Причины восстановления растительного покрова Северо-Западного Прикаспия в конце XX века: анализ климатических и NDVI данных

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The object of the study

- **The chief purpose** of the investigation was to establish the climate and human reasons of vegetative cover changes in semi-arid and dry sub-humid areas of the European Russia at the end of the 20th century using climate and NDVI data.

- **Areas:** semi-arid and dry sub-humid areas of European Russia (45-48°N, 44-48°E, Kalmykija and Astrachan regions). Degradation of the vegetative cover under the impact of overgrazing dominates in this regions.

- **Hypothesis:** Re-vegetation (increase of NDVI with a prominent peak in 1991-1994) is observed in this regions. It is suggested that re-vegetation can be caused in the first place by increase of water income in 1987-1994s and secondly by the socio-economic change in the begin of the 1991-2000s.

The source data

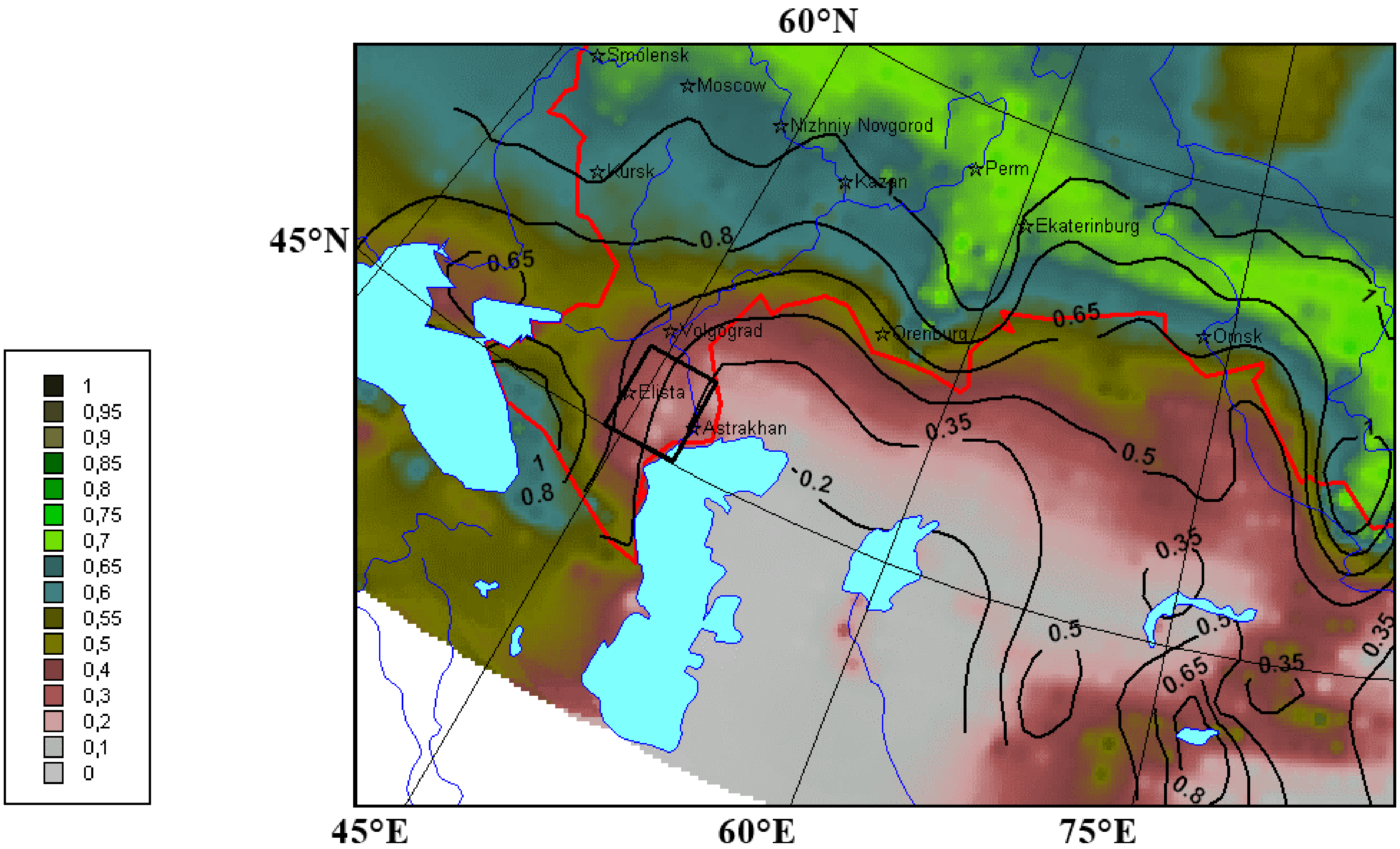
- ✓ The climate is presented by routine network daily air temperature and precipitation for 1931-2001 (Obninsk ICD). The simulations of daily air temperature and precipitation for Geophysical Observatory’s Regional climate model (MGO RCM) for 1991-2000 and 2041-2050 were used (Shkolnik et al., 2000 in Russian).

- ✓ The monthly NDVI data are presented on a grid 8x8 km and 1×1˚ for the season of May - September, 1982-2001 (DAAC). Indicators of degraded pastures: severely - NDVI<0.09; moderately – 0.09<NDVI<0.14; slightly 0.14<NDVI<0.22 (Borlikov et al, 2000 in Russian)

- ✓ The monthly NDVI, surface reflectance (a) and brightness temperature (t_s) are presented on a grid 16x16 km for the season of May-September, 1985-1991 (Gutman et al, 1995)

