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[See table of contents](#)

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Article abstract

The early 1920s constitute a tentative yet pivotal period for the institution of aerial photography as an innovative surveying and mapping tool in Canada. This study focuses on vertical air photos from an experimental survey conducted in 1921 over the St Croix River boundary between Canada and the United States. Reconstituted as a plan-view mosaic, the photographs reveal a dense cluster of early twentieth century cultural-industrial features and activities that has since vanished. The study suggests that the 100-year-old set of largely unknown aerial photographs at Canada's National Air Photo Library is a valuable source of geospatial information for historical and environmental research.

Early Canadian Aerial Photography: the St Croix River and the International Boundary, 1921

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Abstract: *The early 1920s constitute a tentative yet pivotal period for the institution of aerial photography as an innovative surveying and mapping tool in Canada. This study focuses on vertical air photos from an experimental survey conducted in 1921 over the St Croix River boundary between Canada and the United States. Reconstituted as a plan-view mosaic, the photographs reveal a dense cluster of early twentieth century cultural-industrial features and activities that has since vanished. The study suggests that the 100-year-old set of largely unknown aerial photographs at Canada's National Air Photo Library is a valuable source of geospatial information for historical and environmental research.*

Résumé : *Le début des années 1920 constitue une période provisoire mais cruciale dans l'adoption de la photographie aérienne comme outil innovant d'arpentage et de cartographie au Canada. Cette étude se concentre sur les photos aériennes verticales d'un relevé expérimental effectué en 1921 au-dessus de la frontière du fleuve Sainte-Croix, entre le Canada et les États-Unis. Reconstituées sous forme de mosaïque de vues en plan, les photographies révèlent un groupe dense d'aménagements et d'activités culturelles et industrielles du début du XXe siècle qui ont depuis disparu. L'étude suggère que cette série centenaire de photographies aériennes en grande partie inconnues de la Photothèque nationale de l'air du Canada est une précieuse source d'information géospatiale pour la recherche historique et environnementale.*

Keywords: Aerial photography, Canada, Air Board, St Croix River, International Boundary Commission

In his comprehensive account of the organization and pioneering efforts to photograph Canada from the air during the inter-war period of the last century, S. Bernard Shaw relates the story of a trying but ultimately successful air photo mission over the Maritimes during the month of September, 1921.¹ Veteran Squadron Leader, and Superintendent of the Dartmouth Air Station, Ambrose B. Shearer, was tasked to transit one of the Curtiss HS-2L flying boats from Nova Scotia to the St Croix River at St Stephen, New Brunswick, and Calais, Maine, where the crew collected a series of vertical air photos over a disputed area between Canada and the United States for the International Boundary Commission (IBC). During the flight, engine trouble precluded climbing above 1,000 metres; deafening engine noise reduced communication between pilot and camera operator to exchanging short handwritten notes. In spite of these challenges, the crew completed a run between the international bridge at Milltown and the two border towns further downstream on the St Croix River. Shaw's description concluded with a statement that the effort contributed to the award of a disputed river island to Canada.²

Looking back at this episode of early Canadian aerial photography after the First World War, multiple strands intertwine in this brief narrative. One ties together nascent aeronautical activities and early opportunities to take photographs from the air. A

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second strand hints at emerging domestic and international institutional arrangements behind these novel undertakings and the organizational and technical challenges confronting them.³ The third alludes to the practical-use case for air-photo experimentation at the time and the supposed significant outcome pertaining to ongoing boundary delineation and mapping. But notably absent from this summary is any reference to the photography itself that might convey *prima facie* evidence, complement the event record, and constitute a key source for further study.

This essay is focused primarily on the actual air photos of the 1921 St Croix survey mission and its geographic setting. In doing so, the inquiry attempts to answer a series of questions.⁴ How did the survey and its aerial photography originate? What was the motivation for the survey in the context of the IBC work, and its technological impulse and geographical scope? What photographic products were obtained and shared, and how were they eventually archived? What did the air photos show and who used them? Lastly, what was their impact at the time, and what practical value might the vertical air photos that Ambrose Shearer's survey mission obtained one hundred years ago retain today?

