Climate change and Land use Effects on pastoral systems In Eurasia

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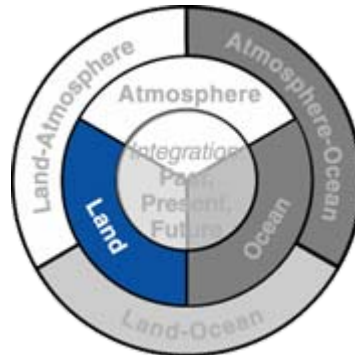
FUNDING
SPONSORS:
NSF & NASA

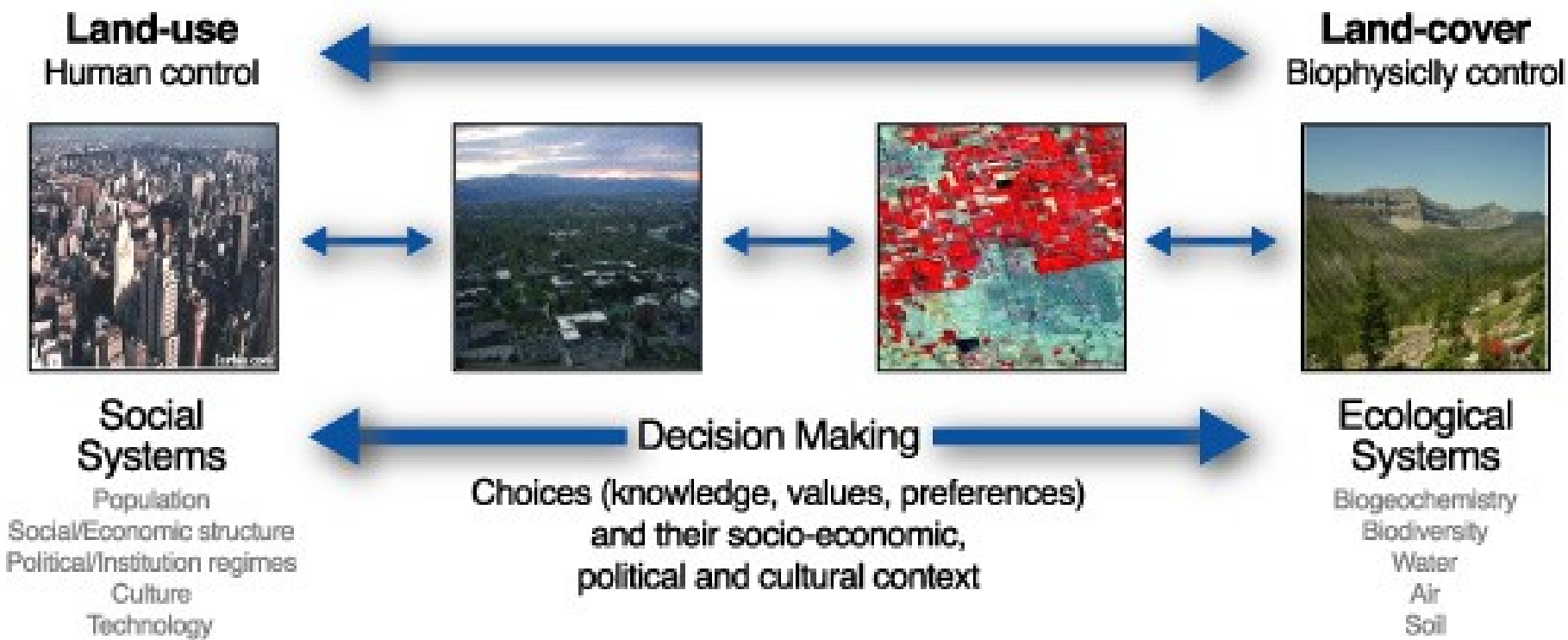**CRITICAL REGIONAL ISSUES AFFECTING SOCIETIES IN TRANSITION FACING GLOBAL ENVIRONMENTAL CHANGES**

Land

- Dynamics of land systems.

- Consequences of land system changes.

- Integrating analysis and modelling for land sustainability.

Dynamic Land Transitions

Land-use
Human control

Land-cover
Biophysiclly control

Social Systems
Population
Social/Economic structure
Political/Institution regimes
Culture
Technology

Decision Making
Choices (knowledge, values, preferences)
and their socio-economic,
political and cultural context

Ecological Systems
Biogeochemistry
Biodiversity
Water
Air
Soil

Social challenges	Ecological challenges	Ecosystem goods and services
poverty	pollution	clean air
conflict	diseases	clean water
social justice	food/fibre/fuel shortages	waste recycling
migration	overcrowding	food/fibre/fuel
consumption	clean water supply	recreation
health		

Dynamics of Land-Systems

- How does globalisation and population change affect regional and local land use decisions and practices?

- How do changes in land management, decisions, and practices affect biogeochemistry, biodiversity, biophysical properties, and disturbance regimes of terrestrial and aquatic ecosystems?

- How do the atmospheric, biogeochemical and biophysical dimensions of global change affect ecosystem structure and function?

GLOBAL
IGBP
CHANGE

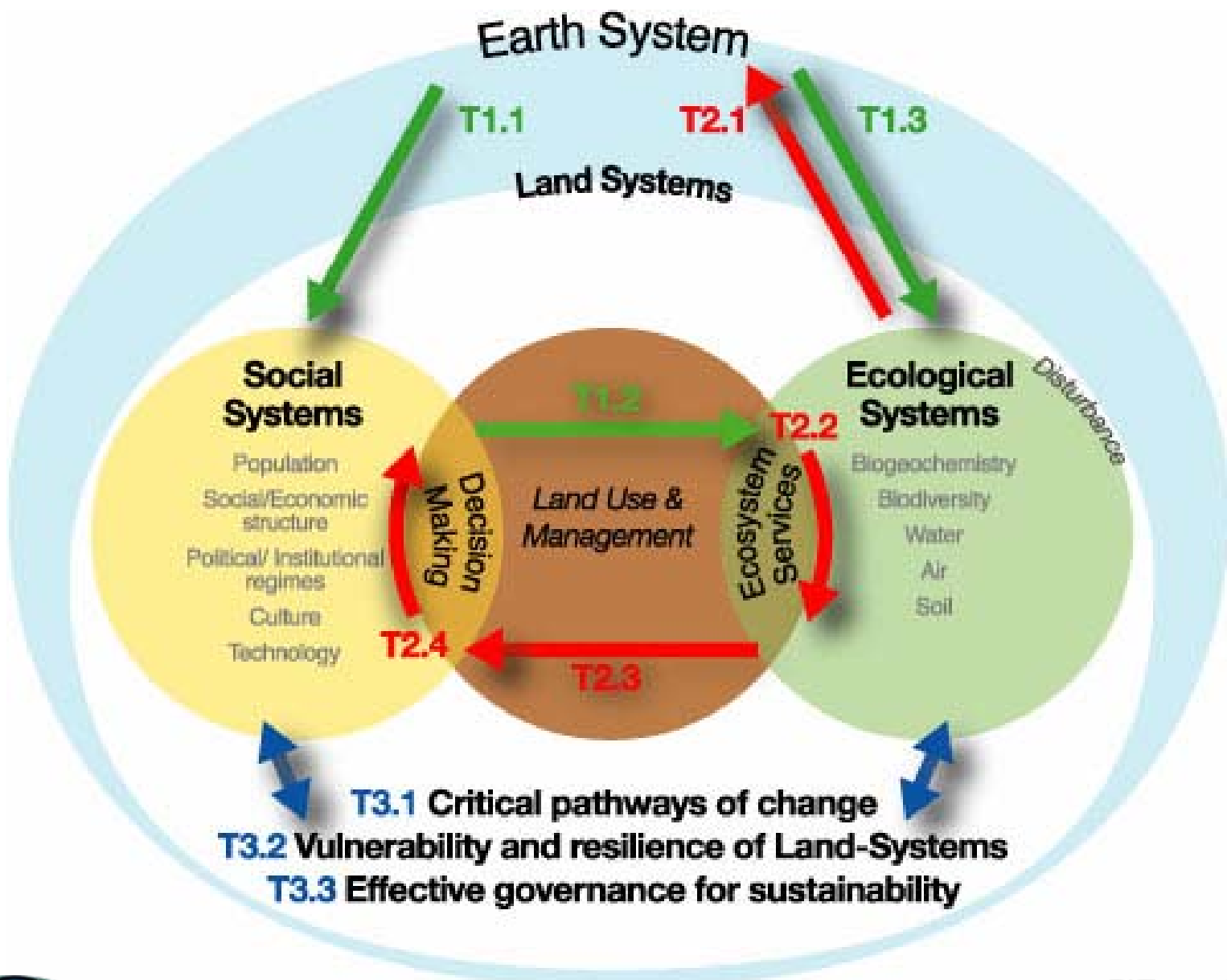# Consequences of Land-System Change

- What are the critical feedbacks from changes in ecosystems to the coupled Earth system?

- How do changes in ecosystem structure and functioning affect the delivery of ecosystem services?

- How are ecosystem services linked to human well-being?

- How do people respond at various scales and in different contexts to changes in ecosystem service provision?