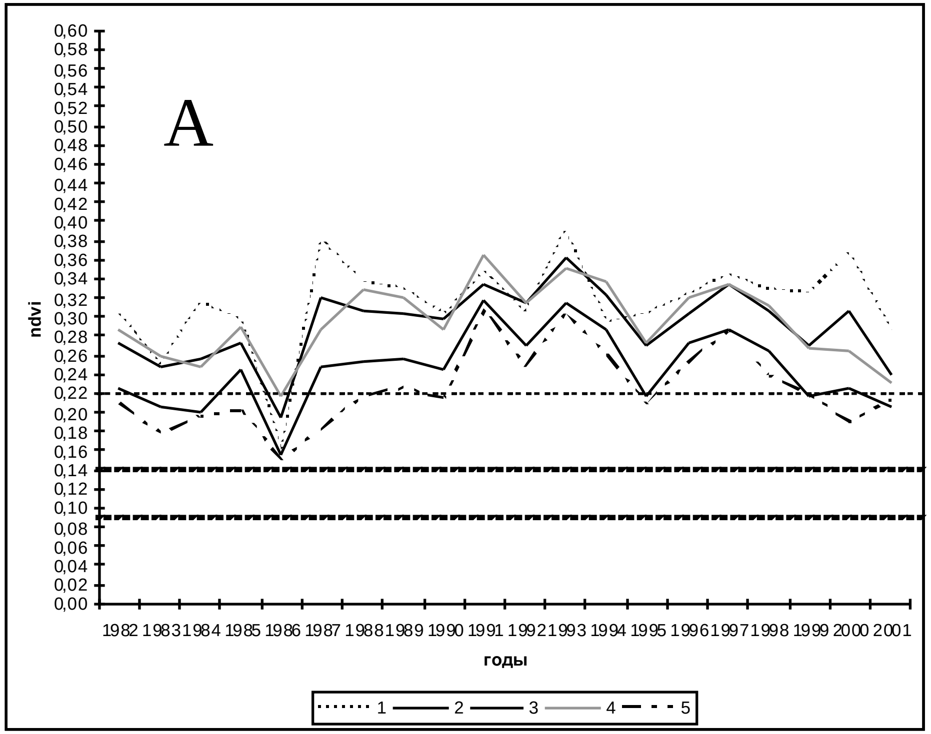
The study region: 45-48N,44-48E

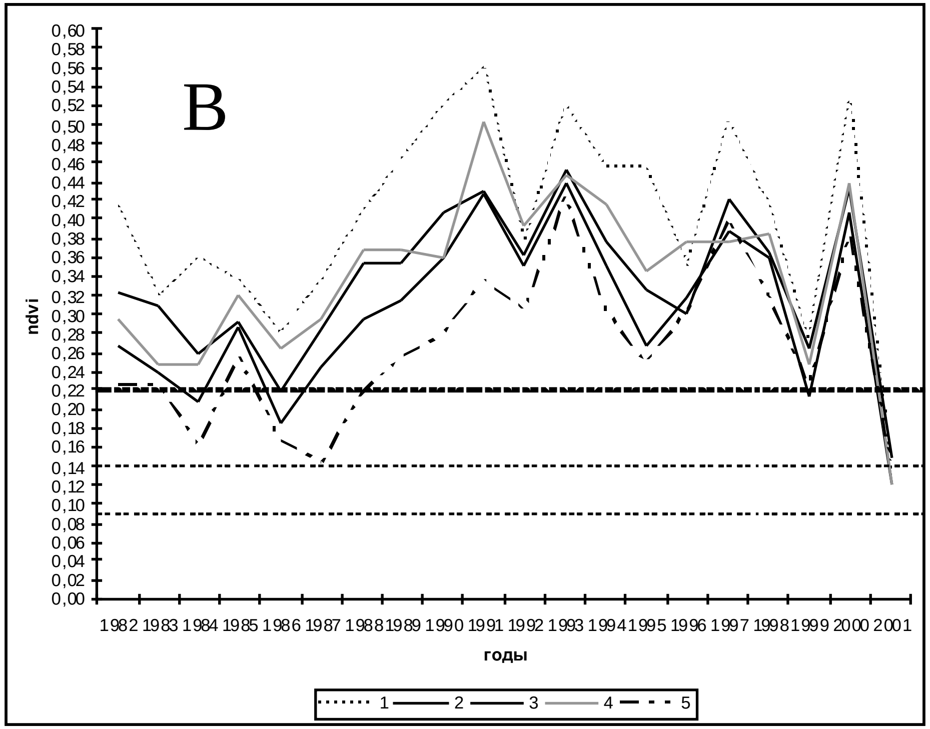
Thornthwaite Moisture Index (1936-2000) and NDVI (June-August, 1982-2001)



NDVI series: A-(May-September); B-(May)

**Areas: 1-(45-48N, 44-48E); 2-(45-47N, 45-47E); 3-(45-46N,45-46E);
4-(45-46N,46-47E); 5-(46-47N, 44-45E).**





Indicators of degraded pastures

Severe: NDVI<0.09

Moderate: 0.09<NDVI<0.14

Slight: 0.14<NDVI<0.22

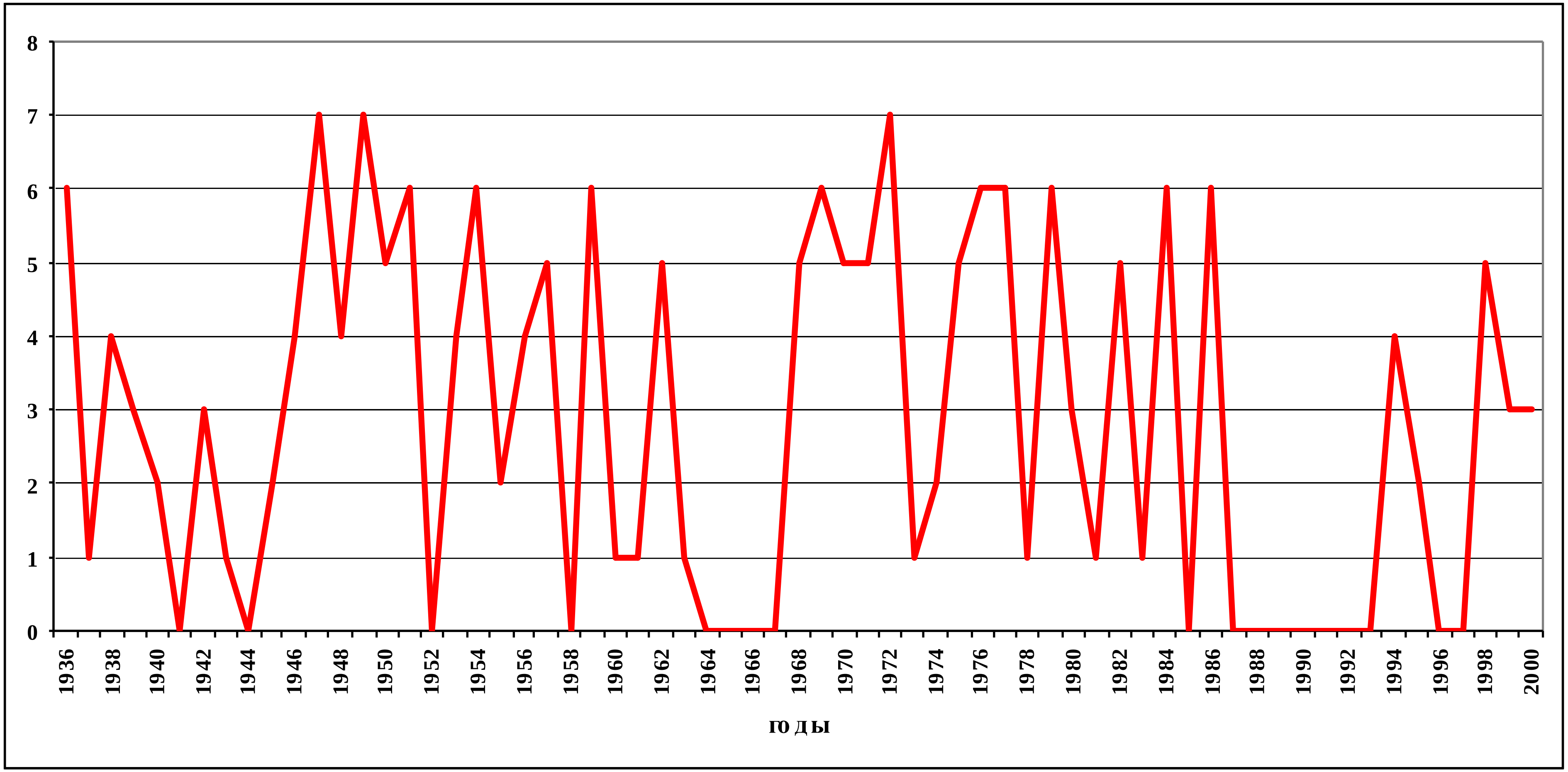
Table 1: NDVI anomalies climate

Area:46-47N, 44-45E (Elista m.st.)

	Positive anomalies of NDVI	Negative anomalies of NDVI	Difference
NDVI	0.33	0.30	0.03
Thornthwaite Moisture Index	0.56	0.46	0.10
Selyaninov aridity index	0.68	0.56	0.12
Modified Selyaninov aridity index	0.43	0.35	0.08
Annual Precipitation, mm	394	332	62
Cold season precipitation, mm	198	103	95

Dryness indicator series

Area: 46-47N, 44-45E (Elista m.st.)



