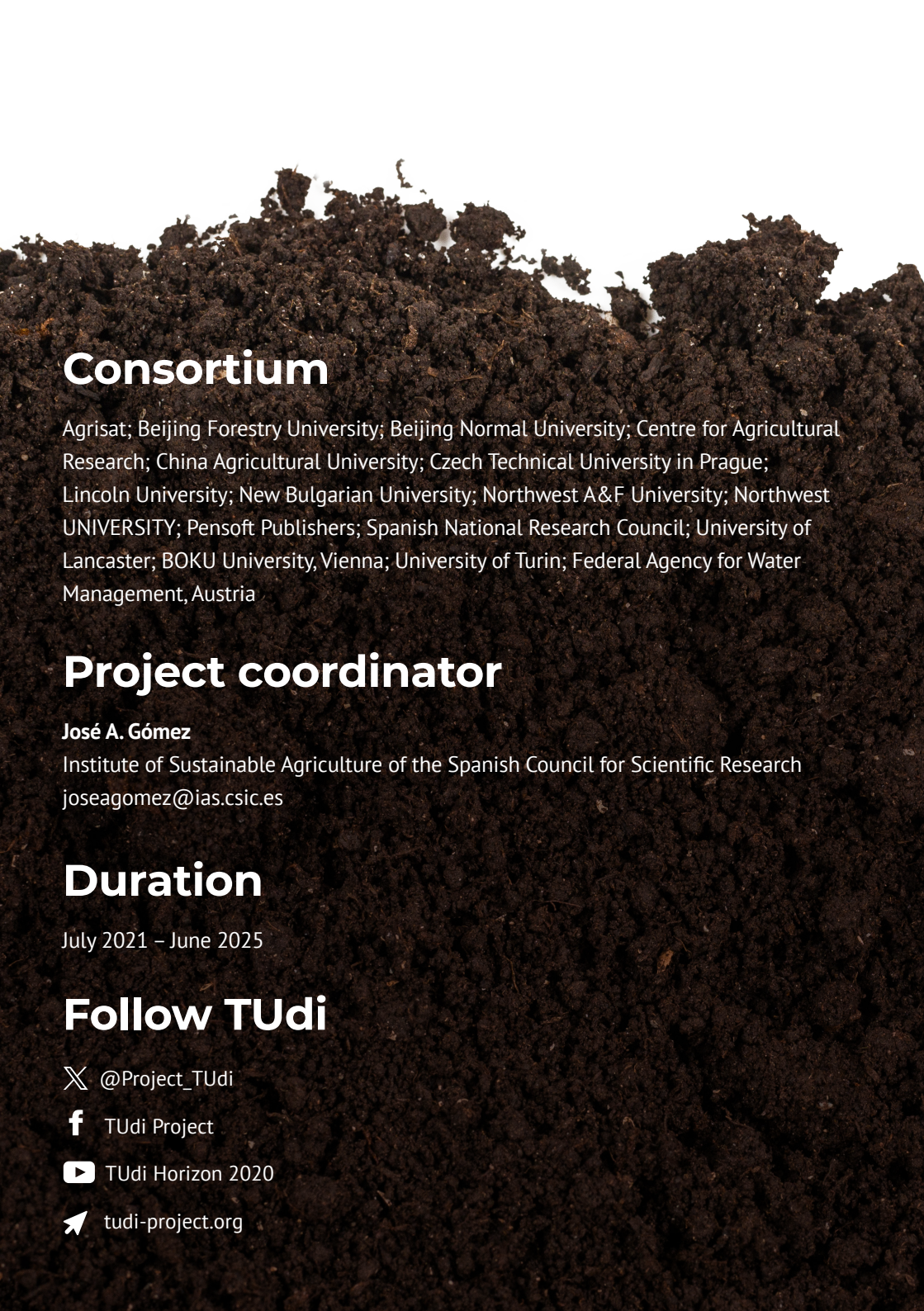
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Consortium

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