Integrating Analysis and Modelling for Land Sustainability

- What are the critical pathways of change in land-systems?

- How do the vulnerability and resilience of land-systems to hazards and disturbances vary in response to changes in human and environment interactions?

- Which institutions enhance decision making and governance for the sustainability og land-systems?

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Earth System

Land Systems

T1.1   T2.1   T1.3

Social Systems
Population
Social/Economic structure
Political/ Institutional regimes
Culture
Technology

Decision Making

Land Use & Management

T1.2   T2.2

Ecosystem Services

Ecological Systems
Biogeochemistry
Biodiversity
Water
Air
Soil

Disturbance

T2.4   T2.3

T3.1 **Critical pathways of change**
T3.2 **Vulnerability and resilience of Land-Systems**
T3.3 **Effective governance for sustainability**

T1. Dynamics of land-systems

T2. Consequences of land-system change

T3. Integrating analysis and modelling for land sustainability

GLOBAL
IGBP
CHANGE

GLP
LCLUC/NEESPI

- Land System Changes in NEESPI Region are issues critically important to GLP Research

- Research Issues deals with
  - Dynamics of Land System Change
  - Consequences, and Vulnerability, Resilience
  - Sustainability of Land Systems

- Land system changes that are related to key GEC include coupled human environment interactions, biogeochemical changes, and land use dynamics

NEESPI Focus Research Center for Land Use Studies

- **Venue:** Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, Colorado, USA
- **Objectives:** conduct, promote, and facilitate research aimed at integrative study of coupled human-environment interactions of land use change in Northern Eurasia
- **Links to International Projects:** GLP, IGBP-IHDP
- **Leaders:** Ojima
- **Current Science foci:**
  - Land use
  - Coupled Human-Environment System
  - Interaction between Land use and hydrological changes

IGBP LAND COVER (1990'S)

IGBP Land Cover Classifications
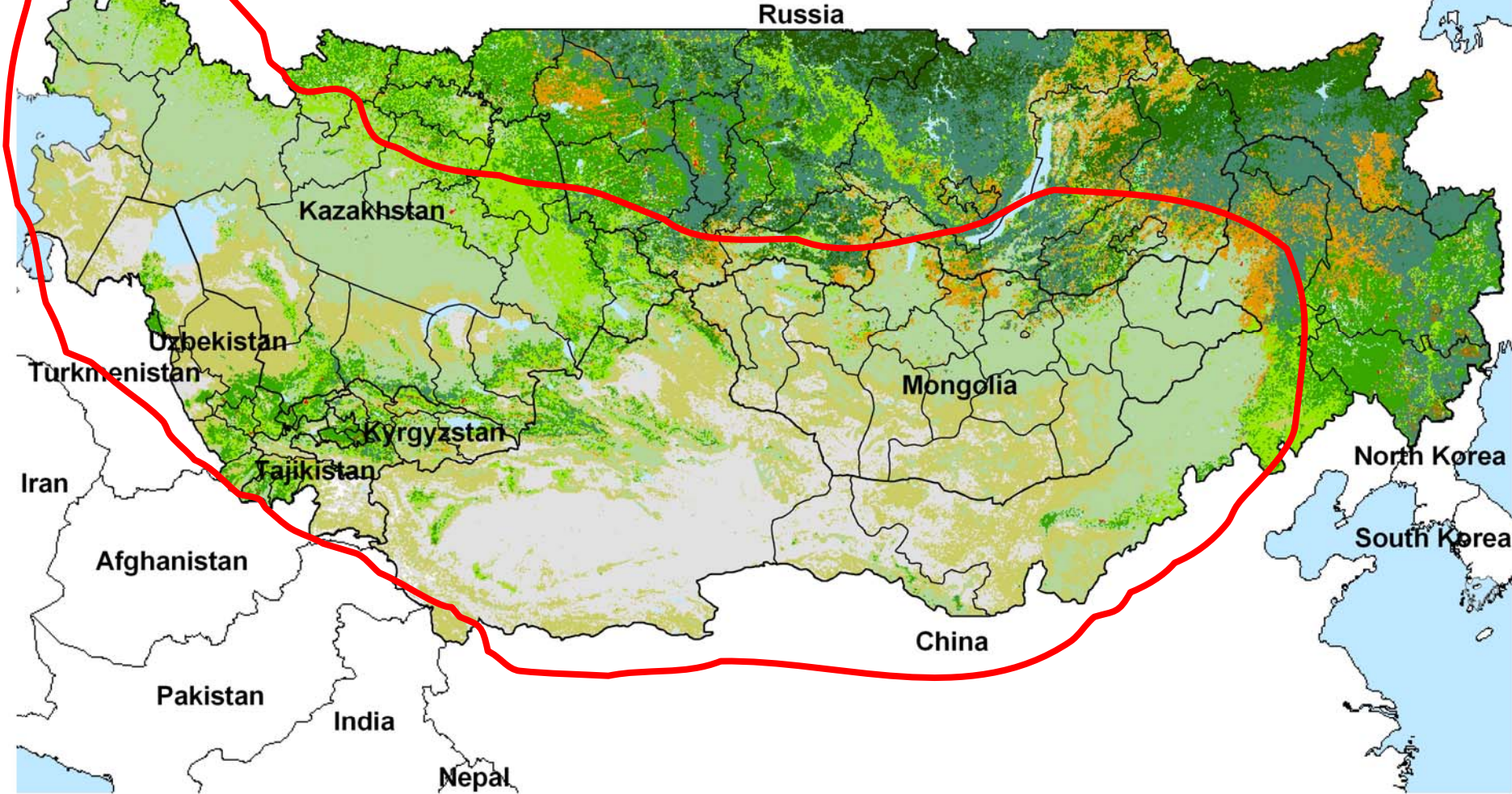
IGBP Value

Evergreen Needleleaf Forest	
Deciduous Needleleaf Forest	
Deciduous Broadleaf Forest	
Mixed Forest	
Closed Shrublands	
Open Shrublands	
Woody Savannas	
Savannas	
Grasslands	
Permanent Wetlands	
Croplands	
Urban and Built-Up	
Cropland/Natural Vegetation Mosaic	
Snow and Ice	
Barren or Sparsely Vegetated	
Water Bodies	

MAIN ISSUES IN THE NORTHERN EURASIAN REGION

EXAMPLES FROM MONGOLIA AND KAZAKHSTAN

- INTERACTIONS OF CLIMATE AND LAND USE
- WATER AND LAND RESOURCE MANAGEMENT
- INFRASTRUCTURE DEVELOPMENT
- INSTITUTIONAL AND POLICY CHANGE
- MARKET ACCESS

Social and Biogeographical Context

- Thousands of years of pastoral and cropland development
- Gateway of trade and cultural exchange between East and West
- Rich Natural Resources
- Variable Climate

IGBP LAND COVER
(1990'S)

IGBP Land Cover Classifications

IGBP Value		
Evergreen Needleleaf Forest	Deciduous Broadleaf Forest	Open Shrublands
Deciduous Needleleaf Forest	Mixed Forest	Closed Shrublands
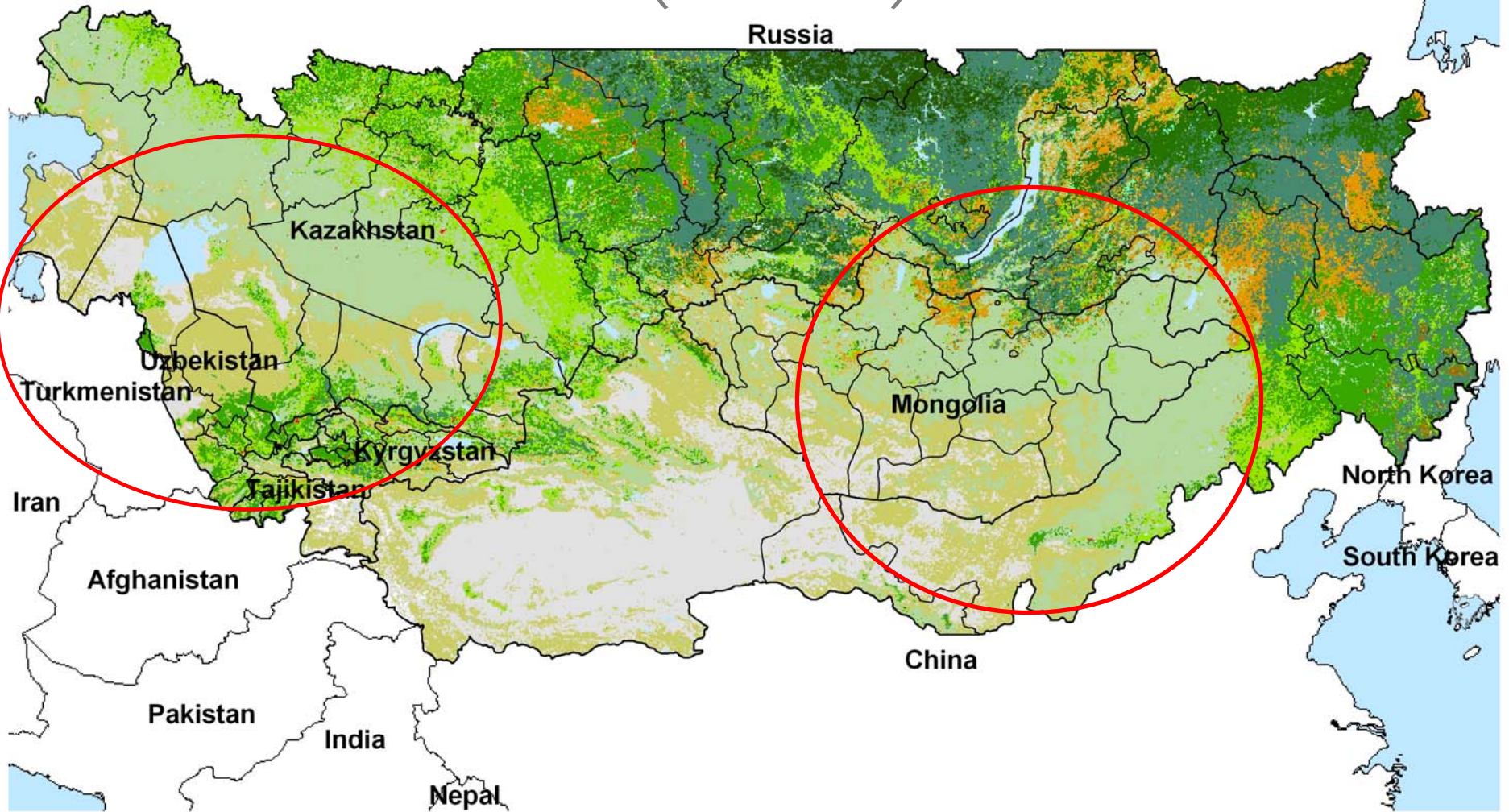
Grasslands · Urban and Built-Up · Woody Savannas · Permanent Wetlands · Cropland/Natural Vegetation Mosaic · Savannas · Croplands · Snow and Ice · Barren or Sparsely Vegetated · Water Bodies