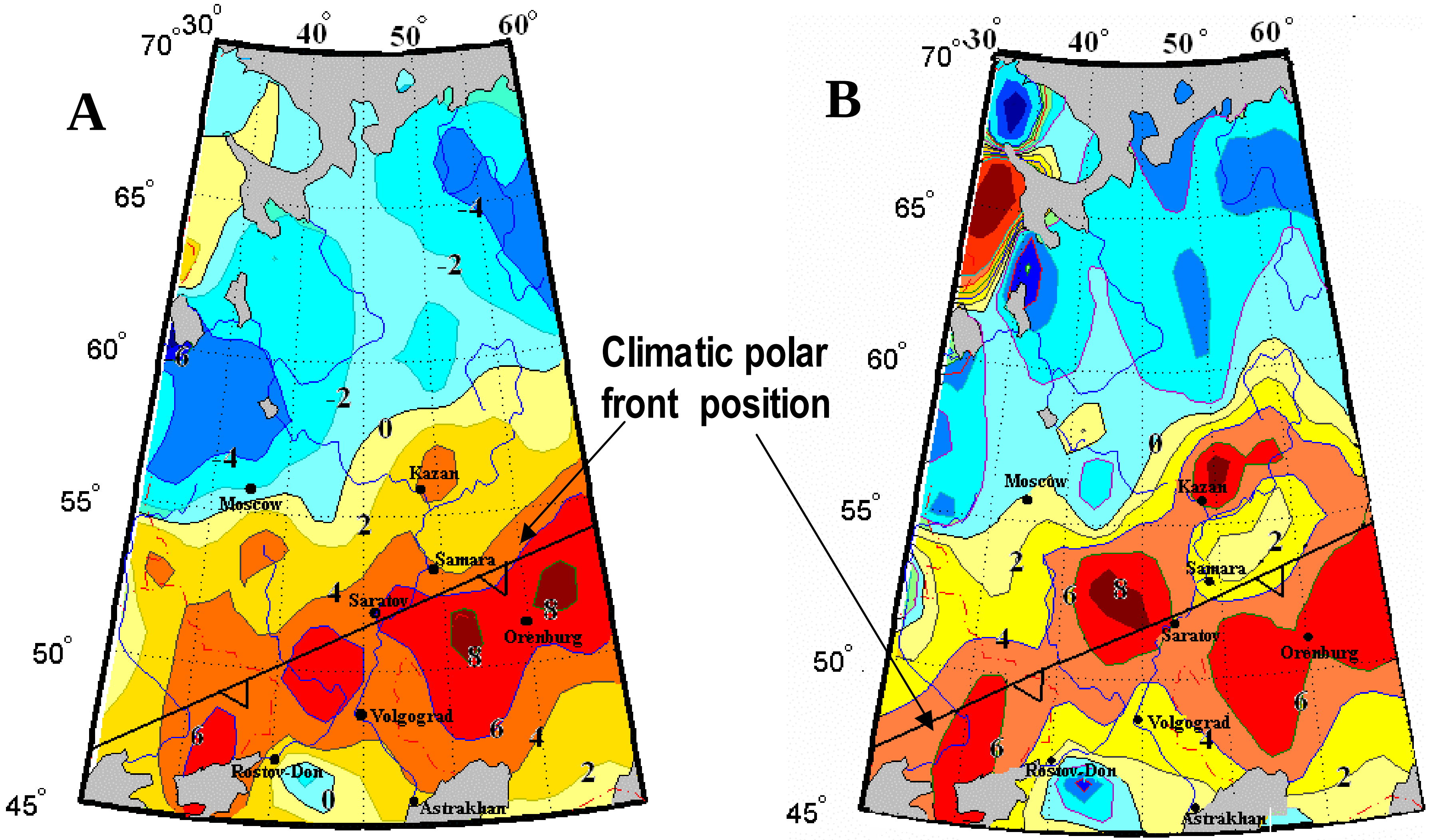
Results 1

- Re-vegetation phenomenon (increase of NDVI) was observed in semi-arid and dry sub-humid areas of the European Russia (Res.1.Fig. 7) at the end of the 20th century. Some researches attribute this phenomenon to socio-economic changes in the early 1990s, when overgrazing decrease occurred. But NDVI series (Fig.5), demonstrate that re-vegetation began in the middle of 1980s. The 1993-1994 greenness peak has been reported also in other vegetation indices based studies in adjacent arid and semi-arid regions of Eurasia (de Beurs and Henebry, 2004; Henebry et al., 2005; Lioubimtseva, 2005).

- The reason of re-vegetation is that dryness indicator has decreased in 1987-1993 (Fig.7). During this time annual and cold season precipitation, Thornthwaite moisture index, Selyaninov mosture index have increased. Synchronously, positive anomalies of NDVI became often (Table 1).

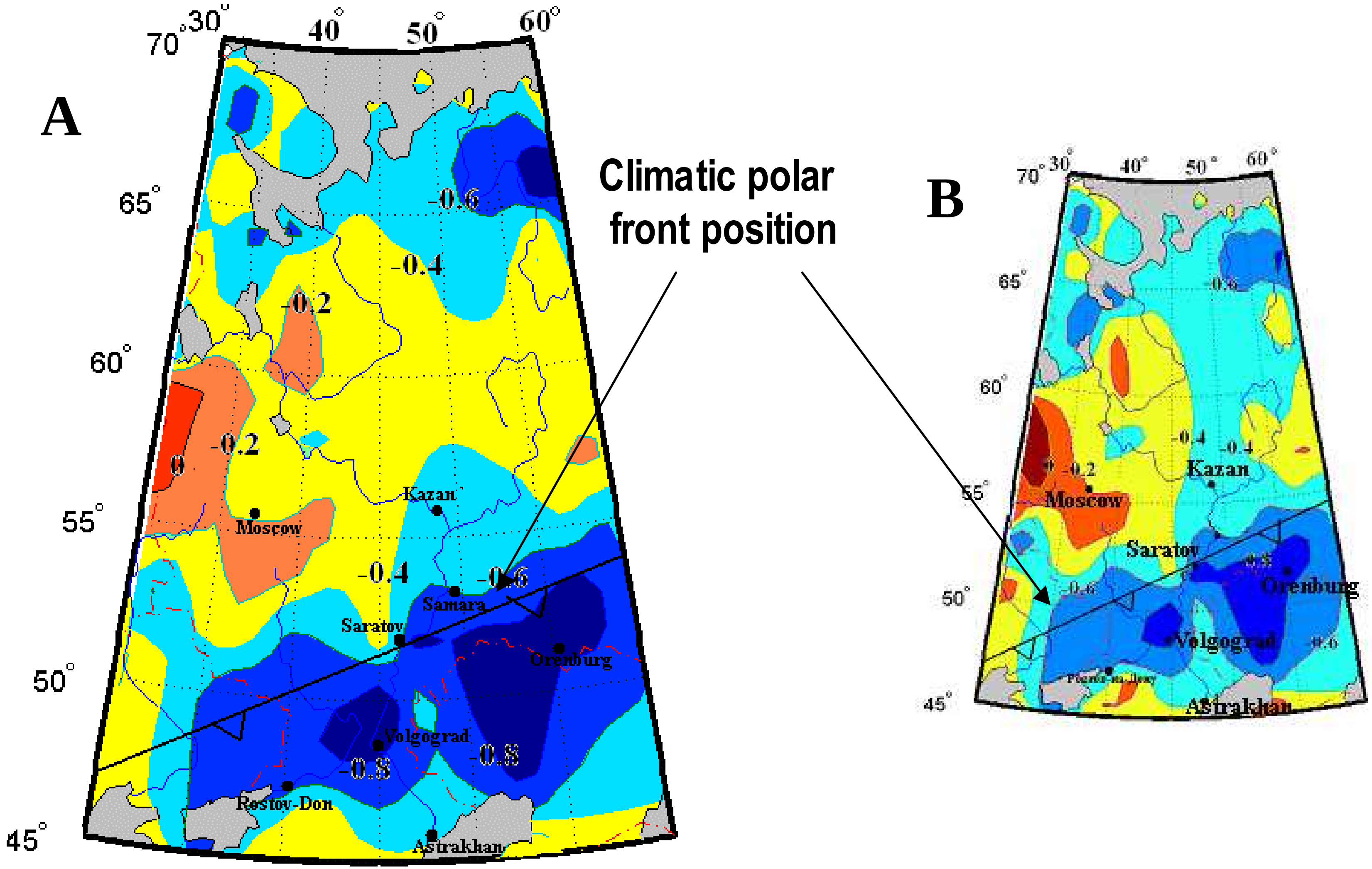
July meridional gradients of precipitation

