

Chapter 2

Overview of the Study Area

2.1 Natural Conditions of the Study Area

2.1.1 Location

The Sanjiang Plain is located in the northeast corner of Heilongjiang Province, northeast China. It is a marshy low plain mainly formed by the alluvial confluence of the Heilongjiang, Songhua and Ussuri rivers, and is one of China's largest contiguous distribution areas of freshwater wetlands. It is also greatly affected by human activities, and is a region with one of the fastest reductions in natural wetland area (Liu and Ma 2002).

The Sanjiang Plain includes the low plains formed by alluvium from the Songhua, Heilong and Ussuri rivers to the north of Wanda Mountain and the plains formed by alluvium from the Ussuri River including its tributaries and Xingkai Lake to the south of Wanda Mountain. The northernmost latitude is 48°28' and the southernmost latitude is 45°01'; the western edge is east longitude 130°13' and the eastern edge is longitude 135°05'. The entire region includes 23 cities, counties, and 52 state farms and 8 forest industry bureaus, which are located in these cities and counties. The total area of the region is 1.089×10^5 hm², with a total area of plains of 51,300 hm² (not including the Wanda Mountain area). The setup of the sampling sites in this study and their locations on the Sanjiang Plain are shown in Fig. 2.1.

2.1.2 Topographical Features

The Sanjiang Plain is located in a Cenozoic inland rift basin, which later accumulated deep unconsolidated sediments from the Tertiary and Quaternary periods. Since the Quaternary period, neotectonic movement has resulted in intermittent

2.1.3 Climate Conditions

This temperate zone area has a humid or sub-humid continental monsoon climate, with dry and cold winters, warm and rainy summers, fast-warming and windy springs, and sharply cooling autumns. According to statistical analysis, the annual average temperature is 1.9 °C, the annual effective accumulated temperature greater than or equal to 10 °C is 2300 °C, the annual rainfall is 500–650 mm, with 70 % concentrated from June to September, and the frost-free period is 120–125 days. Temperatures tend to be higher in the south and lower in the north, while precipitation tends to be higher in the east and less in the west. Evaporation is low in the rainy summer and the land surface may evaporate 550–650 mm annually. The potential evaporation of this area is less than precipitation. Therefore, the moist index in this area is low, being less than 1 in the eastern region and 1.0–1.1 in the western region. More precipitation and less evaporation provides the water source for the formation of marshes in this area, which has a long frozen period with the frozen layer being completely melted at the end of June. Because of the low thermal conductivity of the grassroots layer or the peat layer, wetland areas, especially peat marsh areas, are often not completely melted until July or early August, which promotes the development of wetlands (Cai 1990; Chen 1996).

2.1.4 Hydrological Characteristics

The Sanjiang Plain has sparse rivers and a low river network density. Except for the three major rivers, most rivers are small and medium-sized. The main rivers in this area are the Songhua, Heilongjiang and Ussuri rivers and their tributaries (Bielahong River, Naoli River etc.). Major lakes are the Great Xingkai Lake and the Mini Xingkai Lake. A large area of stagnant water has been formed and marsh development promoted because of overflowing of broad floods caused by backwater lift and water terrace detention on the surface. Wetland development has been enhanced by the poor drainage (Cai 1990; Chen 1996).

2.1.5 Distribution of Vegetation

Plant species of the Sanjiang Plain belong to the flora of Changbai Mountain. The watery and over-wet environment provides favorable conditions for the growth and reproduction of marsh and wetland plants. Roots of densely clustered marsh or wetland plants are intertwined and generally form a 20–30 cm thick root layer, with a high water-holding capacity. Ecological and geographical conditions that constrain vegetation formation are the low and flat terrain, the heavy and sticky clay soil, the high water content, the cold and long winters, and the

warm and short summers. Thus, the constructive plants, the dominant plants and the main associated plants in this area, are all water-adaptive helophytes, hygrophytes and a few mesophytes, mainly including *Carex lasiocarpa*, *C. meyeriana*, *C. pseudocuraica*, *Calamagrostis angustifolia*, *Betula fruticosa*, and *Salix rosmarinifolia* var. *brachypoda*, in association with *Iris laevigata*, *Menyanthes trifoliata*, *Caltha palustris*, *Lythrum salicaria*, *Pedicularis grandiflora*, *Verairum dahuricum*, *Sanguisorba parviflora* and other species. Meadow vegetation is distributed on the high floodplain, terraces and piedmont sloping plain, mainly including *Calamagrostis angustifolia* meadow and *Betula fruticosa*-miscellaneous meadow (Zhao 1999).