HISTORICAL BACKGROUND

Historically, low population densities of nomadic pastoralists have utilized the rich grassland region to graze their mixed herds of cattle, sheep, goats, horses and camels. Grazing patterns were dictated more by intra- and inter-annual climate variability than political or economic factors.

	Rangelands million ha	Croplands million ha	Collectivization	Privatization
Mongolia	123	1.35	Late 1950's	Early 1990's
Inner Mongolia	63	8	In 1950's	Early 1980's
Central Asia	246	43	In 1930's	Mid 1990's

LAND USE IN TRANSITIONAL ECONOMIES

- ECONOMIC LIBERALIZATION
- POLITICAL CHANGE
- DEMOGRAPHIC SHIFTS
- ENVIRONMENTAL POLICY
- CLIMATE CHANGE

Mean Winter Temperature Change 1965 to 2004 over the globe

−1.5ºC −0.9ºC −0.6ºC −0.3ºC 0ºC 0.3ºC 0.6ºC 0.9ºC 1.2ºC 1.5ºC 2ºC 3ºC 4ºC > 4ºC
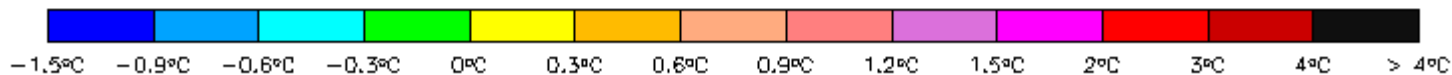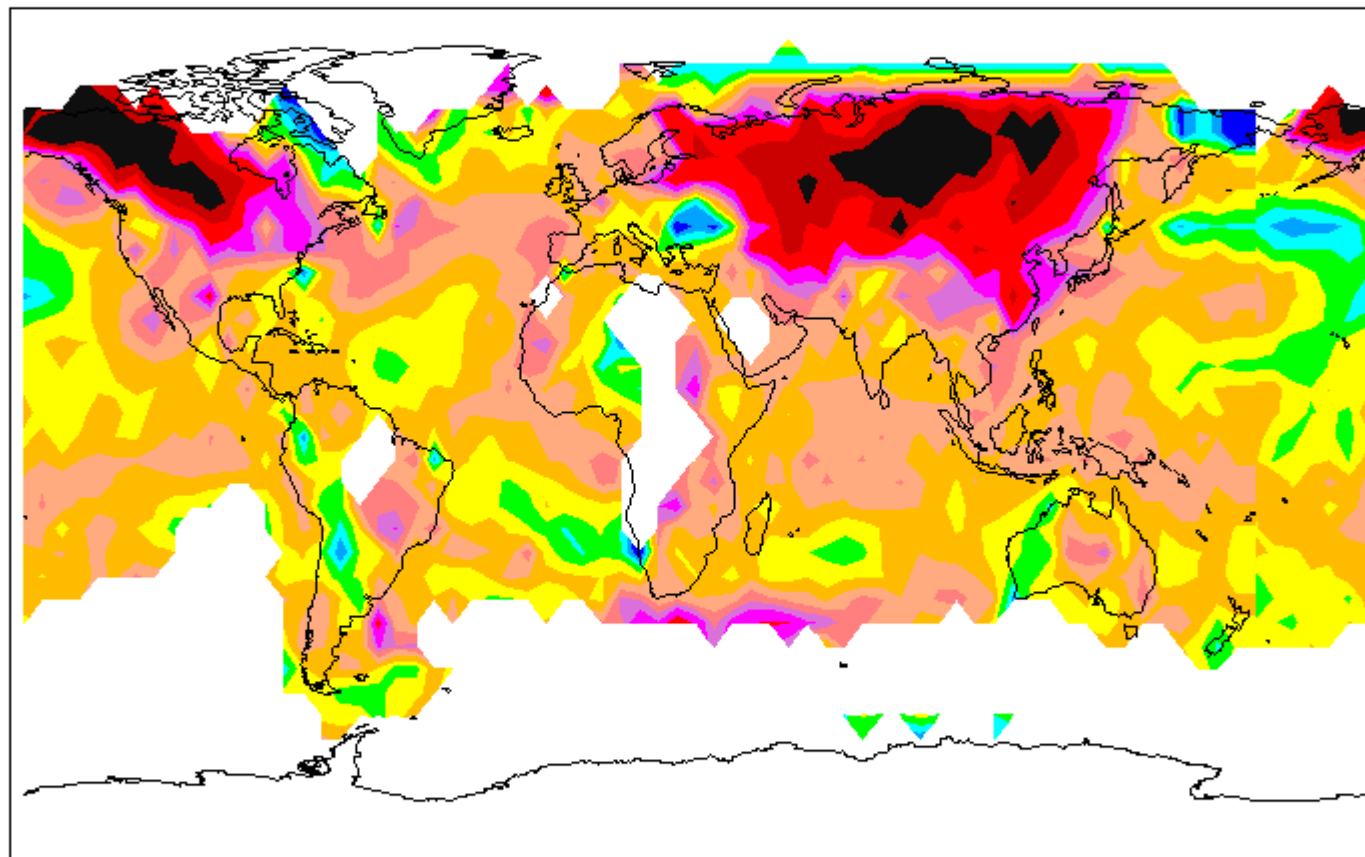
- **Data source: (Jones and Moberg 2003). Processed by the U.S. NOAA NCDC Global Climate at the Glance Mapping System.**

HARSH ENVIRONMENTAL CONDITIONS

Pasture usage (ha) per unit livestock unit (LU)
(Data source is FAOSTAT, 2004)

Location	1990	1995	2000
Kazakhstan	10.1	12.4	26.8
Kyrgyzstan	2.6	4.1	4.5
Mongolia	14.2	12.2	12.2
Tajikistan	NA	1.9	2.3
Turkmenistan	NA	12.3	14.9
Uzbekistan	NA	3.0	3.2