A -1961-1990; B-1982-2001



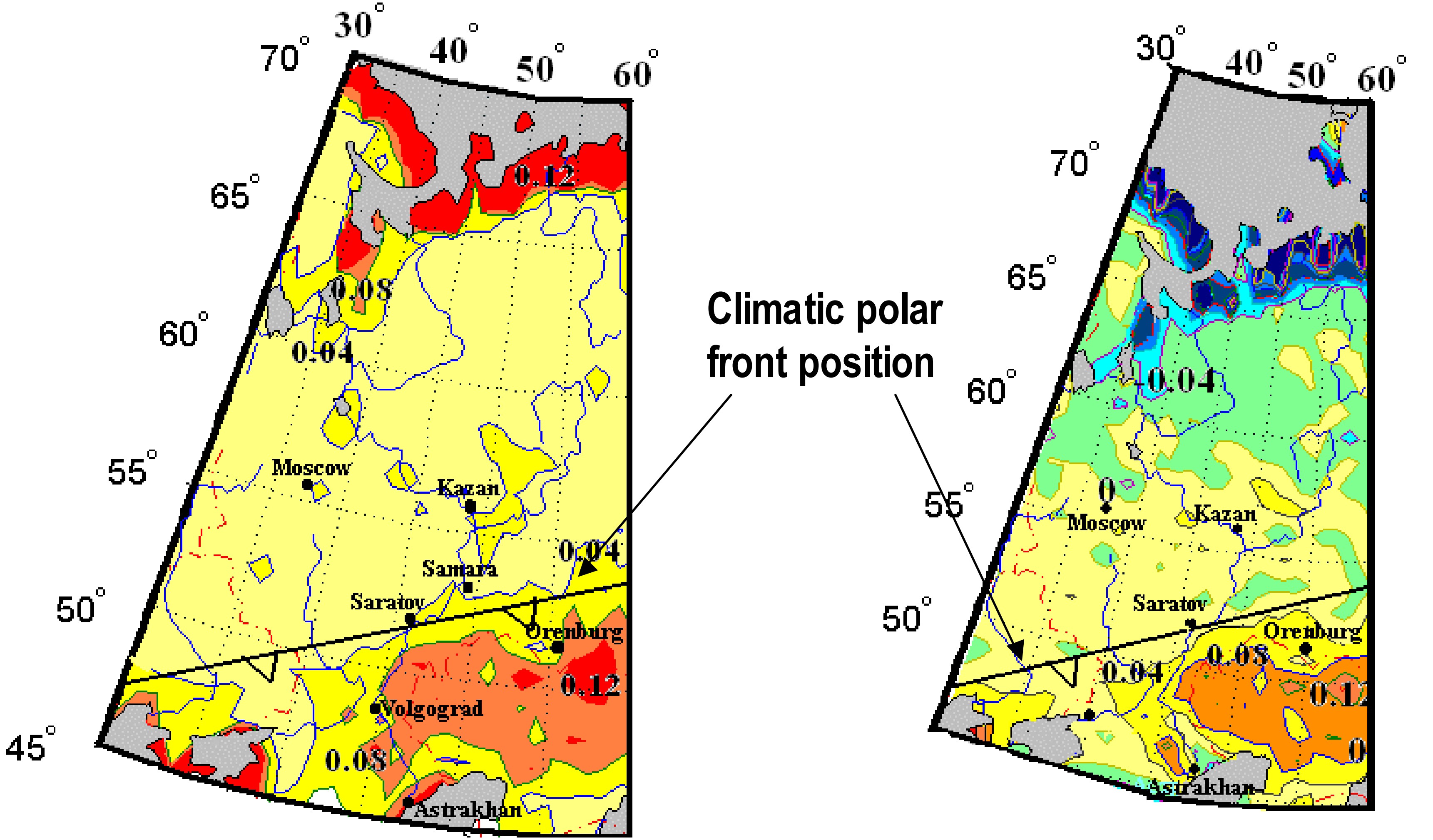
July meridional gradients of temperature