When the crew and camera of the Curtiss HS-2L flying boat captured a sequence of 20 vertical aerial photographs over the St Croix River in 1921, the use of photography for mapping frontiers, fronts, and boundaries was neither novel practice nor unproven technological territory. Photo-topographic techniques and surveying methods were initially developed and applied in the late nineteenth and early twentieth centuries by the Dominion Land Survey (DLS) under Surveyor General Edouard G. Deville and surveyors William Ogilvie, James J. McArthur, and Morrison P. Bridgland.⁵ They employed oblique-angle mountaintop photography and the laws of perspective in their work which made key contributions to mapping Canada's mountainous western regions. Their *ground-based* photographic technique also helped to delineate with accuracy and efficiency the international boundary with the United States for remote sections in the Northwest.⁶ Yet arguably photography's greatest benefits for surveying and mapping were about to be achieved through advancements in *aerial* photography.⁷

The rapid convergence of powered flight and airborne camera deployment during the First World War (1914-1918), concurrent with massive production of classified photographic evidence showing military frontline development,⁸ had no influence on the work of Canadian land and boundary surveyors while the conflict was still raging in Europe. But immediately after the war, assertions of the civilian potential of aeronautics and vertical aerial photography reverberated through political and professional circles in Ottawa. The Government of Canada reacted with the institution of the Air Board in 1919 to administer, among other aeronautical issues, the establishment of a network of air stations across the country and oversee flying operations using surplus military equipment and trained personnel of the Canadian Air Force. The Air Board relied on the advice of its Committee on Photographic Surveying from Aircraft, including Surveyor General Deville and IBC Commissioner McArthur, to identify experimental air survey missions and secure logistical support.⁹ The committee's recommendations were well-informed by members' experience with terrestrial photo-topography and the survey requirements of their respective departments. During the first full year of

Table 1: Experimental boundary-related aerial survey missions initiated by the Canada Air Board during the early 1920s

Year	Area	NAPL Roll	Frames	Scale	Source
1921	Johnstown, ON	H5	73	1:4,000	NAPL ¹
1921	Cornwall, ON	n/a	140	1:4,000	<i>Flight</i> (1922) ²
1921	Welland Canal and Niagara Falls, ON	H20, H21	150	1:6,000	Brock University ³
1921	St Croix River, NB	K3	20	1:4,000	NAPL ¹
1923	Manitoba-Ontario border	FA15-20	571	1:5,000	NAPL ¹
1924	Alberta-Saskatchewan border	CA49	27	1:20,000	NAPL ¹
1924	St Lawrence R., ON	H25, H26	198	1:9,000	NAPL ¹

¹ <https://www.nrcan.gc.ca/maps-tools-publications/satellite-imagery-air-photos/air-photos/national-air-photo-library/9265>

² "Map-making and aerial photography – Canada's use of the new method," *Flight* 28 September Issue (1922): 556.

³ <https://brocku.ca/library/collections/mdg/maps-geodata/air-photo-collections/>

aerial surveying operations in 1921, no less than four out of Canada's 7 border-related missions of the early 1920s were carried out along the international border with the United States (**Table 1**). The Ontario-based air stations supported three experimental surveys of sections along the St Lawrence River at Cornwall and Johnstown and along the Welland Canal and the Niagara Falls. The fourth one was designated to cover the locale of an apparent US-Canada boundary issue along the St Croix River¹⁰ (**Fig. 1**). The area was situated at the outer perimeter of the operating range of the Dartmouth Air Station.

Until the early 1900s the easternmost section of Canada-US border along the course of the St Croix River from its source to Passamaquoddy Bay had been insufficiently marked until the International Boundary Treaty of 1908 made provisions for the IBC to make a detailed survey. Article II of the Treaty stipulated that

the line of boundary through said river shall be a water line throughout and shall follow the centre of the main channel or thalweg as naturally existing, except where such course would change, or disturb, or conflict with the national character of an island as already established by mutual recognition and acquiescence.¹¹

Over numerous field seasons, survey teams determined the final location of the boundary by carefully sounding the river and drawing the line of the centre of the main channel on hydrographic charts. Boundary turning points were located such that the straight-line courses of the boundary joining the turning points formed a close approximation to the course of the channel. Boundary reference monuments were then set in appropriate locations along the river.¹²

