1. INTRODUCTION

Because it is so vast, the scale of Northern Eurasia is difficult to express without superlatives. It covers eleven time zones and an area of about 28,600,000 km^2. This is slightly more than the sum of the areas of the United States, Canada and Europe, or 19% of the land surface of the Earth. From the point of view of understanding the dynamics of the earth system, the Northern Eurasian Earth Science Partnership Initiative (NEESPI) study region is about 60% of the terrestrial land cover north of 40°N and about 35% of the Earth outside of the tropics and subtropics. It is a diverse region. Covered by tundra in the North and semi-deserts and deserts in the South (Figure 1.1), Northern Eurasia holds a substantial fraction of the Earth's boreal forest (about 70%) and more than two-thirds of the land on Earth that is underlain by permanent soil ice or permafrost (Zhang et al., 1999, 2000). Thus, when global change processes involve these two biomes, Northern Eurasia is a key region for studying these processes and their impact on the global Earth system.

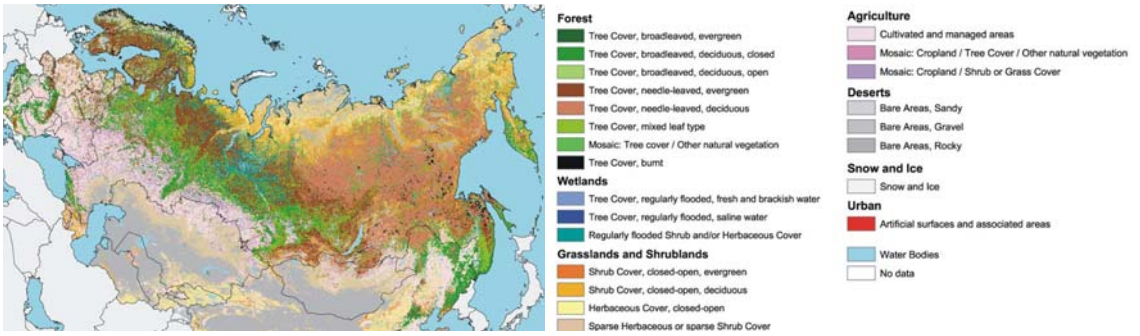

Figure 1.1. NEESPI study area includes Former Soviet Union, Northern China, Mongolia, Fennoscandia, Eastern Europe and the coastal zone of these countries. Inserted map shows land cover for the region. Source: European Commission, Joint Research Center (Bartalev et al. 2003; Bartholomé and Belward 2005).

We see the functioning of the global Earth system as an interaction of three major types of processes (cycles):

- ***Biogeochemical Cycles*** (BC) is defined as processes which affect the composition of the atmosphere and ocean, the formation of soils and the evolution of biomes. Global changes in this cycle can be slow, such as in forest succession, with typical time scales of multiple years and longer. Under this situation, the state of the BC could be considered as the initial condition when changes in processes of shorter time scales are considered. Processes involved in the BC can be also quite rapid (e.g., grassland vegetation dynamics, fires) or instantaneous (e.g., carbon assimilation in the photosynthesis process).
- ***Energy and Water Cycles*** (EWC) are defined as the processes which affect the transfer of energy, water, aerosols, and trace gases between the atmosphere, land surface, hydrosphere, and cryosphere on all time scales.
- ***Human Activity*** (HA), which began to strongly affect the planetary system on the regional level (land use, water withdrawal) with the establishment of the first agricultural civilizations, and now includes effects on the global climate system.

These processes are interrelated and their joint study addresses the overarching theme of the NEESPI, Terrestrial Ecosystem Dynamics. When described in a suite of reliable

models, these dynamics can be comprehensively simulated and projection estimates (scenarios) can be made.

With the industrial revolution, and increasingly since the end of the 19th century, human activity is more and more evident at the global scale with observed changes of the chemical composition of the atmosphere, with air and water pollution, and with large-scale changes in land cover. At present, humankind has become an essential part of the functioning of the dynamics of the planetary system, capable of globally altering the biogeochemical, energy and water cycles and thus changing terrestrial and oceanic ecosystems. We need to know how this will affect our planet and our species' future.

