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Impact of Modern Human Activities on the Songhua River's Health in Heilongjiang Province

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Abstract

The Songhua River is the largest river in Heilongjiang province. During the past decades, intense human activities had extensive effects on the river. Protecting the Songhua River requires diagnosing threats on a large scale. Here we conducted the first comprehensive survey on the rivers' health throughout the Heilongjiang province, investigating into land use of riversides, modern industries along riversides and other human factors. The results showed that water quality, habitat quality and biological assemblages of the Songhua River are facing deterioration. Farmland, sand dredging operations and tourism depending on water resource may be the main factors which lead to the unhealthy state. This study will be helpful for developing riparian zone restoration plans, or adopting both biological and engineering measures to minimize the degradation of the Songhua River.

Key words: Songhua river; Modern human activities; River health; Influence of tourist attractions; Heilongjiang province

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INTRODUCTION

Rivers are important for ecosystem function and human beings. Ecological functions can be summarized as the following: ecological refuge development, productivity, species conservation and natural flood control (Benstead & Leigh, 2012; Lekka et al., 2004). Also, fresh water provides benefits upon which society depends. For decades, they play an important role in the cultural landscape such as transport, irrigation, recreation, fisheries, industrial and drinking water supply (Everard & Powell, 2002; Jia & Chen, 2013; Kamp et al., 2007). Therefore, river health is very important.

Success in protecting the condition, or health, of rivers depends on studying the interactions of landscapes, rivers, and human actions (Karr, 1999). There is widespread evidence of increasing degradation of river quality in many parts of the world (Everard & Powell, 2002). Previous research has shown that nearly 80% of the world's populations are exposed to high levels of threat of water-using security. Regions of intensive agriculture and dense settlement show high incident threat (Vörösmarty et al., 2010). This is because of growing demands for water, more intensive agriculture in floodplains, expansion of urban areas and transport networks, increasing use of hydropower as a renewable energy source and emerging climate change effects on hydrology and water temperature (Raven et al., 2010). The Songhua River is located in the Northeastern Region of China. The rivers are the major freshwater source for industries, farms, and millions of residents along their expansions (Li et al., 2009; Li et al., 2008). The total area of arable land is increasing dynamically in Heilongjiang province, which is different from other provinces in China. Furthermore, Heilongjiang province is violated by floods frequently. Floods have been the most destructive natural hazard in Heilongjiang province. Chum salmon, also called dog salmon, is a famous special product in the Heilongjiang

River and the Wusuli River in Heilongjiang province in Northeast China. It is a kind of migratory fish. In recent years, Chum salmon population has fallen and faces extinction due to the destruction of its natural habitat.

Although river health is very important, there is very little research which has addressed Songhua River health and there is almost no research on river habitat health in China now. Furthermore, streams and small rivers have often been overlooked by traditional mapping techniques, which typically rely on aerial photographs and satellite imagery, neither of which has sufficient resolution to detect small streams (Benstead & Leigh, 2012). In this article, we present a large area of rivers health field investigation, especially river habitat survey on Songhua River Basin. We discuss land use along riversides, factory conditions, water conservancy projects and other human factors which may affect the rivers' health, especially habitat health. The success of integrated water management strategies depends on striking a balance between human resource use and ecosystem protection (Vörösmarty et al., 2010). This study aims to identify the major human factors which influenced rivers' health in Songhua River Basin. By analyzing rivers adjacent landscapes and causes of degradation, we can develop restoration plans, estimate the ecological risks associated with land use plans in the watershed, or adopt alternative development options measures to minimize rivers degradation.

1. STUDY AREAS

The Songhua River, locates between 119°52' –132°31' E, is the biggest river in Northeastern China. The river drains 212,000 km² of land. It flows into the Amur River, as the main tributary, before entering into Russia. It consists of Nen River, Second Songhua River, Mudan River and so on. As the fourth longest river in China, the Songhua River is the main source of water for the cities and villages in the Northeastern region. The plain in northeast of China is famous for its vast and fertile black earth, and is one of the three black earth terrains in the world.

2. MATERIALS AND METHODS

The sampling sites were selected by intervals along the Songhua River in Heilongjiang province in the map using Arcmap-ArcGIS 9.3.1, and a slight adjustment of its reachability. We investigated the geomorphology, hydrological regime, the localization of the urban and industrial discharges, the land use of riversides, channel substrate, habitat features, aquatic vegetation types, the complexity of bank vegetation structure and the type of artificial modification to the channel and banks in Songhua River Basin.