Livestock dynamics in Mongolia

Livestock, millions

Goat   Sheep   Cattle   Horse   Camel
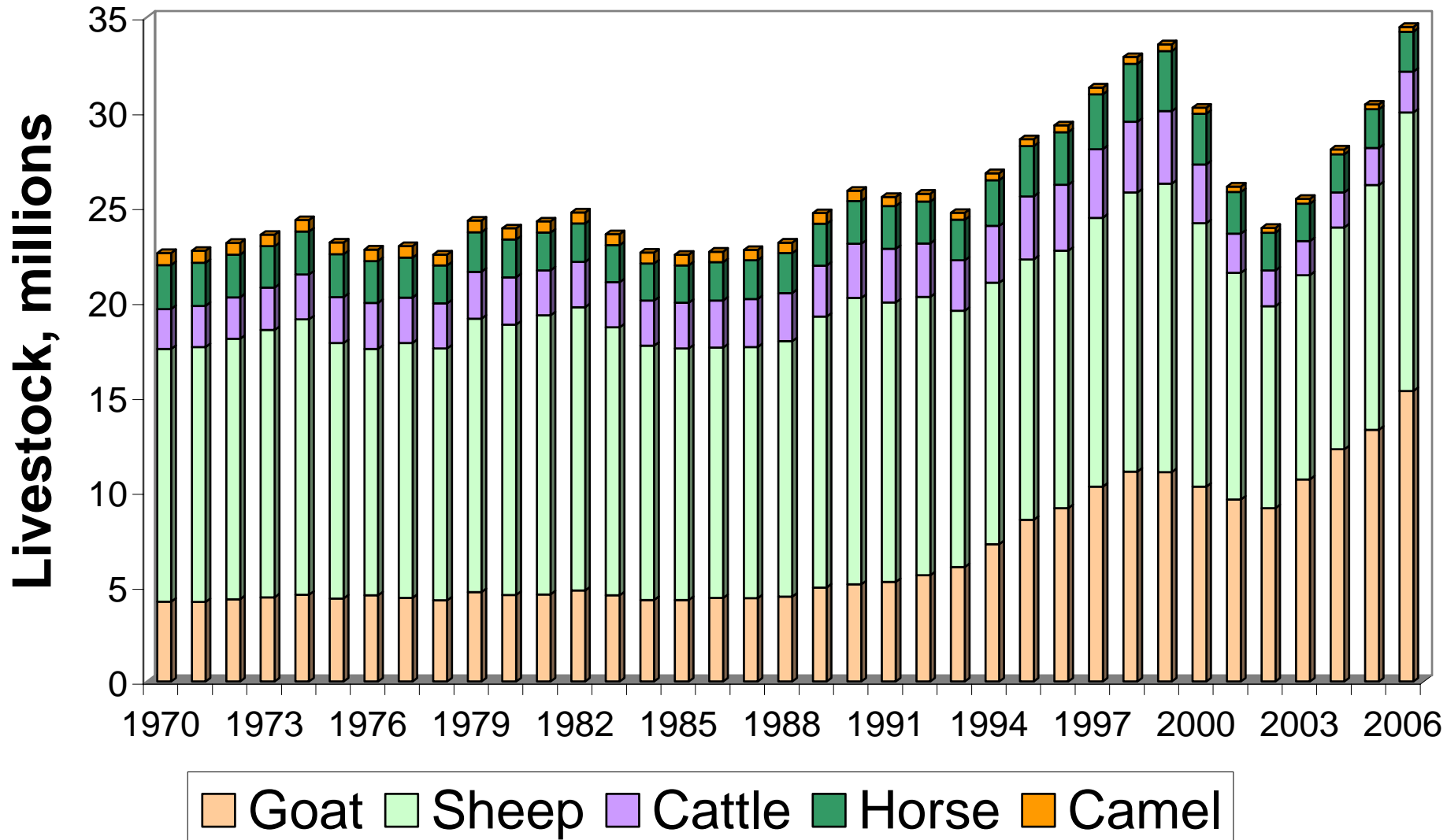
Dynamics of the amount of sheep and goat
in Kazakhstan 1950 – 2004 (mln. head)
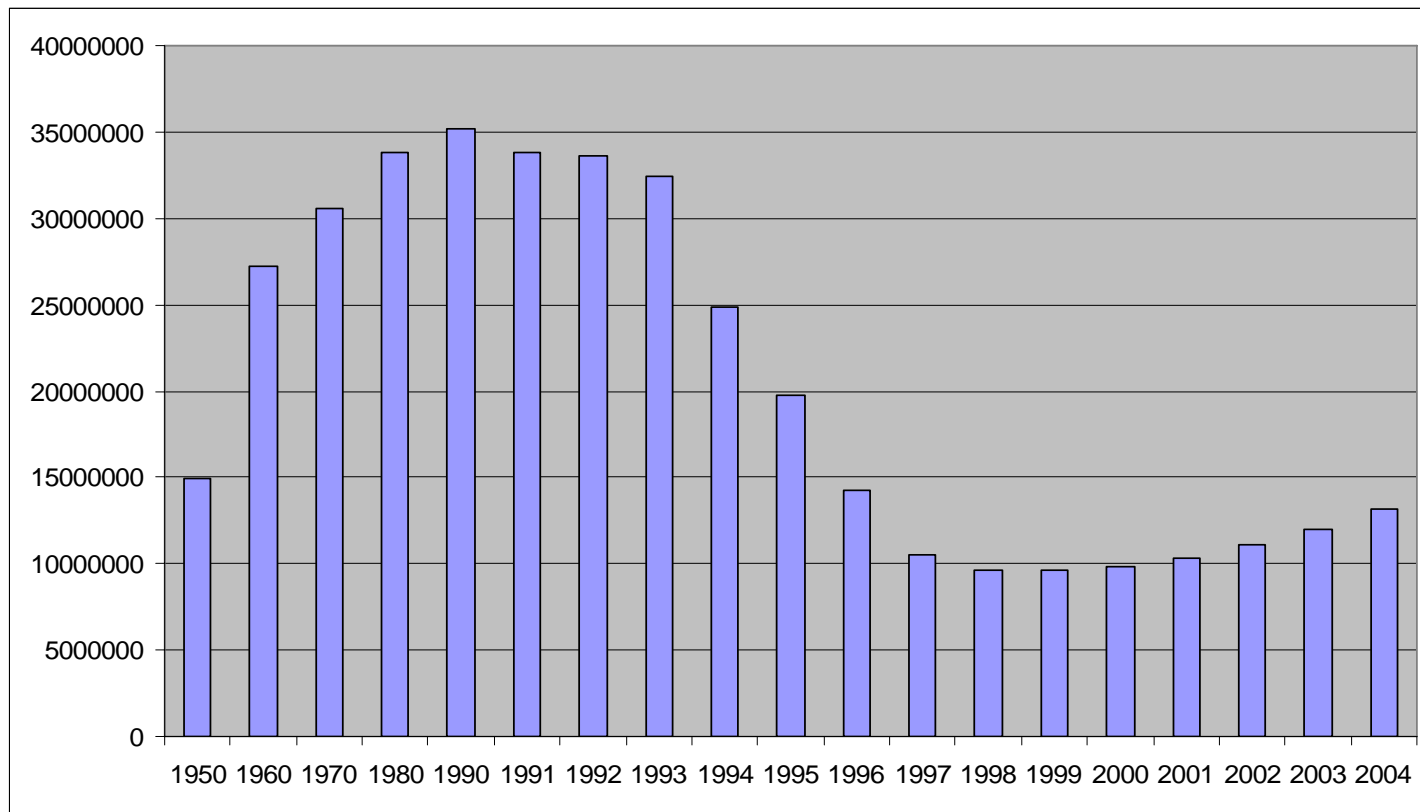
Dynamics of the arable land in Kazakhstan
1950 – 2004 (ha)
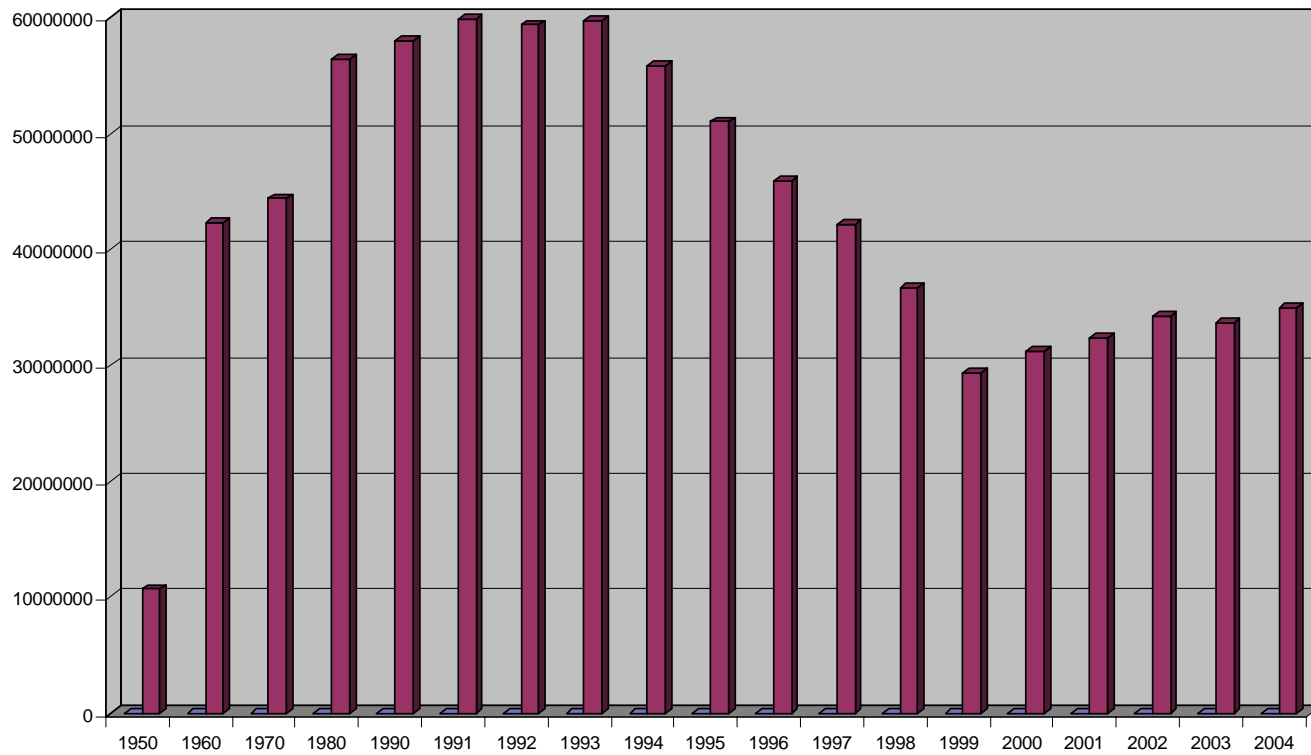
NPP Trends based on Satellite Analysis
(8km AVHRR data product)

