The Peace-Athabasca Delta: Portrait of a Dynamic Ecosystem

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THE PEACE-ATHABASCA DELTA: PORTRAIT OF A DYNAMIC ECOSYSTEM. By Kevin Timony. Edmonton: University of Alberta Press, 2013. 595 pp., $90.00 (softcover).
ISBN: 978-0-88864-730-6.

This large and comprehensive work provides a detailed view of the Peace-Athabasca (P-A) delta in Canada, one of the largest inland deltas of the world. As a deltaic ecologist, I am used to studying coastal systems. But it is striking how similar in so many ways the P-A delta is to coastal deltaic systems. Because of its length (it is almost 600 pages), it is difficult in a short review to do justice to this detailed and engaging work. What I will do here is to provide an overview of the work while giving enough detail to give a feel of how the author has distilled his extensive experience of the delta. The book is divided into five sections and contains extensive information in a number of appendices.

Section A describes the delta as a physical and biological system and has three chapters describing the physical environment, flora and vegetation, and fauna and wildlife. Inflow from the Peace, Athabasca, and several smaller rivers formed the delta as Lakes Claire and Athabasca were filled with sediment, and extensive wetlands formed as the river channels moved back and forth just as happens in coastal deltas. The total flow of these rivers is about 10% of the flow of the Mississippi. The delta landscape today is a montage of active and abandoned deltas, water bodies, terraces, bedrock outcrops, and dunes. As the last glacial period ended, the giant glacial Lake McConnell formed and stretched for nearly 1000 km. About 11,500 years ago, the lake burst through the glacial till holding it back and drained out in a tremendous flood that affected a large area and raised global sea level by about 6 cm. The peak flood lasted 1.5 to 3 years at a discharge of about 500,000 m^3 sec^{-1}. This is about three times the flow of the Amazon. By comparison, mean discharge of the Mississippi is a bit less than 20,000 m^3 sec^{-1}. Vegetation is a complex of many types of wetlands, submerged plants, and forests that is constantly changing due to delta dynamics, fires, and other forces without any permanent climax community. The fauna and wildlife of the delta are rich and diverse, and the area plays a key role in wildlife conservation. Any wetland ecologist will identify with one of the iconic species—horseflies—which are renowned for their abundance. Two animals that strongly impact wetlands are muskrat and beaver, which are keystone species. Through grazing and dam building, they strongly affect vegetation dynamics. The longest documented beaver dam in the world is in the delta, stretching for 835 m. An indicator of climate warming is the black-billed magpie, which has increased in abundance.

Section B describes processes of change and includes two chapters on climate, and physical and hydrological processes. The climate chapter includes a nice discussion of past patterns and the forces affecting climate and clearly demonstrates the impact of global climate change on the system. Global warming is most pronounced at high latitudes in the northern hemisphere, and this is evidenced by earlier spring ice breakup dates, reduced snowpack, earlier snowmelt, later freeze ups, decreased river discharge, and drier conditions, as evidenced by the Palmer Drought Severity Index. This has led to more fires. Striking to a subtropical ecologist is that the mean annual temperature is below 0 °C.

The second chapter in this section deals with the physical and hydrological determinants of change. Of course, river input with associated sediments has led to infilling of water bodies and delta formation. Seiches can lead to water level changes as great as those caused by river input. Humans and beavers have interacted to amplify physical and hydrological change. All of this informs an understanding of ecosystem function and management. The author states that "The delta is an ideal laboratory in which to learn about the behavior of complex systems."

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Section C is about the history of environmental changes and includes two chapters on longer-term natural and more recent historical changes. In the first chapter, the author reviews the history of water level and river discharge over the past 1000 years based on a variety of paleotechniques including radioisotopes, sediment layers, rates of sedimentation, tree rings, and bio-indicators such as diatoms and pollen that document a highly variable system. The results of these analyses show that the ice jam flood frequency was higher in Medieval times, about 1250, low during the Little Ice Age, and high in the 20th century. Medieval winter climate was warmer and more humid leading to higher spring flows and lower summer flow. Conditions were cooler and drier during the Little Ice Age leading to lower spring flows and more prolonged summer flows.

In the second chapter, written records, old maps, instrumental data, fire histories, remotely sensed data, field studies, and wildlife surveys are used to document more recent, human-influenced changes. This information documents major change in the system over the past 200 years. The author shows that on seasonal, annual, and decadal time periods, river discharge has fluctuated, lake levels were variable, fire frequency reflected climate, major changes in vegetation have occurred, and wildlife abundance has varied widely. Annual discharges of the Peace and Athabasca rivers have declined over the past several decades as climate has warmed and dried and there is an indication that fire frequency has increased in recent decades. The warming has led to an increase in exotic plants.