A -1961-1990; B-1982-2001



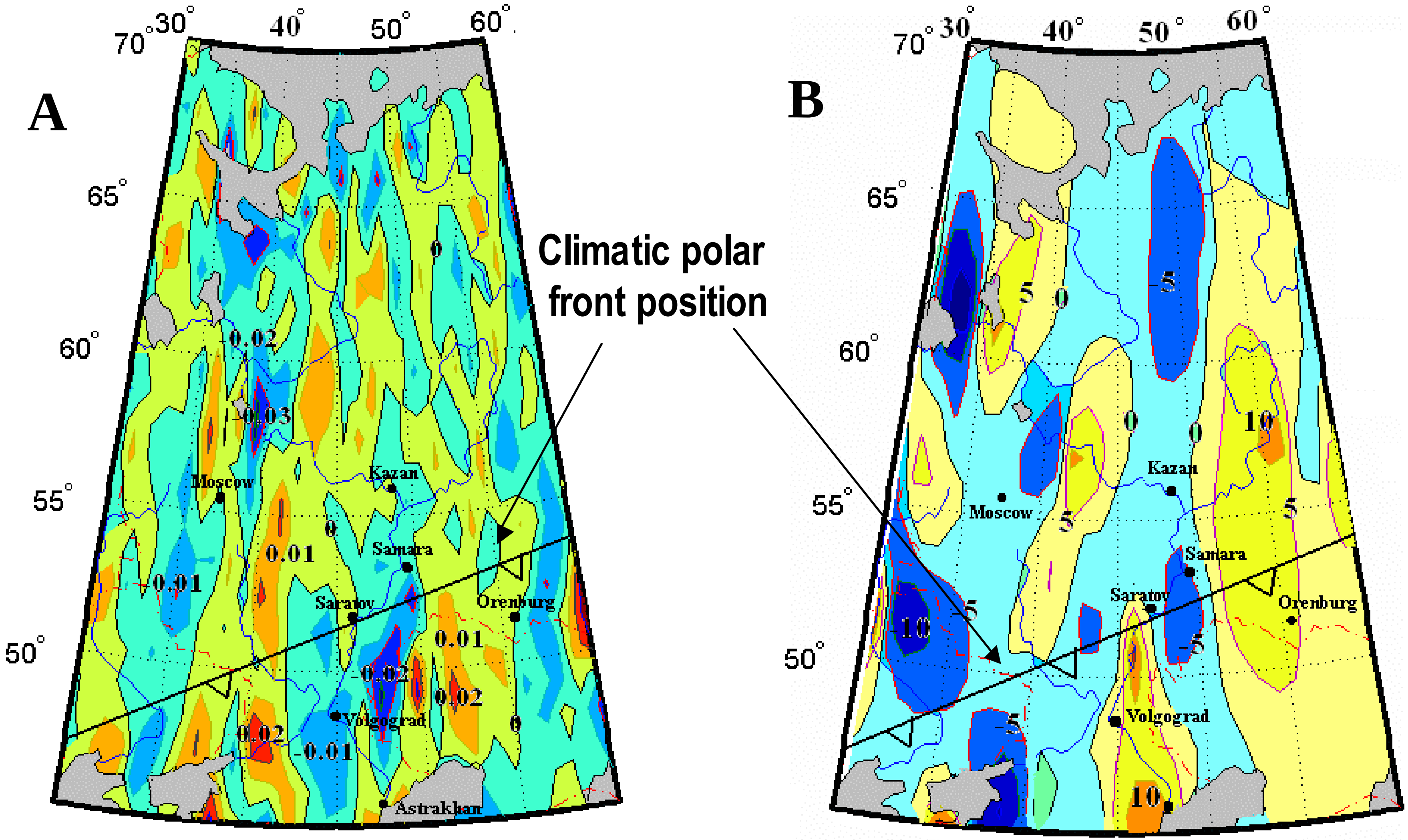
July gradients of NDVI

(1982-2001) **A-meridional+zonal; B-meridional**



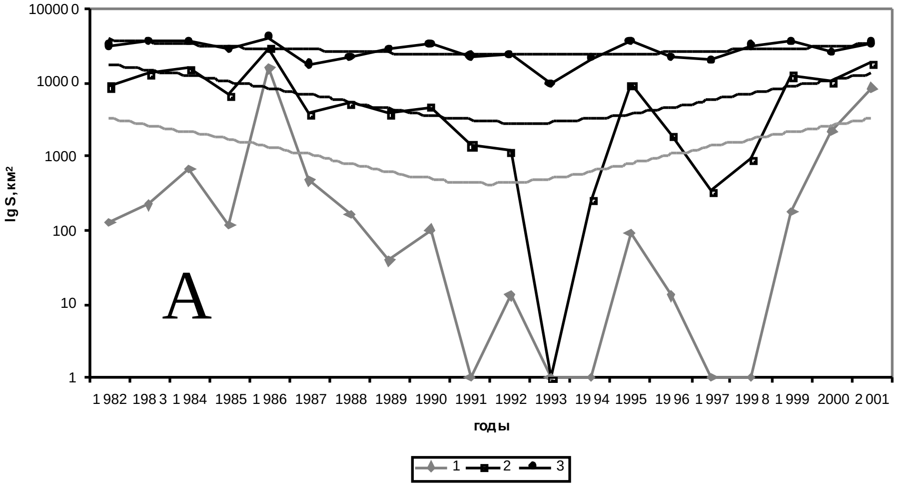
Changes of July zonal gradients of NDVI and precipitation in 1992-2001 compared to 1982-1991

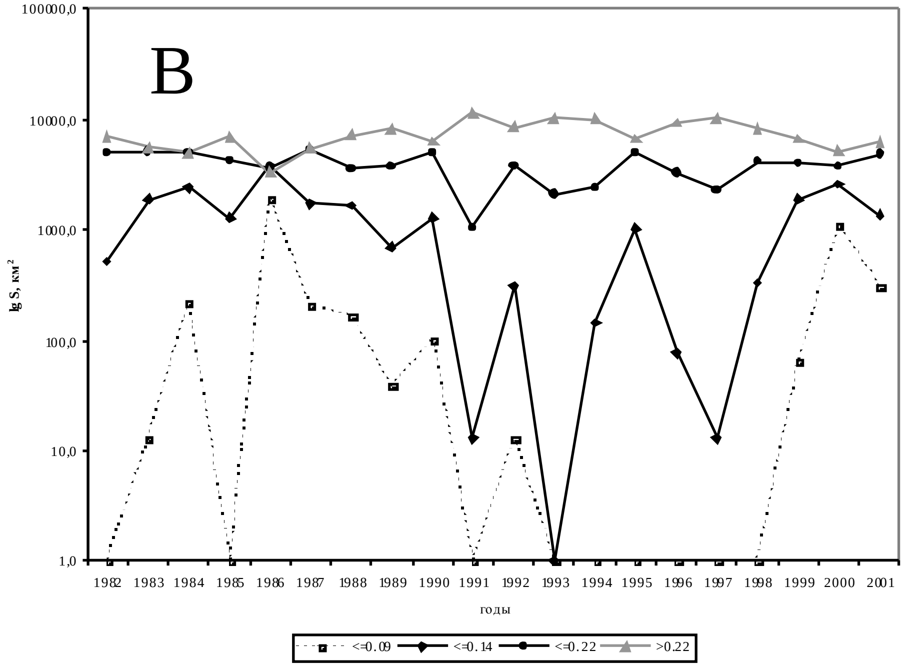
A- NDVI; B-precipitation



Size series of the vegetative cover degradation

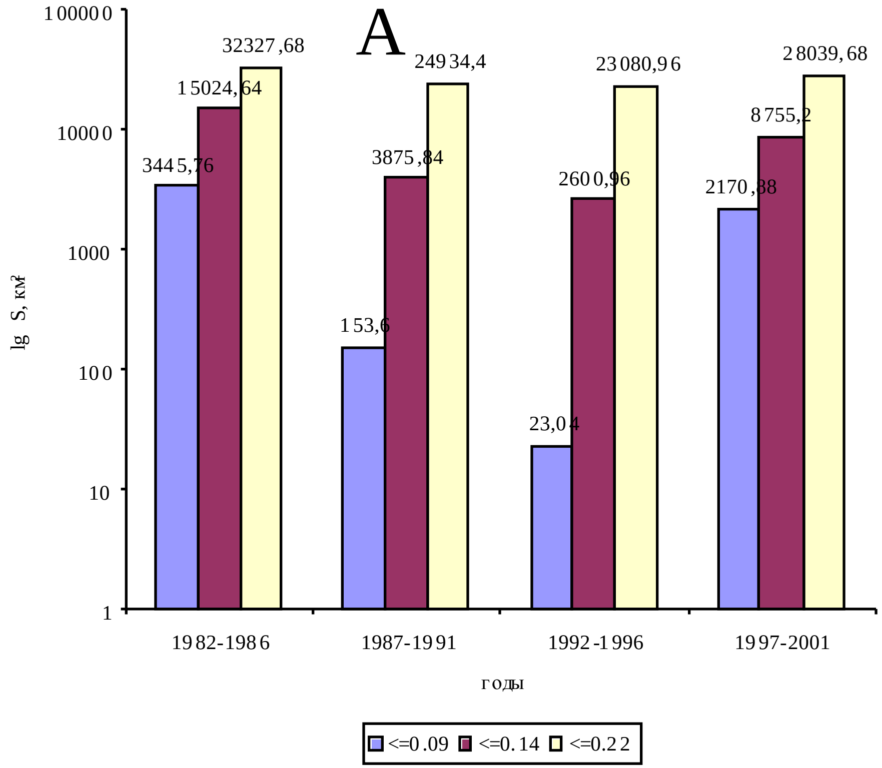
Areas: A-(45-48N, 44-48E); B-(45-46N,46-47E)