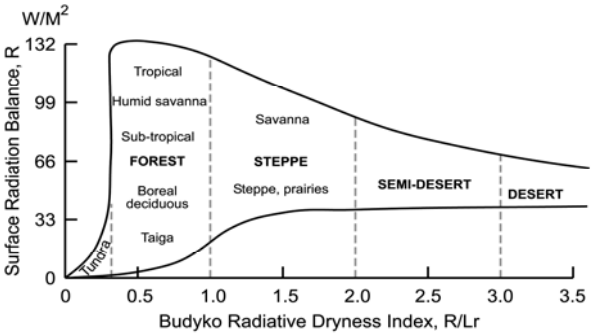

Figure 1.2. Geobotanical zones as functions of the annual surface radiation balance, R, and Budyko radiative dryness index (R/Lr), where r is annual precipitation and L is specific latent heat of vaporization.

EWC largely defined the state of the landscape up to as late as the beginning of the past century. The Law of Geographical Zonality (Grigoriev 1954, Budyko, 1971; Figure 1.2) describes the general relationship between major ecosystems and climate conditions. In the past, ecosystems have gradually adjusted themselves to slowly changing climate conditions, even in Northern Eurasia, which was historically more sensitive to climate variations and changes than most of the globe (Vinnikov 1986). This adjustment has always been interactive, because changes in terrestrial ecosystems feed back causing appropriate changes in EWC affecting the physical properties of the landscape (surface roughness, soil water holding capacity, river routing), as well as heat and water fluxes themselves (e.g., by controlling physical evaporation and transpiration). Thus the movement towards a new equilibrium occurs. When HA became a substantial factor, the time scale of changes in both EWC and BC shifted to shorter time scales with added forcings. Many of these changes (e.g., emission of greenhouse gases, deforestation, agricultural land use) have been one-directional and introduced trends that we now observe in meteorological and environmental records (IPCC 2001a,b). Figure 1.3 schematically shows the difference between the pre-industrial and present relationships among these three types of the processes. ***Studying any one of these cycles or activities often requires analyses of its interaction with the other two and of the transitional (non-equilibrium) character of these interactions.***

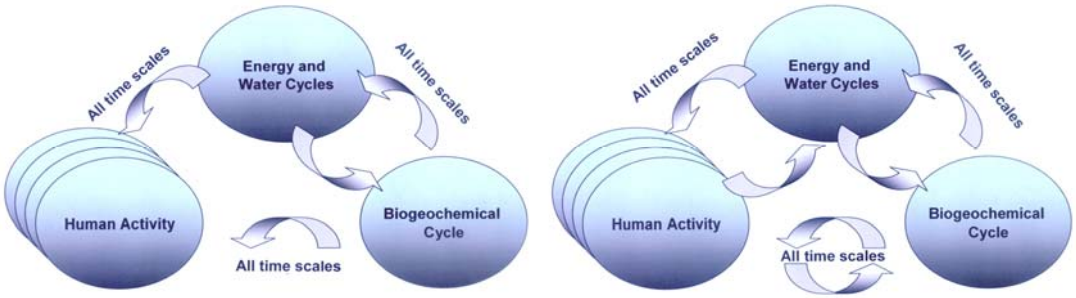

Figure 1.3. Pre-industrial (up to circa mid 19th century) and present interactions in the Earth Global System

Most of the energy that arrives at the Earth is first absorbed by the surface and only then is transferred to the atmosphere, cryosphere, biosphere, and into the deep ocean. Therefore, the energy exchange properties at the surface have a strong direct influence on all major processes of the global earth system, namely, on the biogeochemical, energy and water cycles, and on human activity. This includes the climate system. This science plan is focused on surface and near-surface processes in the Northern Eurasian region for three fundamental reasons:

- The changes in this region have the potential to affect the entire Earth system and may already be doing so.
- The processes in this region and their effects on the Earth system are so important and powerful that without clear understanding of them, the description/modeling of the entire Earth system is not possible.
- The study will have benefits to the societies in the region, helping to alleviate the negative aspects of environmental change and to respond to the positive aspects of these changes. This has special importance in this region with fast demographic trends, abrupt social changes, and a weak infrastructure.

These fundamental reasons will be discussed in greater detail in the "Major Scientific Topics" sections of the plan (Chapter 3). Tools to address these topics are described in Chapters 4 through 6. Our plan of action includes an education component (Chapter 7).The last chapter (Chapter 8) outlines the key elements of the NEESPI research strategy.

Most of factual information (physico-geographical description, climatology, state of the environment and society, as well as description of the observed changes, etc.) from all Chapters has been moved to ***Scientific Background Appendix***. This information as well as list of cited references is too volumetric to be presented in the Science Plan.