Section D is about human activity in the delta with three chapters on human history before and after 1900 and human effects on the delta. The first evidence of native peoples in the region date from about 11,500 years ago. Their arrival coincides with the disappearance of the mammalian megafauna, and it is still debated what role they played. A succession of cultures, collectively called the Great Lakes Cultural Complex, occupied the area and is documented by abundant artifacts such as projectile points. These peoples were nomadic hunters who subsisted off the abundant wildlife and fisheries. There were caribou, deer, moose, and beaver for food; fur; and bone for various purposes. European contact brought disease and the development of the fur trade, the latter decimating furbearer populations as trapping pressure became much higher, which led to warfare among tribes. This led to the establishment of a number of forts and small settlements. As in the United States, there was large-scale slaughter of bison and loss of native lands to whites. Railroads and steamships came to the area in the second half of the 18th century. Missionaries also came to the area, and native beliefs were suppressed. This was also a time when the first scientists came to the area, and the first maps were produced.

The last two chapters in this section concern the activities of humans in the 20th century. The first discusses human history and the second human impacts. The 20th century brought accelerated change to the region. These changes included treaties and more government intervention in the lives of native peoples, the Spanish influenza epidemic in 1920–1921, the micro-village period where local people lived in small scattered settlements, and the influx of Euro-Canadians and unsustainable fur harvests. There was commercial exploitation of bison, lumber, and fishes. Locally generated electricity began in Fort Chipewyan in 1959, and treated running water and sewage treatment arrived only in 1982. Modern transport based on roads, rail, and shipping developed. The Athabasca was dredged to 1.5 m. There was commercial logging along both the Peace and Athabasca rivers. Exploitation of oil and metal ore resources, including gold and uranium, began in earnest. Most of these have now played out. Rivers were dammed for hydroelectricity, and Timoney describes some of the controversy associated with this. One of the most recent developments is the large-scale production of oil from mining of bitumens. These are called tar sands or oil sands although they are neither. This tar-like substance was first mentioned in 1791 (native peoples used it to waterproof their Canoes) but commercial production did not occur until 1967. There is both surface and underground (to >75 m) mining of bitumens. The latter accounts for about 90%. It takes an enormous logistical effort and energy input to mine and process bitumens. Many in Canada look upon tar sands as the next big energy source.

The third chapter in this section concerns the impacts of the activities described in the second one. The prevention of avulsion (or delta lobe switching) is the largest single habitat impact, as in the Mississippi and other coastal deltas. This has had the effect of creating a new controlled system and prevented the development of extensive new wetland and shallow water habitat. Logging has resulted in a fragmented habitat, and dredging and weirs have changed hydrology. Climate change has led to increased aridity, decreased river discharge, more wildfires, and an increase in exotic plants and wildlife. Dams interact with climate change to increase the summer frequency of high water levels, decreased discharge into low-elevation basins, backwater flooding, and off-channel storage. Exploitation of tar sands has had a pervasive impact on the region. As of 2009, 868 km^2 have been directly impacted. Release of toxic materials into the environment has led to impacts on biota. The monitoring program has been criticized for its poor design and execution. One factor that is not addressed is the net energy yield of the bitumen production. A number of studies have indicated that there are very low net energy yields from tar sands production. Thus, the enormous costs and environmental impacts are not offset by great new energy available to society.

Section E concerns the future of the delta. The delta is a dynamic ecosystem that has been impacted, sometimes critically, by human activity. Climate has been the major driver of hydrological processes for centuries, and climate change is likely to drive the system beyond the limits it has operated within during the last 10 millennia. The author makes the point that a vast experiment is taking place in the delta region. He draws a number of conclusions about this. Simple cause and effect is rare in this complex ecosystem. Hydrological and water level variability are fundamental to ecosystem dynamics. There are multiple influences on hydrology and the entire system. It is difficult to separate directional change from short-term variability. The delta has been evolving over the past ten thousand years but in the past two to three centuries, change has accelerated, especially in the 20th century.

The future portends more change for the delta. Climate change will lead to a warmer, drier climate with associated ecosystem changes. Fire will become a major driver of change. New dams are being considered for hydropower that will flood large areas and interact with other drivers of change. Expanded bitumen extraction will make greater demands on the system (higher water use, for example) and lead to increasing environmental impact. There is also talk of exporting water south to the United States. Even with all this, the author ends on a note of optimism based on the resilience of the delta itself.

According to the author, the book is a synthesis of what is known about the delta, an environmental history, a reference book, and a field guide. It is all of these. The book is intended for a wide audience including natural scientists; those involved in the management, health, and policy of natural systems; naturalists; engineers in government and non-governmental organizations; and students and teachers of ecological and environmental studies. The

book will be of particular interest to those in Canada who have concerns about the region. But the book should be of interest to ecologists and environmental scientists generally as a compendium of information on one of the more important wetland ecosystems of the world.

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