3. RESULTS AND DISCUSSION

3.1 The Influence of Land Use Along Riversides on Songhua River's Health

Land use can reflect the relationship between human and nature directly. In this survey, we summarized the land use of riversides in 134 surveyed points in Songhua River Basin of Heilongjiang province. The percentage of land use in riparian zones in Songhua River Basin showed that: Farmland accounted for 75% of the total land, including 81 only farmland points, 4 points mixed by farmland and forest, and the remaining 14 points are surrounded by both farmland and grassland. And the other 17 points surrounded by cities and towns.

The Songhua River Basin is an important production base of commodity grain in China. From this field investigation, we can find that many natural riparian zones are replaced by farmlands. Riparian habitat can support a high biodiversity, which can protect the main channel from temporal changes and play an essential role in stream health and watershed function (Bennett & Simon, 2004; Clerici & Vogt, 2013; Dosskey et al., 2010; Gregory et al., 1991; Hunolt et al., 2013; Munné et al., 2003). In health status, it should be more than 90% of the stream bank surfaces and immediate riparian zones covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes (Barbour et al., 1999). Artificial modification had changed the health state of Songhua River now. A lot of meadows and forests were converted into farmlands. Since the natural barrier of the river had lost, it will cause a serious threat to the rivers healthy. Thus it can be seen that rivers physical habitats were threatened by excessive farming in the Songhua River Basin.

Furthermore, riparian habitat plays a key role in stream non-point nutrient and pollution reduction. Riparian plants minimize pollutants entering a stream by physically slowing water and allowing solutes to settle and by assisting transformation of those pollutants into less harmful and in some cases beneficial byproducts (Dosskey et al., 2010; Gurnell, 2012). Chinese agriculture has intensified greatly since the early 1980s on a limited land area with large inputs of chemical fertilizers and other resources. In China, terrestrial and aquatic ecosystems receive very high nutrient inputs as compared with those of other agricultural systems worldwide, which will cause rivers' pollution (Guo et al., 2010; Vitousek et al., 2009). As one of the intensive agricultural basins, various pesticides, especially herbicides have been increasingly used in recent years. Previous research has shown that the basin has a long cold winter, windy dry spring, and rainy summer, chemical fertilizers and various herbicides used in spring are much easily adsorbed into soil and vulnerable to losing with soil erosion in summer (Liu et al., 2013; Sun et al., 2013, 2011; Wilson & Xenopoulos,

2008). Many natural riparian zones are replaced by farmlands, which can increase the delivery of nutrients such as nitrogen and phosphorus to fluvial ecosystems. From the above-mentioned evidence, we can conclude that destruction of riparian zones in Songhua Rivers had caused the rivers water quality decreased. Especially we must pay close attention to water quality problems resulted from cultivating fungus. Northeast of China is a basin that intensively grows some types of edible mushrooms. According to statistics, the annual production of edible mushrooms reached 505.974 tons in 2011 in Heilongjiang province. There are areas that widely cultivated funguses, and cultivated waste directly discarded into the rivers and their riparian zones, which will have a great threat to water quality and habitat quality. Edible fungus dregs discarded freely in rivers and their riparian zones in many research areas. In the Northeast China, river pollution can seriously affect the residents' health due to the reason that people often drink groundwater directly.

We summarized the land use of riversides in 134 surveyed points in Songhua River Basin of Heilongjiang province. There are only 5 points surrounded by grassland, 7 points surrounded by forests, and there are 4 points surrounded by both forest and meadows. Since the reduction of meadows and forests, soil erosion will increase. The loss of soil particles and nutrients from arable land may adversely affect the water quality of freshwater recipients. Particle erosion depletes soil fertility and leads to reduced depth transparency in lakes (Braskerud, 2002). A river habitat that is strongly human-influenced might lead to loss of water retention capacity that might result in flood damages. Water system changes, reclaiming farmland from lakes, etc., posed a serious threat to flood and waterlogging control. Reclaiming farmland from original grasslands and forests will exacerbate the occurrence of floods (Kamp et al., 2007; Munné et al., 2003). Riparian zones can stabilize the river bank and control floods, their disappearance will also exacerbate the floods outbreak. Floods have been the most destructive natural hazard in Heilongjiang province. Biggest flood disaster since 1998 has taken place in Songhua river basin in 2013, and there are 543.9 million people affected by floods in Heilongjiang province. From the above, it can be seen that Heilongjiang province was violated by floods frequently which had a close relationship with the rivers health decreased.

In summary, the changes in riparian habitat quality and water quality caused by unreasonable development and utilization of farmland greatly exceeded that by natural processes. The influence of riparian habitat has long been overlooked. Managing or rectifying farmland perceived problems is needed for Songhua River health. A shift to adopt a more holistic approach to environmental

management is needed, such as returning cropland to forest and meadow.

3.2 The Influence of Sand Mining on Songhua River's Health

In recent decades, due to sustained and healthy development of China's economy followed by a synthesis of construction aggregates, substantial sand demand increasing year by year. Uncontrolled sand excavation has occurred in many rivers. In 134 surveyed points, 38 points have to sand mining operations in the rivers.