NPP Trend (1982-2002) (g C m^{-2} yr^{-2})
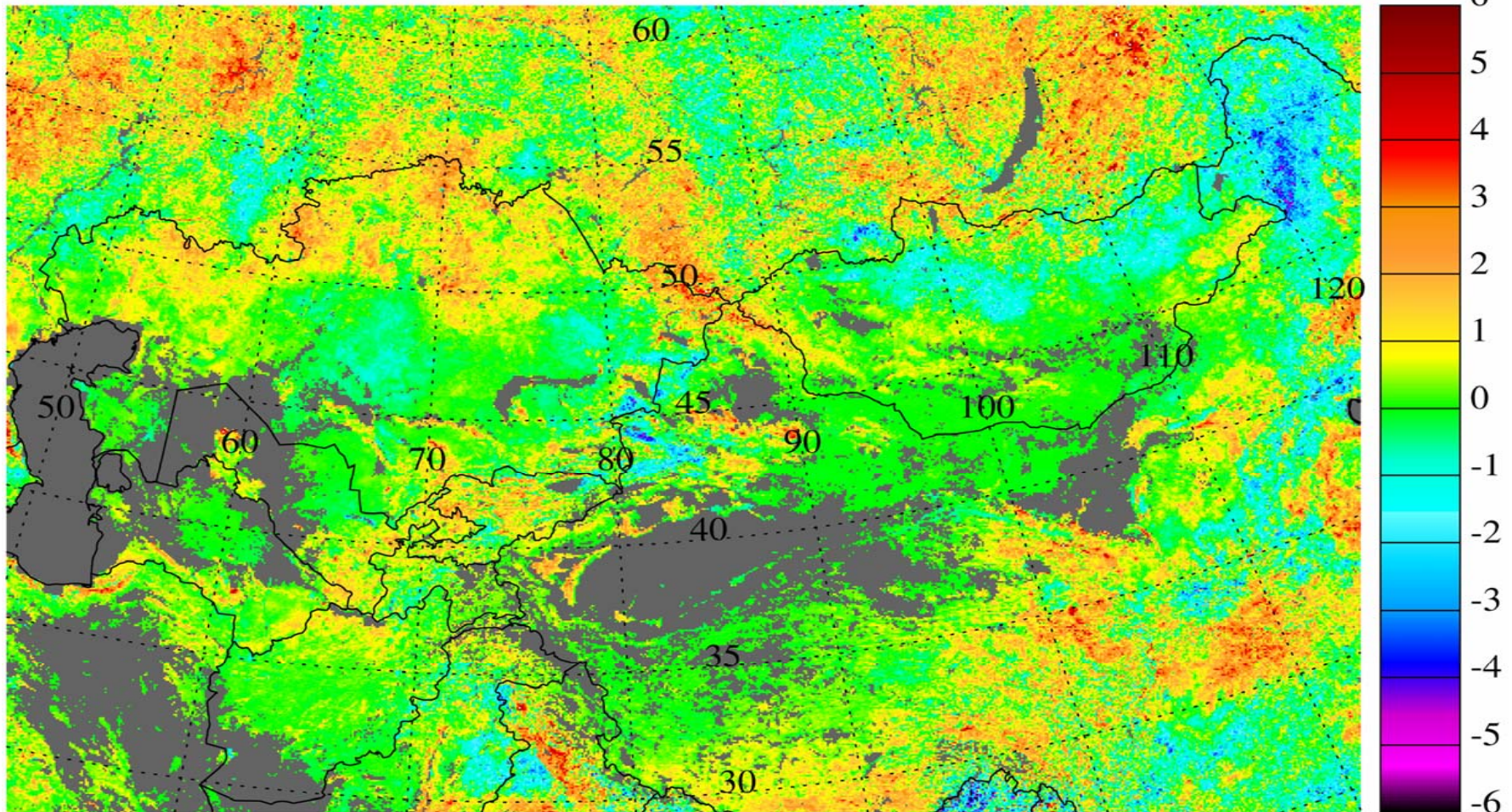
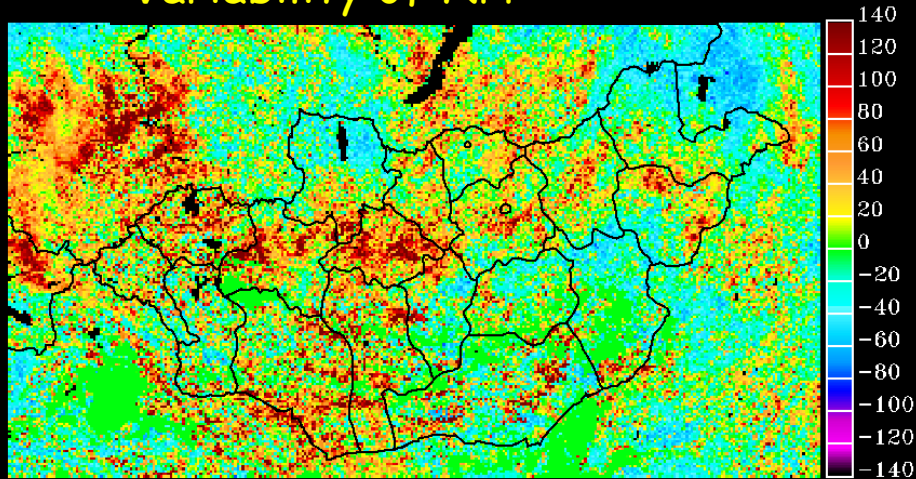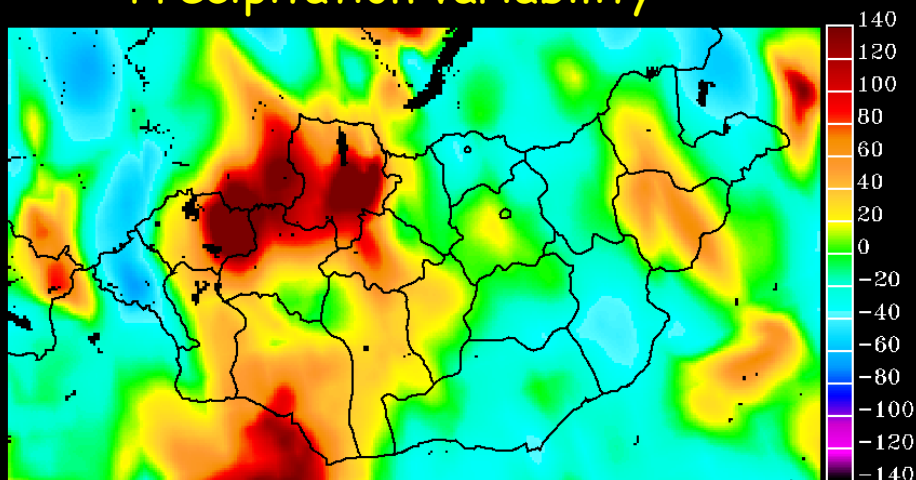Analysis of Hicke and Tucker