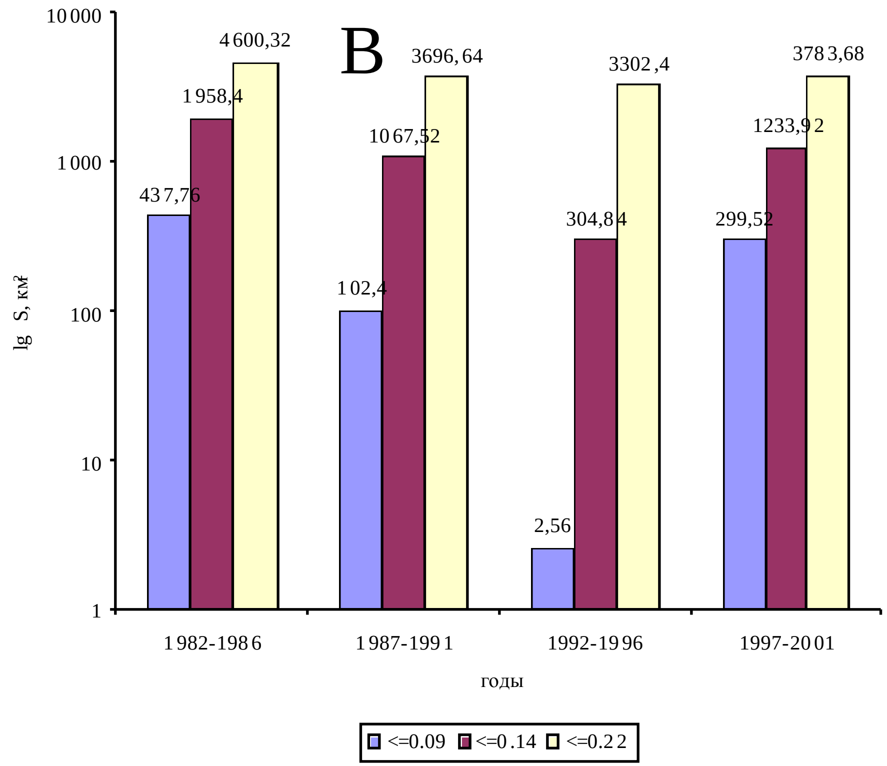


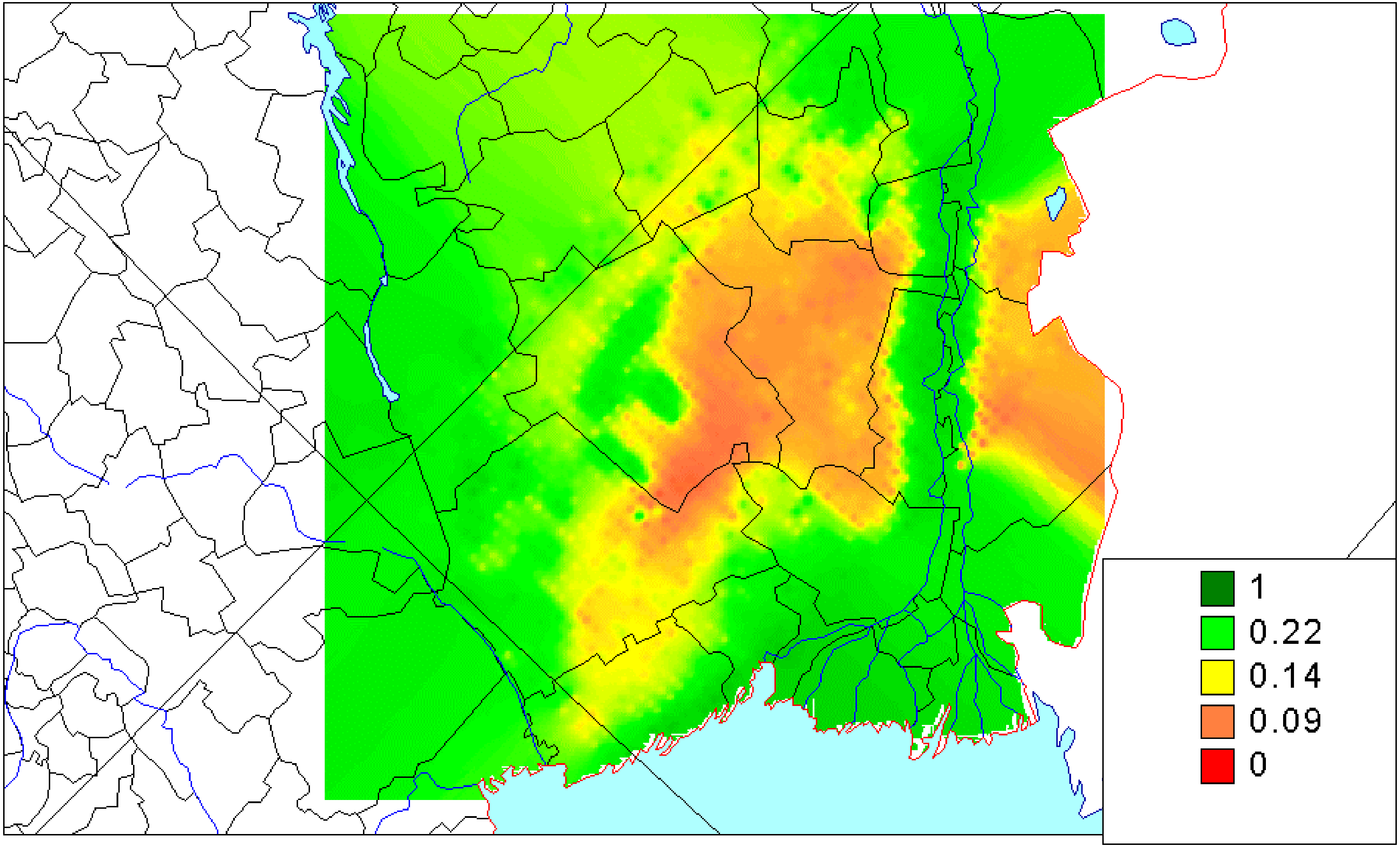


Size series of the vegetative cover degradation

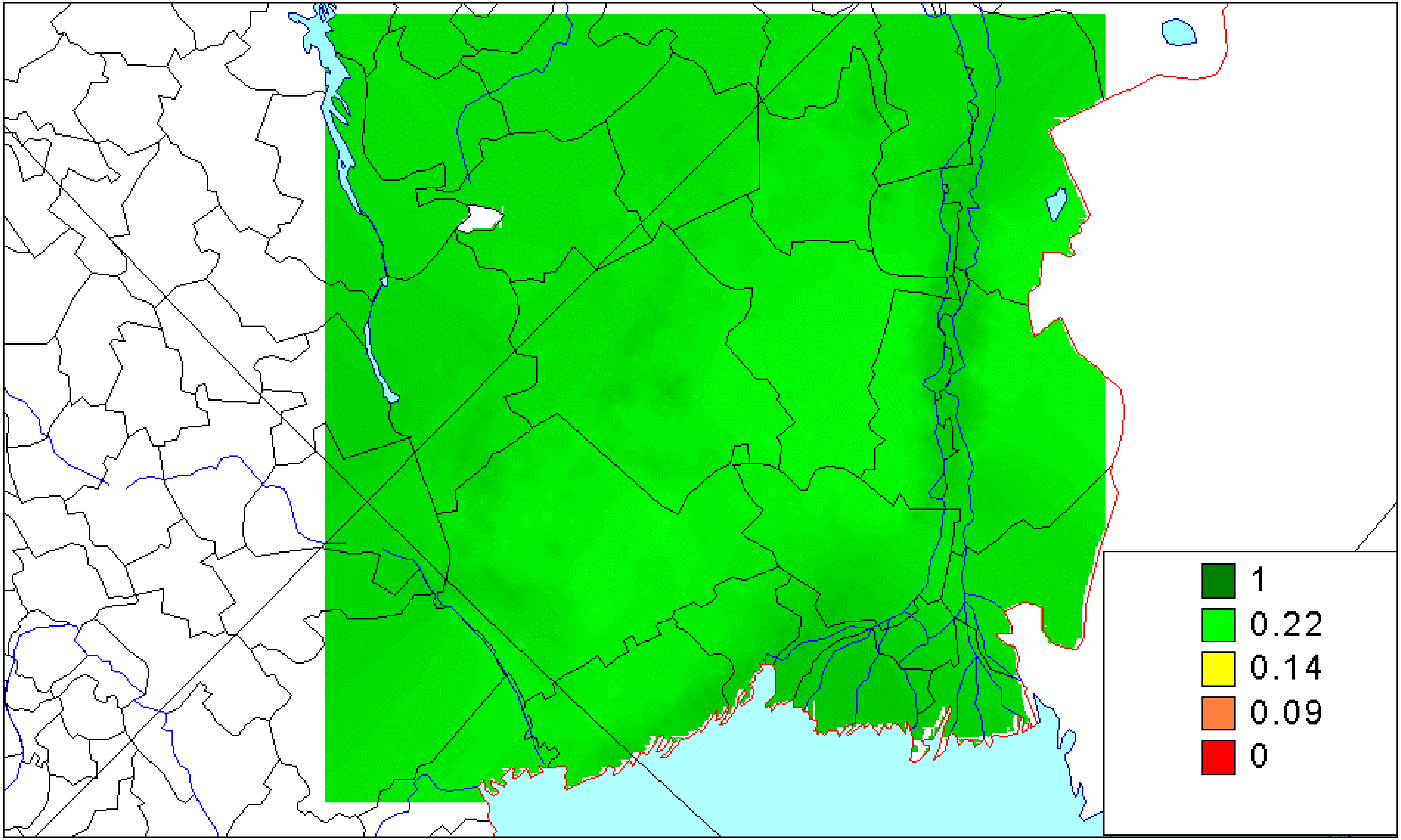
Areas: A-(45-48N, 44-48E); B-(45-46N,46-47E)