There are many in-depth investigations of the effects on the ecological environment and water quality of sand-mining in developed countries. We do not pay much attention to the effects of sand mining in China. The situation is becoming very grim. But if sand-mining exceeds the capacity of the river system, it will cause a huge negative impact. It will not only change water quality and affect health and development of river natural evolution, but also affect human activities and their living environment.

Sand-mining can change river channel geometries and morphodynamic (Dosskey et al., 2010). Furthermore, Changes in hydrodynamic and fluvial process. Large-scale sand excavation has great effects on the fluvial processes including increasing the channel volume, lowering the riverbed altitude and deepening water depth, which causes severe drop of water level and obvious strengthen of tidal action. Uneven sand dredging between the upstream and downstream reaches changes the water surface gradient. In addition, a stream that has a uniform substrate in its pools will support far fewer types of organisms than a stream that has a variety of substrate types (Sun et al., 2013). Sand-mining changed this natural state in Songhua Rivers. The most direct physical impact of sand-mining is the removal of natural substrate and increases mud and fine sediment. By analyzing river sediment of the 134 points, we found that more than 75% channels were choked with silt and fine sediment, rather than the natural state of the rivers sediment. Furthermore, uneven sand dredging between the upstream and downstream reaches also changes the water surface gradient, which increases flow velocity and strengthens head cut scour in Songhua Rivers.

Moreover, sand-mining can change biomass and structure of the aquatic organisms (Kim et al., 2008; Luo et al., 2007; Nairn et al., 2004). From a biological perspective, mining sand from the rivers would directly disturb benthic communities and indirectly disturb trophically dependent pelagic species. In this study, few species and low biomass of aquatic organisms are observed in the surveyed rivers. In the 134 surveyed points, attached algae were observed only in 81 points. In these points, most of them can be observed 2-3 species of attached algae. The most abundant points only had five species of attached algae. Furthermore, after a preliminary

investigation, the species of zooplankton, phytoplankton and zoobenthos were also affected.

From the above, we can conclude that large-scale sand mining is one of the most important human activities that affect the river health in the Songhua River Basin. To reduce environmental damage associated with long-term and large-scale sand-mining, we should standardize sand-mining activities.

3.3 The Influence of Tourist Attractions on Songhua River's Health

There are many tourist attractions which depending on the water resource in Songhua river basin. For example, Jingpo Lake, Wudalianchi, Yuting National Urban Wetland Park and so on. According to our observation, river health of these points is facing a great threat. Water quality, habitat quality and biological assemblages all suffered varying degrees of damage. Owing to overbuilding of the tourism service facilities, original vegetation was destroyed and water pollution was increased.

Mudanjiang is the second largest tributary of the Songhua River Basin, and Jingpo Lake is the headstream of Mudanjiang. And headwater pollution is a serious problem for important fisheries. Jingpo Lake is not only a famous summer resort, but also the water sources for downstream residents. In recent years, with the rapid development of tourism, too many hotels, nursing homes and training centers have been built in Jingpo Lake tourism region. Furthermore, there are a large number of waste oil and sewage from cruise ship discharged into the lake directly. The quality of surface water and groundwater are related to each other, because they have the same source (Majumder & Jana, 2013). In this area, people use groundwater for drinking without adopting any means of purification. The contaminated groundwater could cause serious public health problems. Quality decreasing of the rivers and their riparian zones will threat the quality of downstream water for industry and people's living. Yuting National Urban Wetland Park is located in Nehe Town in Heilongjiang Province. The park covers an area of 45.5 hectares, and green land and water covers 43 hectares. It has been completely modified by anthropogenic wetlands now, and has lost the original natural wetlands. According to this survey, there are many other natural wetlands disappearing in the Songhua River basin. Wetlands are important because they trap sediments and other materials in surface flow that would normally reach the stream, and wetlands help to stabilize stream flows because they hold water during storm events (Diana et al., 2006). Therefore, the disappearance of the natural wetlands will affect the rivers health greatly in the Songhua River Basin.

Thus, we need to pay more attention to inappropriate tourism development which can affect Songhua river health.

3.4 The Influence of Dams and Reservoirs Construction on Songhua River's Health

In our survey, we found that there are many dams in Songhua River Basin, especially in towns. In the 17 sampling sites surrounded by cities and towns, more than half of the points have dams. Dams can regulate flows, generate hydropower and provide water for industry, irrigation and human consumption. However, dams have been recognized as one of the primary means by which humans alter fluvial ecosystems. Habitat effects can be summarized as follows: Dams convert river sections from lotic to lentic systems; they inundate terrestrial landscapes, they modify the export of water, sediment and nutrients to downstream systems; they alter fluvial thermal regimes; and disconnect river segments from their floodplains, riparian zones and adjacent wetlands (Wang et al., 2011). Moreover, dams affect rivers ecosystem including the blocking of migration routes, the fragmentation of habitat with associated isolation of populations (the mortality of larvae and juveniles at water intakes), declining in biodiversity and the alteration of natural food webs and disruption of riparian plant communities (Benstead et al., 1999).