NPP became more variable in the 1990s

Variability of NPP

Precipitation variability
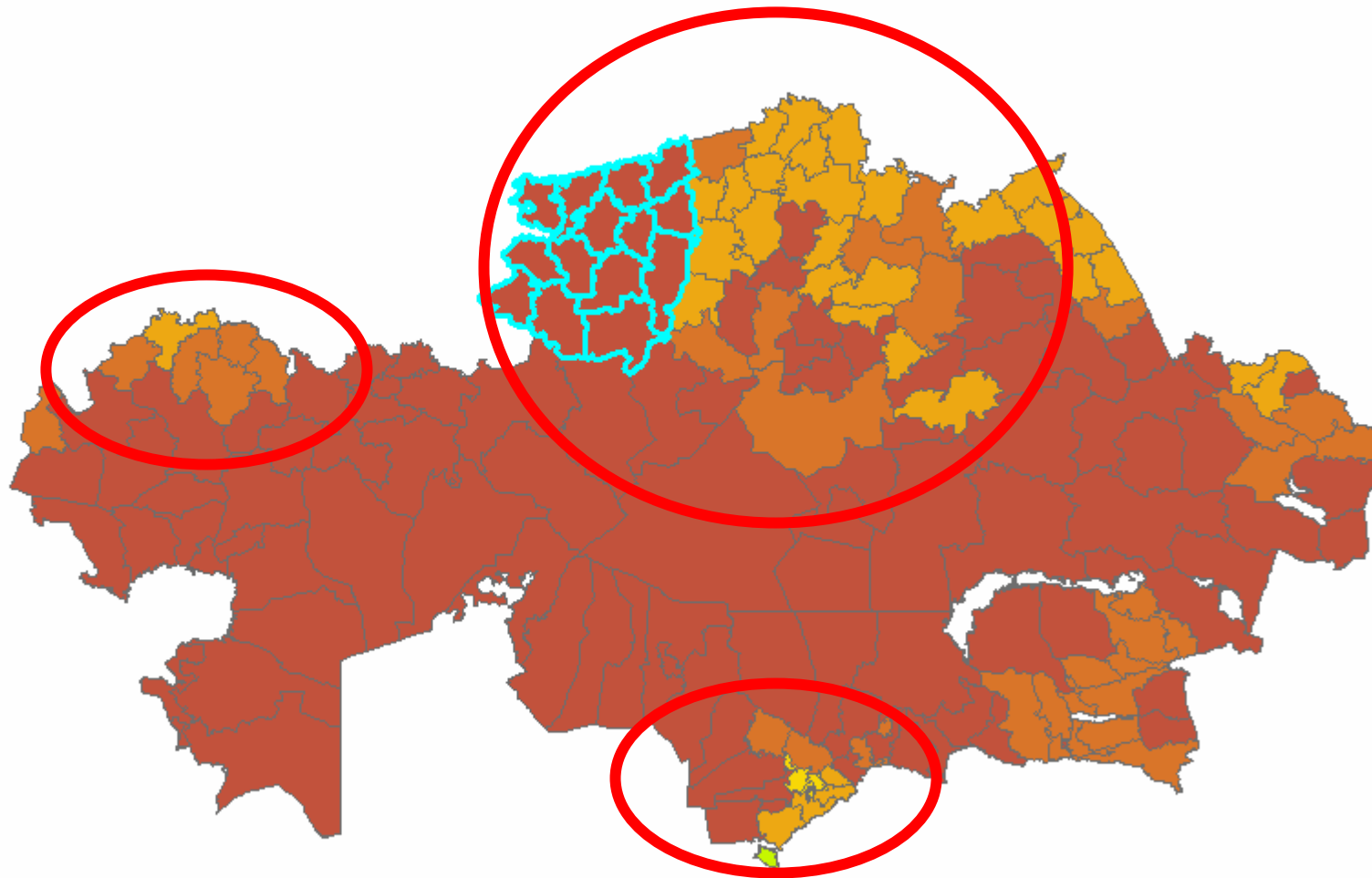
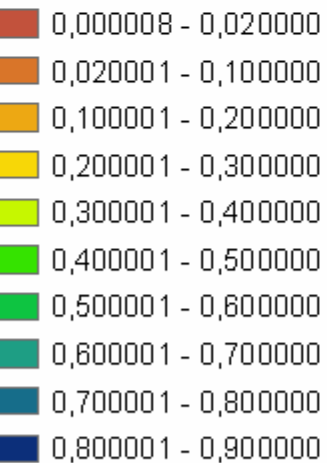$$\frac{StDev(90s) - StDev(80s)}{StDev(80s)} \times 100$$

Precipitation behavior likely to influence NPP in some regions, but not all...

...other climate variables? shifts to croplands/different crops? grazing? other land-use changes?

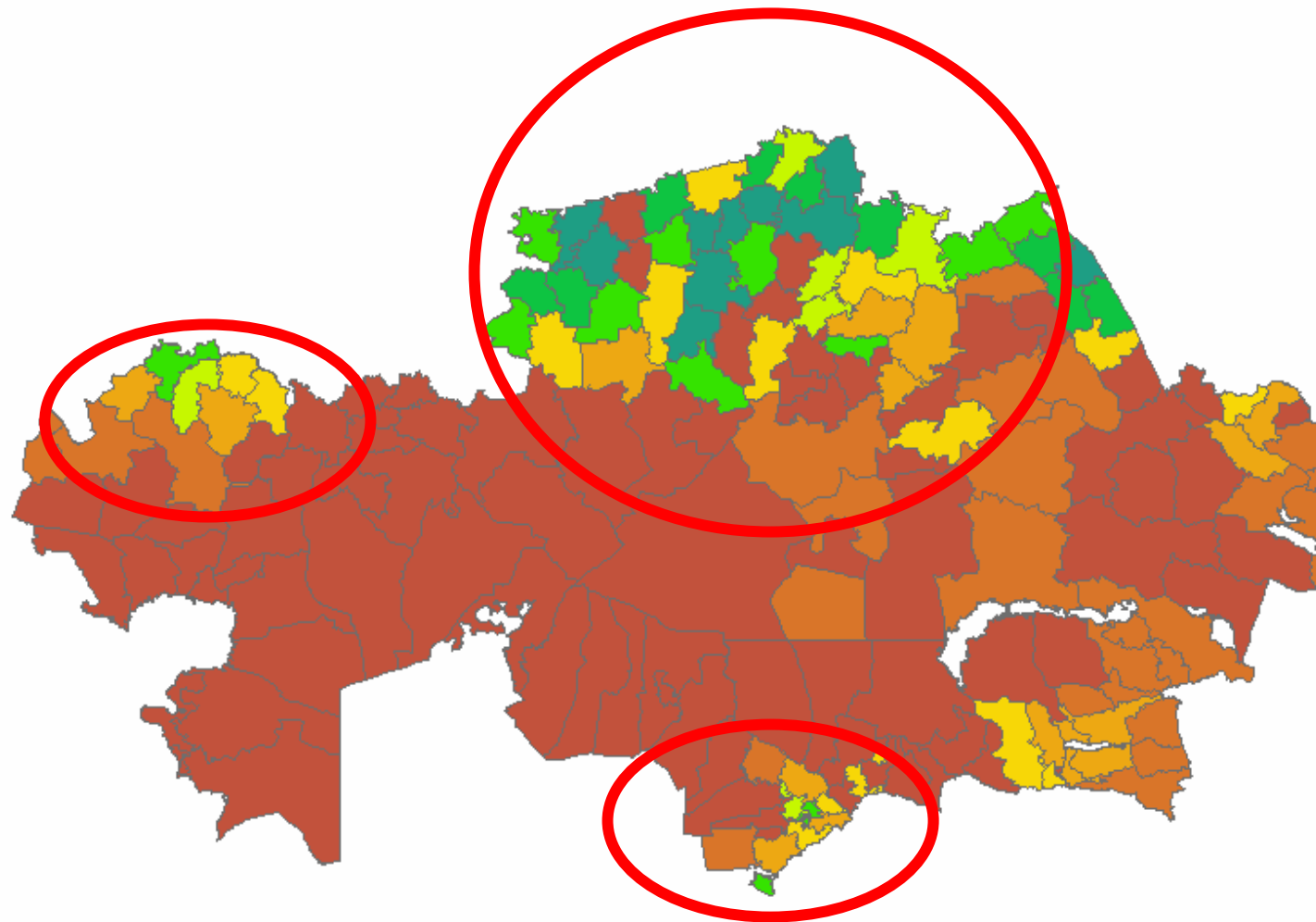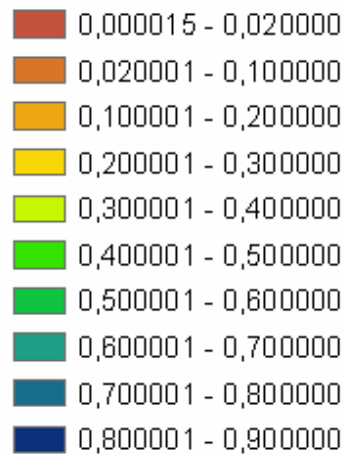Fraction of arable land in raions of Kazakhstan, 1950

KZ_raions_Project

Cr50.Expr1

- 0,000008 - 0,020000
- 0,020001 - 0,100000
- 0,100001 - 0,200000
- 0,200001 - 0,300000
- 0,300001 - 0,400000
- 0,400001 - 0,500000
- 0,500001 - 0,600000
- 0,600001 - 0,700000
- 0,700001 - 0,800000
- 0,800001 - 0,900000