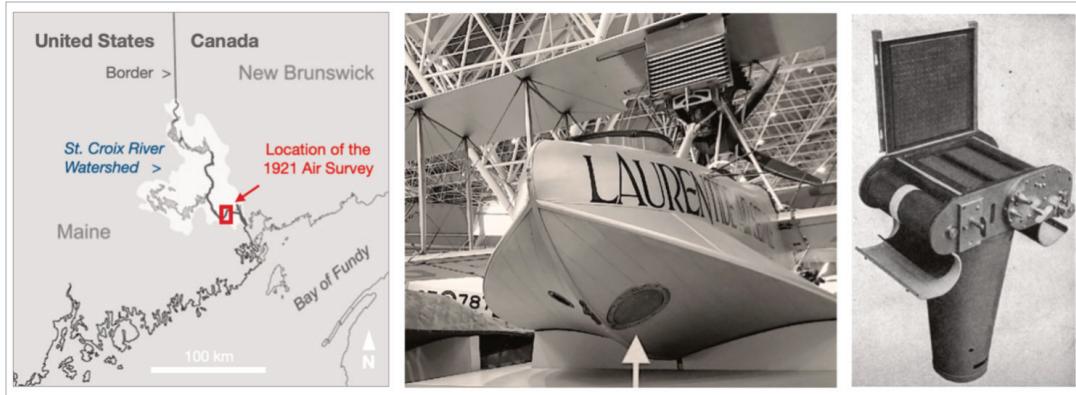


Figure 1. Location map of the 1921 St Croix air survey (left); Curtiss HS-2L flying boat (centre), on display at Canada's Aviation and Space Museum in Ottawa, with covered camera bay for vertical aerial photography (arrow); and Fairchild air photo camera model K-1, with roll film magazine, similar to the model used for the St Croix survey. Credits: Map modified after Wikipedia; photo by Dirk Werle; camera illustration modified after Herbert E. Ives, *Airplane Photography* (Philadelphia: JB Lippincott, 1920), 148

However, two turning points proved to be potentially contentious. Concerns arose regarding their placement with respect to two channels of nearly equal depth around Todd Island, a fragmented, partially treed outcrop of rock, some 80 metres in diameter and a few metres high. The island is located mid-river just below the Milltown bridge, from where the main St Croix manufacturing district extended to the international bridge at Calais and St Stephen. Curiously, the island was not identified at all on a detailed 1874 map of the Milltown and Salmon Falls area, although the location of half a dozen sawmills, including rail access, were clearly identified (**Fig. 2**). During the 1921 field season, the IBC commissioners for the United States and for Canada, E. C. Barnard and J. J. McArthur, decided that additional information and more detailed soundings were needed to determine on which side of Todd Island the main channel, or *thalweg*, was located. Subsequent survey work at a scale of 1:600 yielded 2,000 hydrographic measurements.¹³ It was only in 1934 that the IBC commissioners finally settled on Canadian ownership of Todd Island; they did so by agreement, after many attempts to determine the *thalweg* proved inconclusive.¹⁴

Toward the end of the 1921 field season, Shearer's aerial survey mission added further plan-view evidence of the problematic situation at Todd Island (**Fig. 3**). The official IBC Report of 1934 does not mention this survey or any use of aerial photography. The report itself is generously illustrated with ground-based photographs, some of which depict the multitude of structures around Todd Island during low- and high-water conditions in 1918 and 1920, respectively (**Fig. 4**). However, reference is made to an "unsatisfactory" attempt by a Canadian field party in 1919 to utilize photo-topographic means to map the terrain of Campobello Island on the Bay of Fundy, citing a lack of sufficiently high ground for the purpose.¹⁵ For the Canadian IBC commissioner this result was disappointing, but not entirely unexpected. If lack of high ground was the critical issue during the ground-based experiment, he also knew as a well-informed member of the Air Board's Survey Committee that mechanically produced *vertical* photos from a movable airborne platform could compensate for this insufficiency.