Furthermore, river systems are fragmented by multiple reservoirs in the Songhua River Basin. Depending on reports, there are 65 reservoirs in the Songhua River in Heilongjiang province. Large reservoirs in Heilongjiang province include: Nierji reservoir, Lianhua reservoir, Jingpo Lake Reservoir, Shankou reservoir, Longtou Bridge Reservoir, Xiquanyan Reservoir, Youth Reservoir, Kuerbin Reservoir, Xiangshan reservoir, Shuangyang River Reservoir, Dragon Mountain Reservoir, Taoshan Reservoir, Yinhe Reservoir, Dongfanghong Reservoir, Hamatong Reservoirs, Sunny Mountain Reservoir, Taiping Lake reservoir, Xigou reservoir, Huashuchuan Reservoir, Unity reservoir, Red bubble reservoir, Nihe reservoir and Daqing reservoir. Reservoirs have few negative effects on human water supply, but substantially affect aquatic biodiversity by impeding the movement of organisms, changing flow regimes and altering habitat (Vörösmarty et al., 2010). Construction of reservoirs can also bring about great effects on the hydrodynamic and fluvial process, which causes severe drop of water level and obvious enhancing of tidal action.

Heilongjiang province is frequently violated by floods. Changes in the hydrological cycle have a direct impact on droughts, floods, water resources and ecosystem services. In the developed world, responses to natural disasters such as floods and droughts often involve taming or vexing nature instead of moving people out of flooding areas or rethinking water-use policies. Dams are built, levees are erected, and various infrastructure projects redirect flows to nourish water-stressed regions. Some research shows that river hydrodynamics and wetland sedimentation patterns are mechanistically linked, providing results

that are relevant for plans to restore rivers using artificial diversions (Falcini et al., 2012). Ironically, such actions affect the very ecological processes and natural systems that purify, store and ensure long-term delivery of the abundant fresh water that supports ecosystems and people. Many once-perennial streams and wetlands are now dry much of the year because they have been buried or re-engineered for human purposes (Palmer, 2010). From the above-mentioned evidence, it can be seen that Heilongjiang province is violated by floods frequently and many rivers dried up recently maybe had a close relationship with the rivers' decreased health.

Large-scale alterations of watercourses in the form of channelization, dam building and digging of dikes has been ongoing for several decades in Heilongjiang Province in Northeast China. Projects such as building dams and diverting watercourses enhance water security for humans. But they do little to protect the biodiversity of associated ecosystems, and that's a long-term necessity (Bråthen, 2011). This has eliminated much of the vital natural variation found in rivers that is necessary for optimal fish habitat, and thus, a major cause of declines of the fish population in many watercourses. Chum salmon is a famous special product in the Heilongjiang River and the Wusuli River in Heilongjiang Province. It is a kind of migratory fish. In recent years, Chum salmon population has fallen and faces extinction.

Therefore, it can be seen that dams and reservoirs had changed the overall physical, chemical and biological structure and the function of Songhua river systems. Construction of dams and reservoirs has brought about great influence on the rivers water quality, habitat quality and aquatic organism within the Songhua River Basin.

CONCLUSION

In summary, extensive human activities listed above maybe the main reasons of deterioration of the Songhua River health. The result shows that extensive human activities have great effects on the water quality, habitat quality and biological assemblages within the Songhua River Basin. Firstly, reclaiming farmland from meadows and forests has resulted in deterioration of riparian zone and water quality. Secondly, uneven sand dredging changes river hydrodynamic, geomorphic processes and biological assemblages. Thirdly, owing to overbuilding of the tourism service facilities, original riparian vegetation is destroyed and water pollution increased. Lastly, the dams and reservoirs construction brought about great influence on the Songhua river health. These factors are not mutually exclusive but complementary, and the combined negative effects the best explain the deterioration in the Songhua River. In light of the fact that great anthropogenic effects on the Songhua river health, we suggest developing restoration plans (e.g. riparian restoration plans) and

adopting alternative development options to minimize river degradation. Recently, although deterioration of rivers' health has been recognized, efforts to restore these altered rivers have not been initiated in China. This article provides a preliminary investigation into the Songhua River health. To elucidate how to restore the rivers system so that they can return to their healthy state, we need further research on the relationship of biological status, fluvial processes, hydrological changes and habitat quality in Songhua River Basin.

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