KZ_raions_Project

Cr60.Expr1

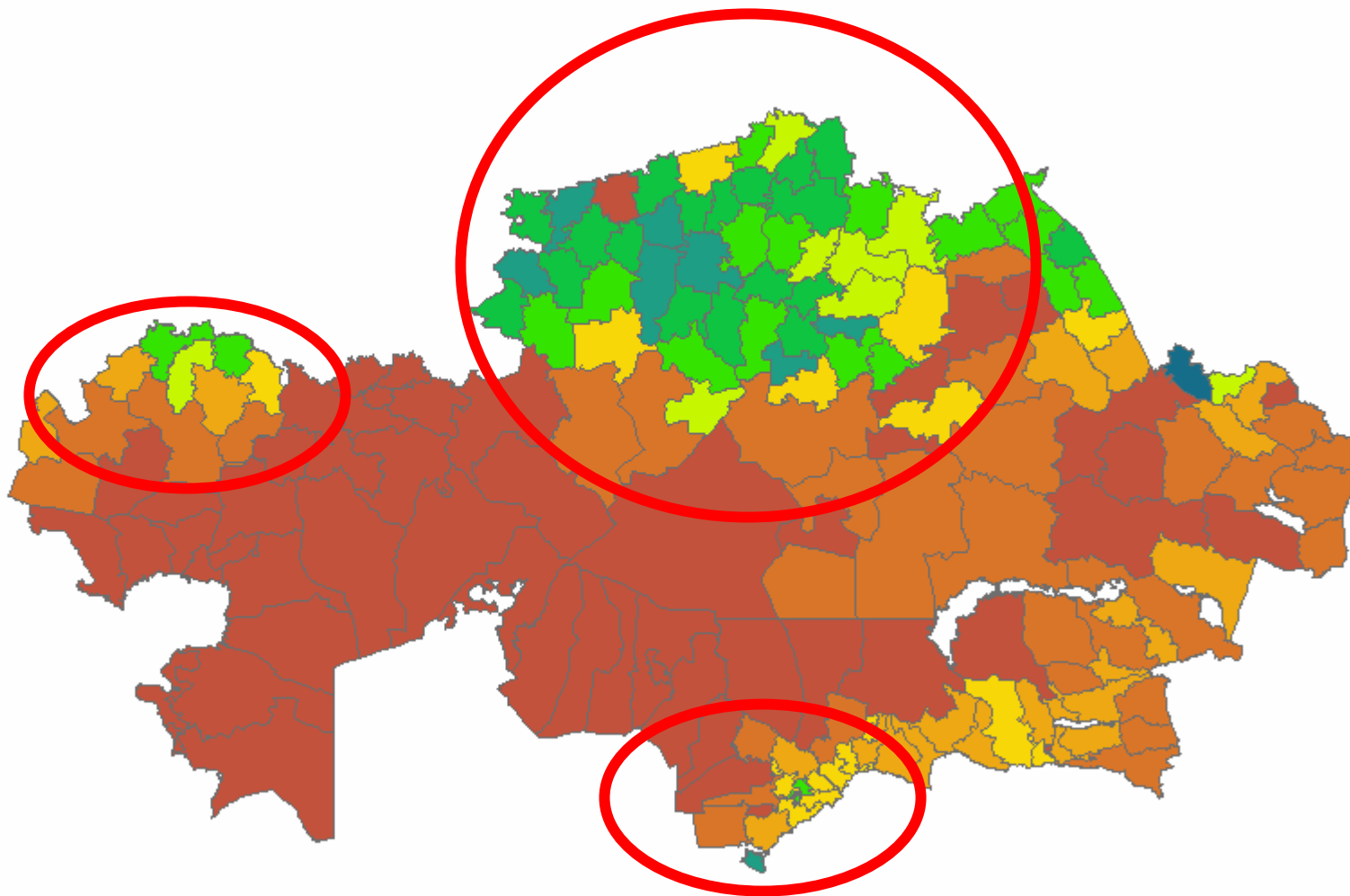|	
■	0,000015 - 0,020000
■	0,020001 - 0,100000
■	0,100001 - 0,200000
■	0,200001 - 0,300000
■	0,300001 - 0,400000
■	0,400001 - 0,500000
■	0,500001 - 0,600000
■	0,600001 - 0,700000
■	0,700001 - 0,800000
■	0,800001 - 0,900000

Fraction of arable land in raions of Kazakhstan, 1960

KZ_raions_Project

Cr92.Expr1

- 0,000000 - 0,020000
- 0,020001 - 0,100000
- 0,100001 - 0,200000
- 0,200001 - 0,300000
- 0,300001 - 0,400000
- 0,400001 - 0,500000
- 0,500001 - 0,600000
- 0,600001 - 0,700000
- 0,700001 - 0,800000
- 0,800001 - 0,900000
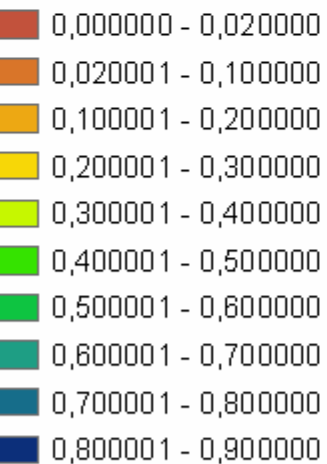
Fraction of arable land in raions of Kazakhstan, 1992

KZ_raions_Project

Cr00.Expr1

- 0,000015 - 0,020000
- 0,020001 - 0,100000
- 0,100001 - 0,200000
- 0,200001 - 0,300000
- 0,300001 - 0,400000
- 0,400001 - 0,500000
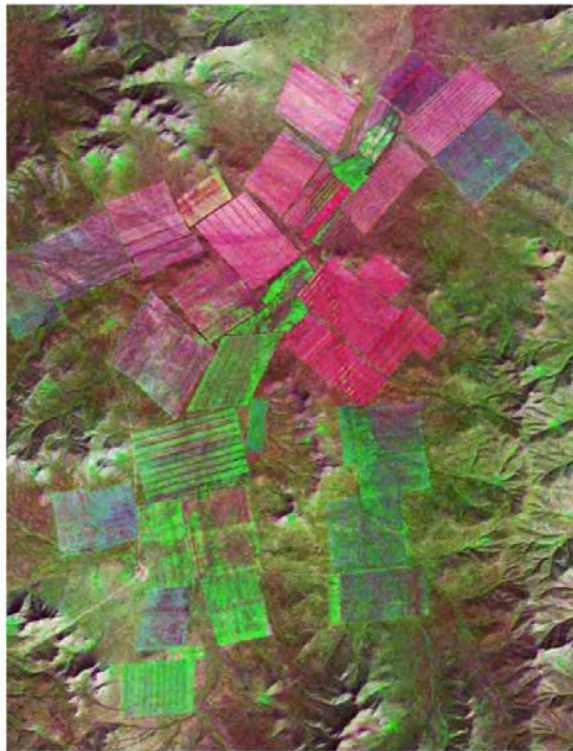- 0,500001 - 0,600000
- 0,600001 - 0,700000
- 0,700001 - 0,800000
- 0,800001 - 0,900000
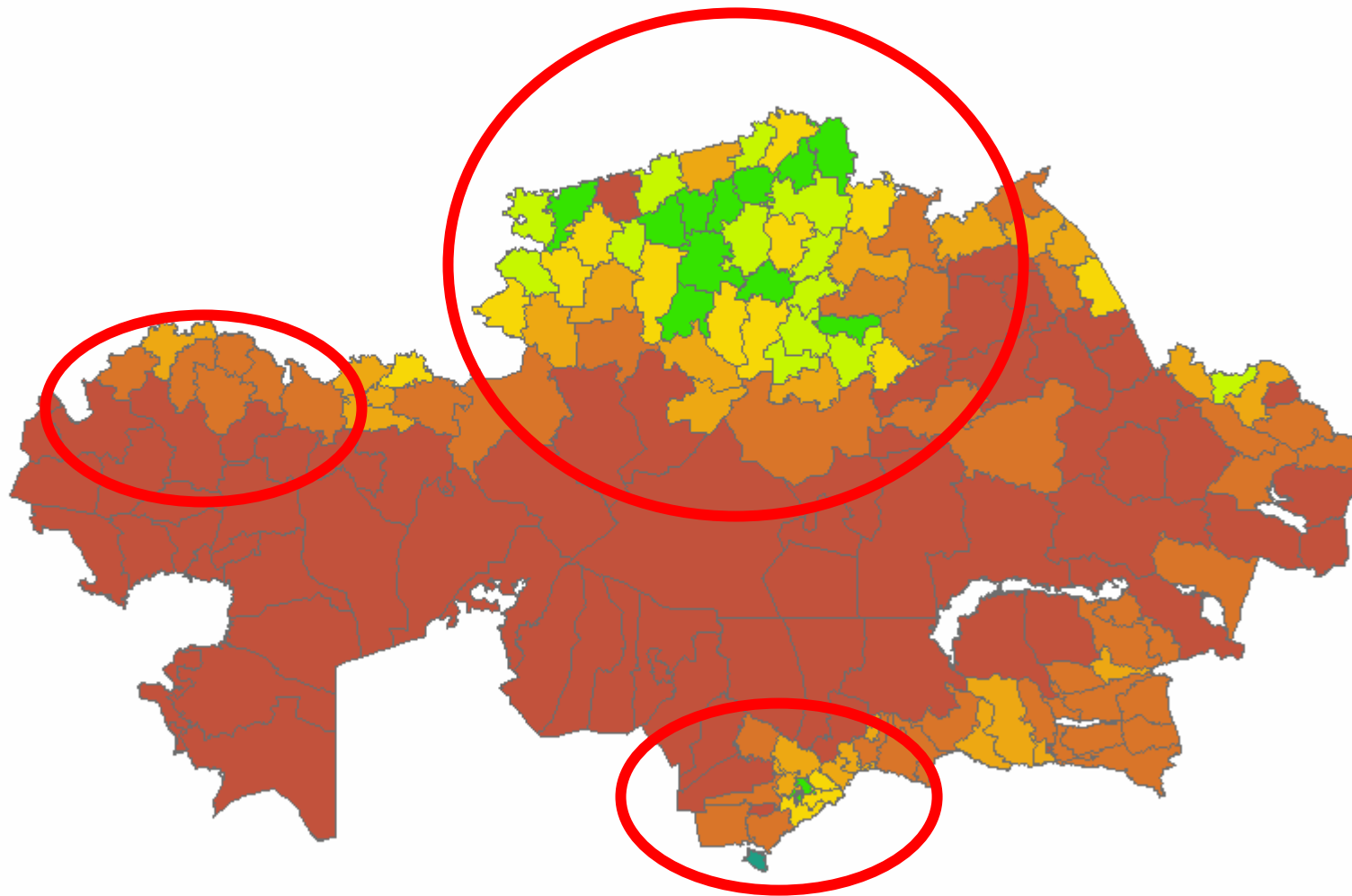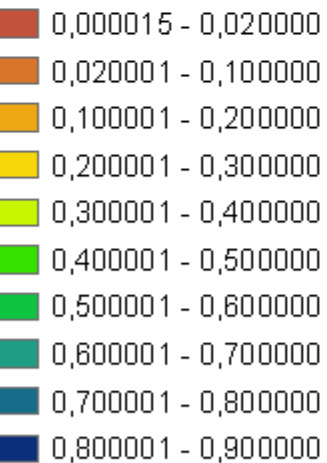
Fraction of arable land in raions of Kazakhstan, 2000

