CHAPTER 4: SNAKES AND LADDERS: NAVIGABLE WATERWAYS AS INVASION CORRIDORS

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1. Introduction

Herodotus, the Greek geographer and historian, supplied us with the earliest reference to a navigable canal – it was constructed in the 6th century BCE and joined the easternmost arm of the Nile with the northern Red Sea. Schooled early in drainage and irrigation engineering, and trained in colossal construction projects, the nilotic civilization built a canal “four day’s voyage in length, and it was dug wide enough for two triremes to move in it rowed abreast. It is fed by the Nile, and … it issues into the Red Sea” (in Godley 1975, II: 158). The idea of digging through the Isthmus of Corinth also dates to the 6th century BCE, and was considered, successively, by Julius Caesar, Caligula and Nero, but each met an untimely death that prevented completion of the canal (Werner 1997). The Grand Canal in China, constructed in the 4th century BCE, connected Peking to Hangchow, a distance of almost 1000km, linking the Huang-ho and Yangtze rivers, was one of the great aquatic engineering projects of the ancient world. However, not until the technological innovations of the 18th century, were processes set in motion that led to a proliferation of canal building, and an expansion of the network of navigable inland waterways, first in Europe and then worldwide.

River-borne transport had been increasing in Europe since the 16th century, following demographic and economic growth. The wider usage of the steam engine in the 19th century facilitated waterborne commerce by powering ships and dredges. The removal of navigational obstacles by deepening river channels, reinforcing riverbanks and connecting river systems allowed for expansion of the navigable network. The early navigable waterways were developed to transport coal, timber and ores to the manufacturing centres and to improve market links. Rapid industrialisation led to an increase of waterborne transport to accommodate the enlargement in trade volume: the length of navigable inland waterways in Germany alone doubled between 1873 and 1914 (Ville 1990). The interconnection of the watersheds of the North American continent, east of the Rocky mountains, by a complex array of canals and canalised rivers from the Laurentian Great Lakes to the Gulf of Mexico, was achieved mainly during the 19th century and the early part of the 20th century. Two interoceanic canals were products of the same period: the Suez Canal (1869) opened a direct route from the Mediterranean Sea to the Indo-Pacific Ocean, and the Panama Canal (1914) afforded passage between the Atlantic and the Eastern Pacific.

Following a period of decline in waterborne transport and conversion of many smaller canals to recreational usage, the last decades of the 20th century saw a revival in inland waterways’ expansion and recognition of their economic importance. A European agreement on the Main Inland Waterways of International Importance was established in the framework of the United Nations Economic Commission for Europe (UNECE), and was joined by Russia in 2002. This Pan-European inland waterway network comprises 28,000km of navigable rivers and canals and connects about 350 ports of international importance. The White Sea and the North Sea are now connected over vast distances across Russia and Europe via a dense network of inland waterways, with the Mediterranean, the Black and the Caspian Seas. These cross-continental
systems of rivers, canals, lakes and inland seas are used by a large number of vessels transporting a significant volume of cargo.

- Through the 280,000km of navigable rivers, lakes and canals in East Asia, more than 1 billion tons of cargo and 500 million passengers are transported each year; the inland waterway fleet consists of 446,000 vessels with combined capacity of 27.5 million tons.
- 11,725 ocean-going vessels passed through the Panama Canal in 2003, transporting 242.5 million tons of cargo.
- 14,000 commercial vessels transit the Suez Canal annually.
- Though closed to commercial traffic between November and April, the Volga-Don Canal has been traversed by 400,000 ships since its opening 50 years ago.
- The volume of cargo expected to pass through the Mittellandkanal in 2010 is 42 million tons.

Inland waterways transport is more energy efficient than overland transport and so produces a lower emission of pollutants per ton of cargo transported. For these reasons water transport is considered to be more environmentally friendly. In seeking to limit the increasingly destructive impact of transport upon the environment, UNECE has promoted inland waterway transport as a more pro-ecological transport system. However, the development of inland waterways entails enlargement of existing canals to allow passage of larger vessels, construction of dams, locks and levees, and reinforcement of riverbanks to withstand the vessels’ increased speed. The hydrological changes threaten floodplains, water meadows and wetlands. The canalisation of rivers, and the prevalent aquatic pollution and eutrophication, tend to homogenise their water quality. The increasing depth and width of the canals, and the creation of reservoirs mean a larger volume of water that buffers temperature and salinity fluctuations, and so provides a more uniform environment, leading to a decrease in habitat diversity and to diminishing biodiversity (Tittizer & Banning 2000). Similarly, the chronic physical disturbance of the river beds leads to habitat loss. Apart from providing transport routes, the cross-continental systems of rivers, canals, lakes and inland seas serve an ever increasing fleet of sea-river vessels that may carry alien species or provide them with many opportunities for natural dispersal. Estuarine ports servicing both inland waterways and overseas shipping, are prone to inoculations of trans-oceanic biota, and may provide occasions for secondary spread of alien biota upstream.

2. Keystone invasive species

Invasive organisms have been dispersed through canal and river systems, examples include: in North America, the alewife, *Alosa pseudoharengus*, and the sea lamprey, *Petromyzon marinus*; both entered Lake Ontario through the Erie Canal. The alewife became abundant in its new environment and competed with native fishes, and the lamprey, a predatory fish, reduced the native salmonid populations and whitefish species (GLFC 2004). The construction of the Welland Canal, bypassing the Niagara Falls, also allowed for their dispersal throughout the Laurentian Lakes (Aron & Smith 1971). The zebra mussel, *Dreissena polymorpha*, formerly a Ponto-Caspian endemic, began its global spread in the early 19th century (Köppen 1883) by reaching the Baltic Sea through canals linking the Dnieper with the Vistula and the Neman, and through canals linking the Volga and the Neva. This mussel also spread through the central European waterways to the Rhine, and with the timber trade to western European ports (Minchin *et al.* 2002). The zebra mussel was first sighted in Lake St. Clair in 1988, and spread within two years throughout the Laurentian Great Lakes, and subsequently dispersed