2.2 Wetland Soil Background of the Studied Area

2.2.1 Characteristics of Wetland Soil Distribution

The main wetland soils in the Sanjiang Plain include three different types of wetland: albic soils, marsh soils and peat soils. The largest area of soils on the Sanjiang Plain is albic soils which are mainly distributed in areas of relatively high terrain. Marsh and peat soils are mainly distributed in the poorly drained marsh environment, such as river, low flood land, high flood land and the loop-type swale on the low-level ground. The soils can be further divided into more than one soil class. For example, from high to low topography, the albic soils can be divided into brown white albic soils, meadow albic soils and gley albic soils, the marsh soils includes peat marsh soils, meadow marsh soils, humus marsh soils and saporopel marsh soils, and the peat soils include thick layer meadow peat soils, middle layer meadow peat soils and thin layer meadow peat soils. Many of these soils have been affected by human activities and reclaimed into farmland and thus have become artificial wetland soils (Liu et al. 2004).

2.2.2 Physical Characteristics of the Soils

Wetland soils on the Sanjiang Plain are mainly low-salinity freshwater wetland soils, and most of them have high organic matter content. The soils are loose with many pores, a high moisture content and low unit surface density, with bulk density values of 0.1–0.8 g cm⁻³ and specific density of 1.60–2.40 g cm⁻³ with most of the specific gravity values of organic soils being below 2.0 g cm⁻³, while values for mineral wetland soils are often greater than 2.0 g cm⁻³. Variation in unit densities of Sanjiang Plain wetland soils occurs because of the very different organic matter contents in the different types of wetland soil. For peat soils and peat marsh soils, plant residue composition in the peat layer is related to the

degree of decomposition of the peat. The unit weights of peat layers composed of different plant residues are significantly different, with the unit weight of residues from mosses and herbs being the lowest. The unit weight of *Calamagrostis angustifolia* communities is the highest at 0.8 g cm^{-3} , followed by the *Carex lasiocarpa*-*Glyceria angustifolia* plant communities.

The wetland soils on the Sanjiang Plain have relatively heavy textures and are sticky. From the analysis of mechanical composition, in white slurry soil more than 55 % of the physically sticky particles are less than 0.01 mm in size, and 25–40 % are less than 0.005 mm in size. The proportions of particles and physically sticky particles decrease with increasing soil depth. In marsh surface soils about 20 % of the physically sticky particles are less than 0.01 mm in size, with the percentage increasing with depth to more than 25 % at a depth of 80 cm. In the surface layer about 10 % of the sticky particles are less than 0.005 mm in size, increasing to 70 % at a depth of 80 cm (Yang et al. 2004).

2.2.3 Chemical Properties of the Soils

Organic matter in wetland soils includes the grass-roots layer of the soil, the humus layer, and the peat layer. Plant residues in soil are continuously decomposed and transformed by microorganisms, finally forming humus or peat layers. The process of formation of humus or peat is a major component of the formation of wetland soils, and it is also closely related to soil development and soil fertility capacity. The organic content in the surface layer of Sanjiang Plain soils is high, with most of them exceeding 10 % although the soil organic content varies between different types of wetlands. The surface organic content of the surface soil layer is between 8 and 10 % for meadow albic soils, about 10 % for gley albic soils, 15–20 % for humus marsh soils, and up to 30 % for muddy marsh soils.

The exchange capacity and pH of soils results from the interaction of comprehensive factors during the soil formation process, and are important indicators of soil fertility. The exchange capacity of the soil surface layer of the Sanjiang Plain wetlands is larger, with a cation-exchange capacity of 20 me/100 g of soil and a base-exchange capacity of 20–40 me/100 g of soil. The exchange capacity sharply reduces below the surface, with the cation-exchange capacity being 10–20 me/100 g of soil in the transition layer. For the parent material layer, the cation-exchange capacity increased to about 20 me/100 g of soil with a base-exchange capacity of 25 me/100 g of soil. Nitrogen, phosphorus and potassium are indispensable nutrient elements for plant growth and are also components of all proteins and protoplasm. Therefore, the amounts of these elements will have direct impacts on plant production yields. Most nitrogen concentrations in wetland soils of the Sanjiang Plain are above 0.5 %, while the total phosphorus concentration is low, and the total potassium concentrations do not vary significantly. Nitrogen, phosphorus and potassium concentrations in wetland soils are relatively high, but most of them are in organic form, which cannot be directly absorbed

and used by crops. The soils have to be ripened so that the organic form of the elements can be released to the soil through mineralization and be utilized by crops, which indicates that the potential fertility of the wetland soils is relatively high (Yang et al. 2004).

2.3 Chapter Summary

In this chapter, the location, topography, hydrologic conditions, climate and vegetation characteristics of the study area, the Sanjiang Plain, are summarized. As China's largest contiguous distribution area of freshwater wetlands, the Sanjiang Plain is an ideal platform to study freeze–thaw processes in marsh wetlands. Through literature and field monitoring, soil environmental characteristics of marsh wetland in the study area (including soil distribution and soil physical, chemical and biological characteristics) were discussed. This provides background information on the regional ecological environment for the subsequent experimental study.

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Effects

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