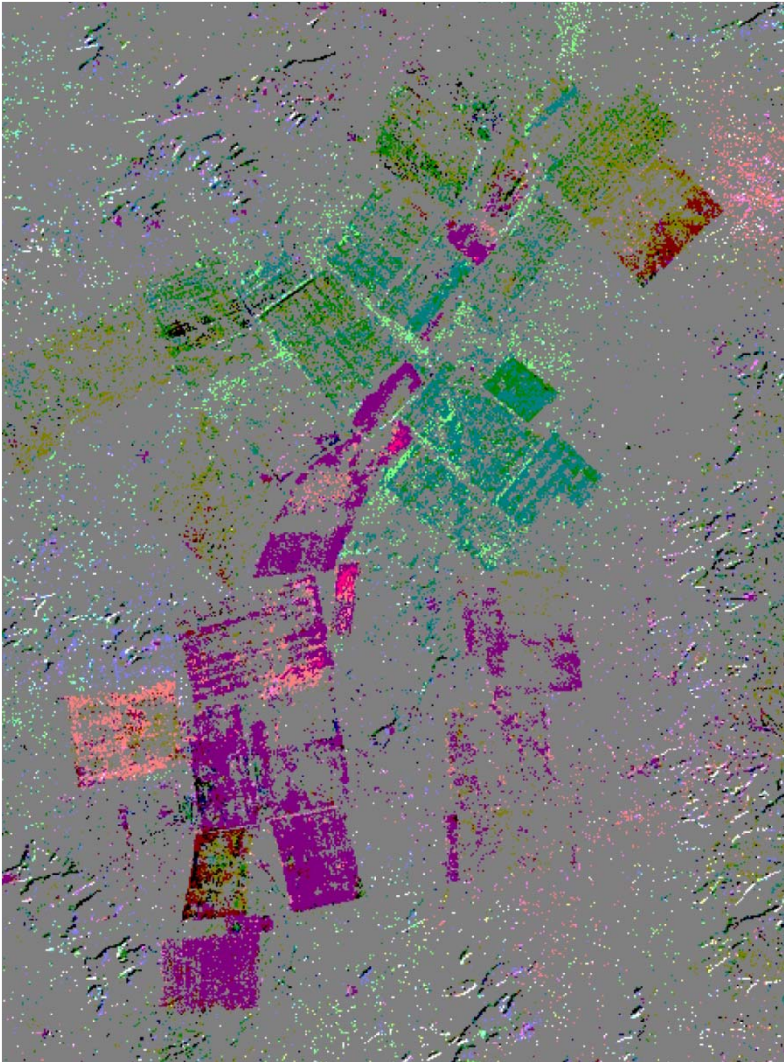**Landsat ETM+ Mosaic circa September 1994**

0 1 2 3 Kilometers
Universal Transverse Mercator Projection

Landsat ETM+ Mosaic circa September 2000

0 1 2 3 Kilometers
Universal Transverse Mercator Projection

Multi-Spectral Image Differencing

0　1　2　3 Kilometers

Universal Transverse Mercator Projection

Sums with the most abandoned croplands

| No.	Aimag	Sum	Territory	Abandoned croplands	Abandoned/territory
			ha	ha	%
1	Tov	Argalant	112,637	9,827	8.7
2	Tov	Arhust	82,925	11,583	14
3	Tov	Bayanhangai	100,733	13,201	13.1
4	Tov	Bayantsogt	147,198	17,742	12.1
5	Tov	Ugtaal	154,789	25,773	16.7
6	Ovorhangai	Harhorin	224,116	25,080	11.2
7	Suhbaatar	Tumentsogt	213,456	12,131	5.7
8	Bulgan	Rashaant	101,212	17,870	17.7
9	Hentii	Herlen	380,878	19,515	5.1
10	Arhangai	Hairhan	254,430	12,498	4.9
11	Arhangai	Tovshruuleh	118,958	12,474	10.5

Change detection in rangelands

Southern part of the oblast was a major livestock rearing region in Northern Kazakhstan. After 1993-1994 privatization in agricultural sector of Kazakhstan this region shows recovery of vegetation around barns at distant pastures and around some settlements (green color on composite of band difference images). This agrees quite well with the data from other maps shown below which suggest that this district has good grazing lands and in the period 1990-2000 livestock amount dropped significantly.
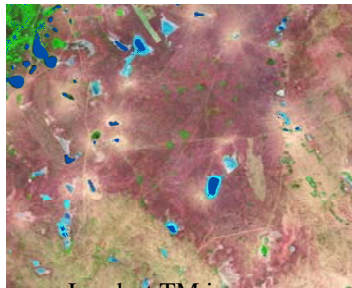
Landsat TM image
Circa 1990
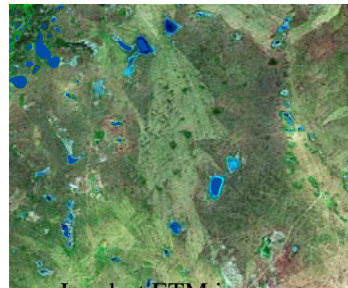
Landsat ETM image
Circa 2000
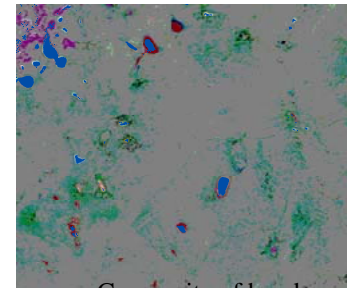
Composite of band
difference images

Data from livestock database on Dzhangildinskii district

1. Amount of sheep decreased by 318,000 head.
2. Amount of cattle decreased by 28,000 head.

Rangeland types by Vegetation Map

1. Bunch grass-sagebrush rangelands on chestnut soils with 10% solonetz. Used as spring-summer-fall pastures for all livestock.
2. Agropyron-forb-sagebrush rangelands on sands in places encroached by bushes and in places overgrazed. Used as spring-summer-fall pastures for sheep, horses and camel; can be partly used as winter pastures.
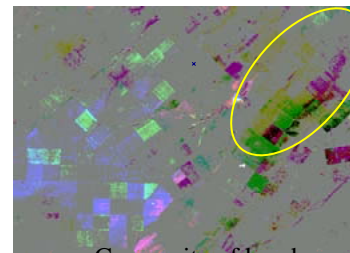
Change detection in croplands

Subset from the central part of the oblast. This area lies in Naurzum district is a transitional zone between grain producing north and livestock raising south. After privatization in 1993-94 wheat fields of this area have been first abandoned as they are the least productive and located on marginal lands with big proportion of light chestnut/solonetz soils. Much of abandoned wheat fields to the north have been brought back to cropping by 2000, but not much in the southern part of this district. Abandoned fields shows up on band difference composite as saturated green, yellowish-green (in yellow circle) and the rest colored fields appeared on the image because of the difference in harvesting/rotation (violet, light green).
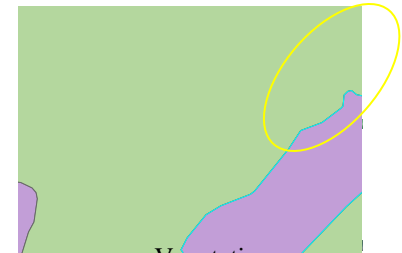

| Landsat TM image | Landsat ETM image | Composite of band | Vegetation map |
| Circa 1990 | Circa 2000 | difference images | |

Data from cropland database on Naurzumskii district

Cropland area decreased in the period 1990-2000 by 272,400 hectares.

Vegatation types by Vegetation Map

1. Green - Grass steppe rangelands on dark chestnut and chestnut soils with up to 20% solonetz (alkaline soil)
2. Purple - Sagebrush, chenopod and bunch grass rangelands on solonetz (alkaline soil) with up to 30% chestnut and light chestnut soils

KEY QUESTIONS

What factors contributes to the change in the vulnerability and resilience of pastoral systems?

How is the recent changes in land use intensification affecting pastoral institutions? Rangeland ecosystem structure and function? Rangeland biodiversity?

How are the changes in social structures of pastoral peoples affecting sustainable development in these dryland regions?

SUMMARY

- Dryland systems are sensitive to climate and land use trends
- Socio-Economic changes are strongly affecting land productivity in the region
- Sustainability and recovery of ecosystems of the region depends on improved management institutions, environmental monitoring and forecasting technologies

THANK YOU