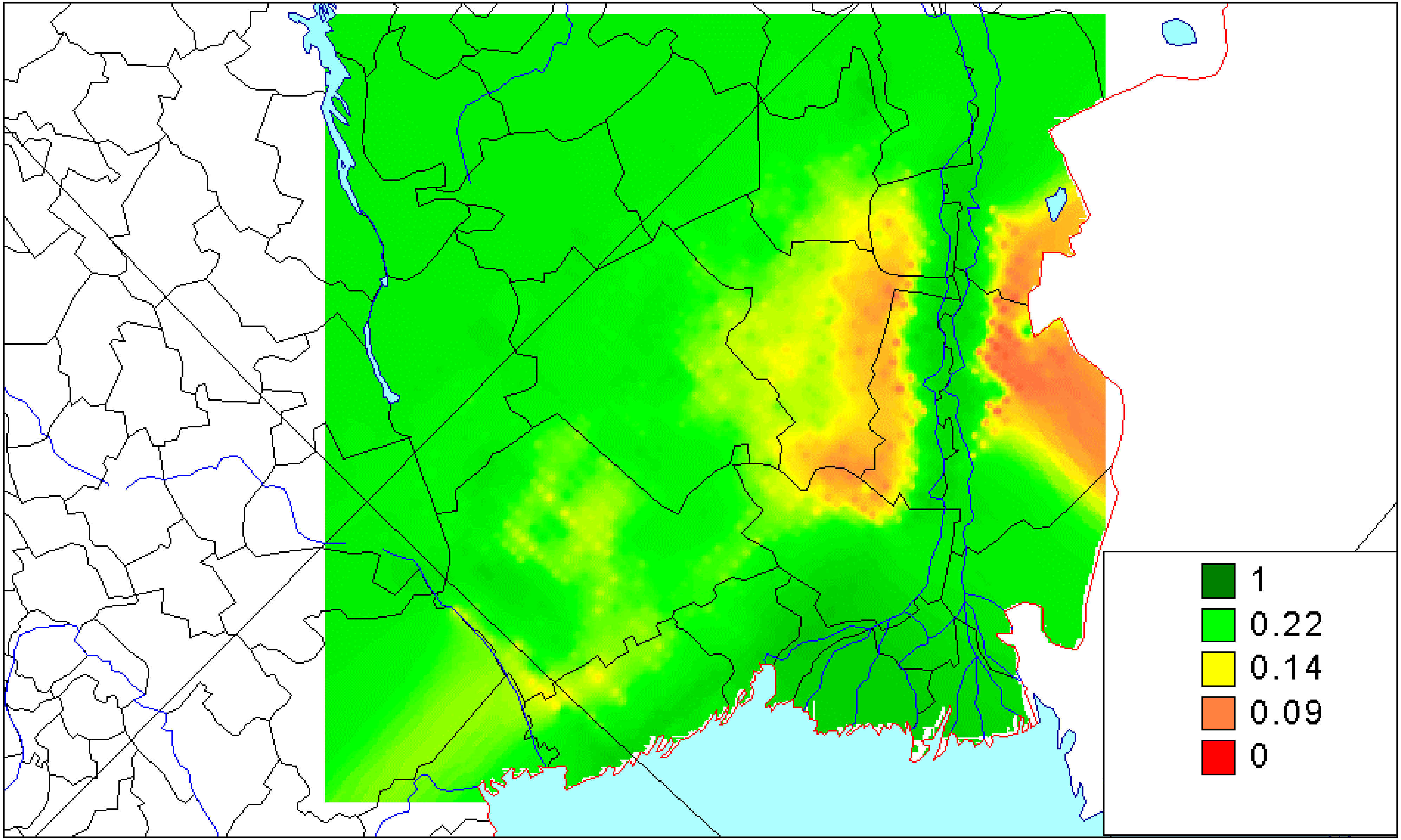




NDVI – май-сентябрь 1986



NDVI – май-сентябрь 1993



NDVI – май-сентябрь 2001

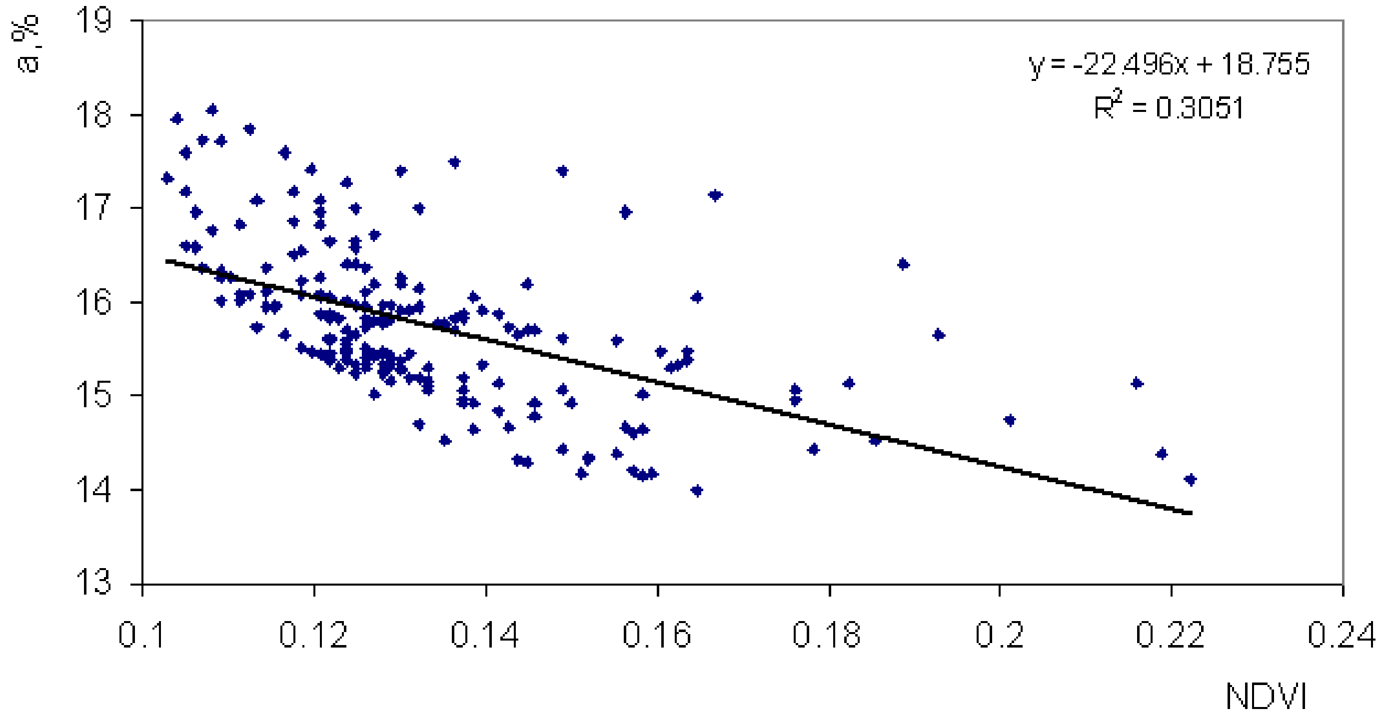
Results 2

- Dryness decrease has resulted from changes of climatologic polar front position, precipitation and air temperature gradients (Fig. 9-10). Precipitation and air temperature gradients changes determined change in NDVI gradients (Fig.11-12)

- Climate-related re-vegetation was enhanced by socio-economic changes in the early 1990s. At this time sharp decrease of the overgrazing and decrease area of degraded pastures has occurred (Fig.13-17). It is significant that overgrazing was enhanced anew at the end of 1990s (Fig.13-17).

Relationship between NDVI & albedo

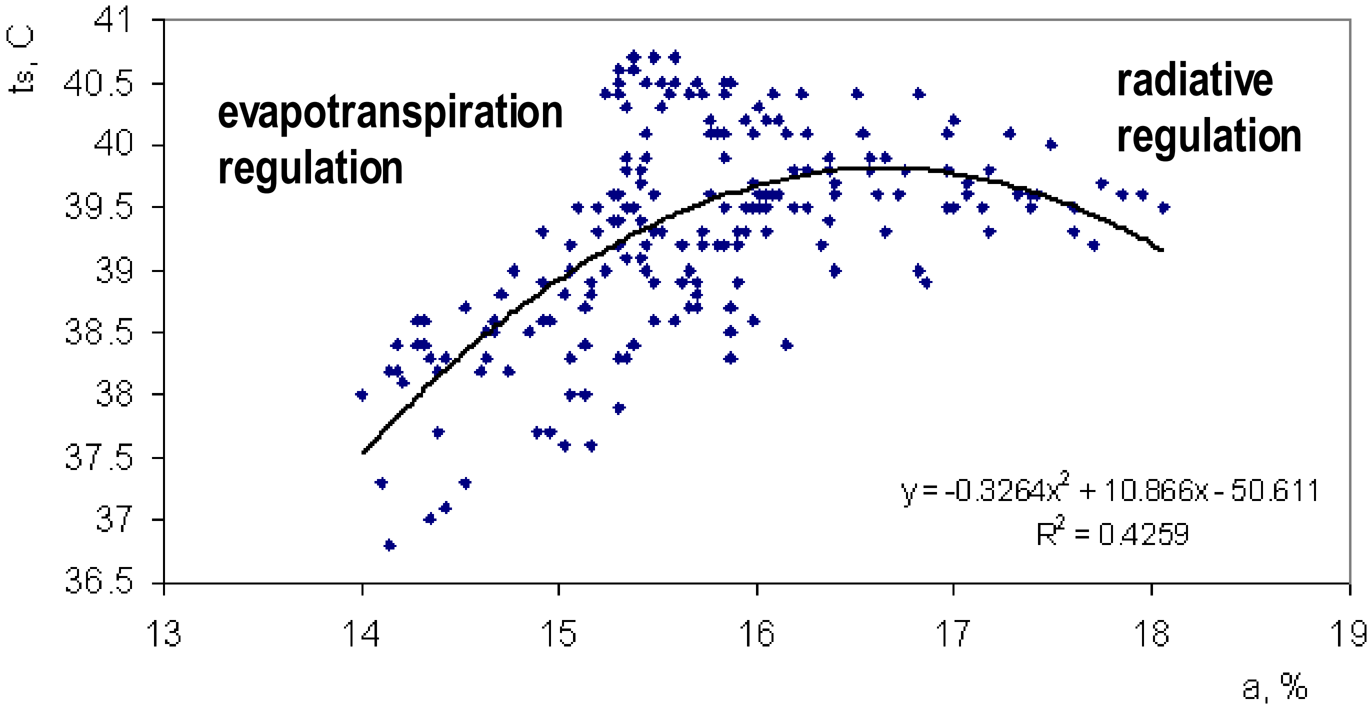
Area: 45-47N, 45-47E. May-September, 1985-2001. Data from Gutman et al., 1995



Relationship between surface albedo & temperature

Area: 45-47N, 45-47E. May-September, 1985-2001. Data from Gutman et al., 1995

Mechanisms regulating surface temperature



Results 3

- NDVI increase from 0.18 to 0.22 in area 45-47N, 45-47E was responsible for decrease of surface albedo from 0.15 to 0.14 (Fig. 19). This albedo change reduced surface temperature by about 1°C in consequence of evapotranspiration domination in regulation of surface temperature (Fig.20).

- Re-vegetation was caused by accumulation of steppe felt (litter layer) on pastures. The litter increased soil moisture and decreased surface albedo. But litter accumulation raised the fire frequency. After the fires albedo decreased sharply. Re-vegetation occurred quickly after the fires. Above-land phytomass has increased after the fires.

Conclusions

- **The main reason of the re-vegetation is regional climate change. It results from increasing of moisture indexes, precipitation, lengthening of season with unfrozen soil due to winter warming. The limitation of grazing in the early 1990s accelerated the re-vegetation to some extent only.**
- **New strongly degraded pastures have appeared at the end of 20th century.**
- **Anthropogenic climate change scenario, obtained from Main Geophysical Observatory regional model, can be considered as preliminary, and it doesn’t show any strengthening of aridization in the coming decades. If the scenario is reliable, the process of climate-related re-vegetation may continue.**