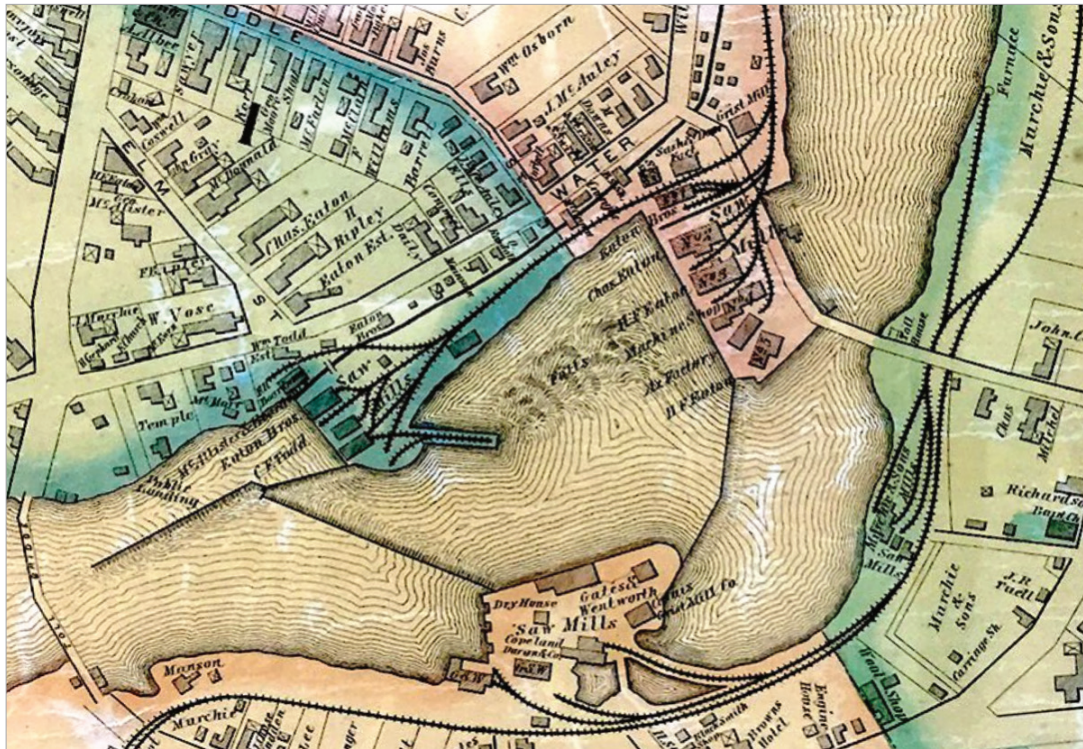


Figure 2. Section of the ‘Upper Milltown Dams Mills Salmon Falls and Toll Bridge’ map, dated 1874, devoid of any cartographic reference to Todd Island. See Figure 3 for air photo detail of the same area. Hatching signatures in the very centre of this section carries the annotation “falls” and coincides with locations “B” and “C” in Figure 3. Courtesy of the Calais Free Library, Calais, ME.

At the time, the involvement of photography-based survey technologies *per se* seemed rather unremarkable according to official IBC documentation of the St Croix boundary survey. There is no subsequent mention, let alone analysis, of the aerial survey to be found in other contemporary reports or in the learned literature. We can only speculate on how the aerial photographs may have been shared among survey parties and departmental officials; likely recipients of a limited number of printed copies include the professional staff of the Air Board and the IBC and possibly DLS in Ottawa.¹⁶ Given the paucity of information regarding the outcome and utility of the aerial survey, the main testimony of it consists of the actual air photos acquired by Shearer’s mission.

With hindsight, Todd Island and the Canadian air photo survey may have been literally a target and mission of opportunity. The process to determine object, extent and general time-frame for the photography and to direct necessary resources, equipment, and personnel toward its execution was strictly an institutional one. It involved CAB survey-committee members, notably J. J. McArthur, as well as Air Board staff in Ottawa and at the Dartmouth Air Station. The dispatch of the open-cockpit Curtiss HS-2L flying boat — strenuous as the passage may have been on crew and engine according to Shearer’s report — resulted in the desired coverage of Todd Island and an approximately five-kilometre-long section of the St Croix River.

A state-of-the-art Fairchild K-1 camera was deployed in the bow of the aircraft. The camera had a focal length of 12 inches and a roll-film magazine for approximately 100



Figure 3. Vertical aerial photograph taken in September of 1921, showing the St Croix River at low flow, Todd Island (at centre), and surrounding sawmill operations with complex waterborne boom arrangements to direct floating logs. This plan view illustrates the difficulty of ground-based surveying efforts to determine the main channel of the St Croix River and international boundary line at this locale. Letter annotations and arrow directions refer to ground photographs shown in Figure 4. (Note: For better depth perception of built-up objects, the air photo is oriented in such a way that the shadows are pointing toward the viewer.) Source: NAPL (1921 air photo K3-9)

7" by 9" exposures. During airborne operation the camera lens was pointing straight downward through a round opening in the fuselage (see Fig. 1). Based on factors involving area coverage, aircraft altitude and speed, and camera focal length, the camera operator determined the shutter-release intervals and shutter speed for the vertical photographs of the scene below. The resulting frames were aligned along two flight paths parallel to the southwest-northeast oriented course of the St Croix River between Milltown and St Stephen and Calais. The photo sequence of both lines started over the northeastern sector in a southwesterly flight direction (Fig. 5).

As it turned out, the first line was covered by nine consecutive photos and the second by eleven exposures with a forward overlap of approximately 30 to 50 per cent and sufficient side-lap between the two lines to avoid coverage gaps that commonly result from wind gusts and drift during flight.¹⁷ Judging from shadow direction the 20 photos were collected around noon, in a matter of 10 to 15 minutes, at intervals of 20 seconds between exposures. The large 1:4,000 scale of the vertical photographs relates to the relatively low aircraft altitude that was imposed by apparent engine problems. This circumstance may have effectively reduced area coverage, but it led to a gain in spatial detail captured by the camera lens and film. Ultimately, the curtailed photographic coverage beyond the primary area of interest — Todd Island — included the downstream section of the St Croix with its economically significant manufacturing district.

Although the practice of aerial survey photography was still in its infancy and experimental, the St Croix episode of 1921 already revealed distinct characteristics with

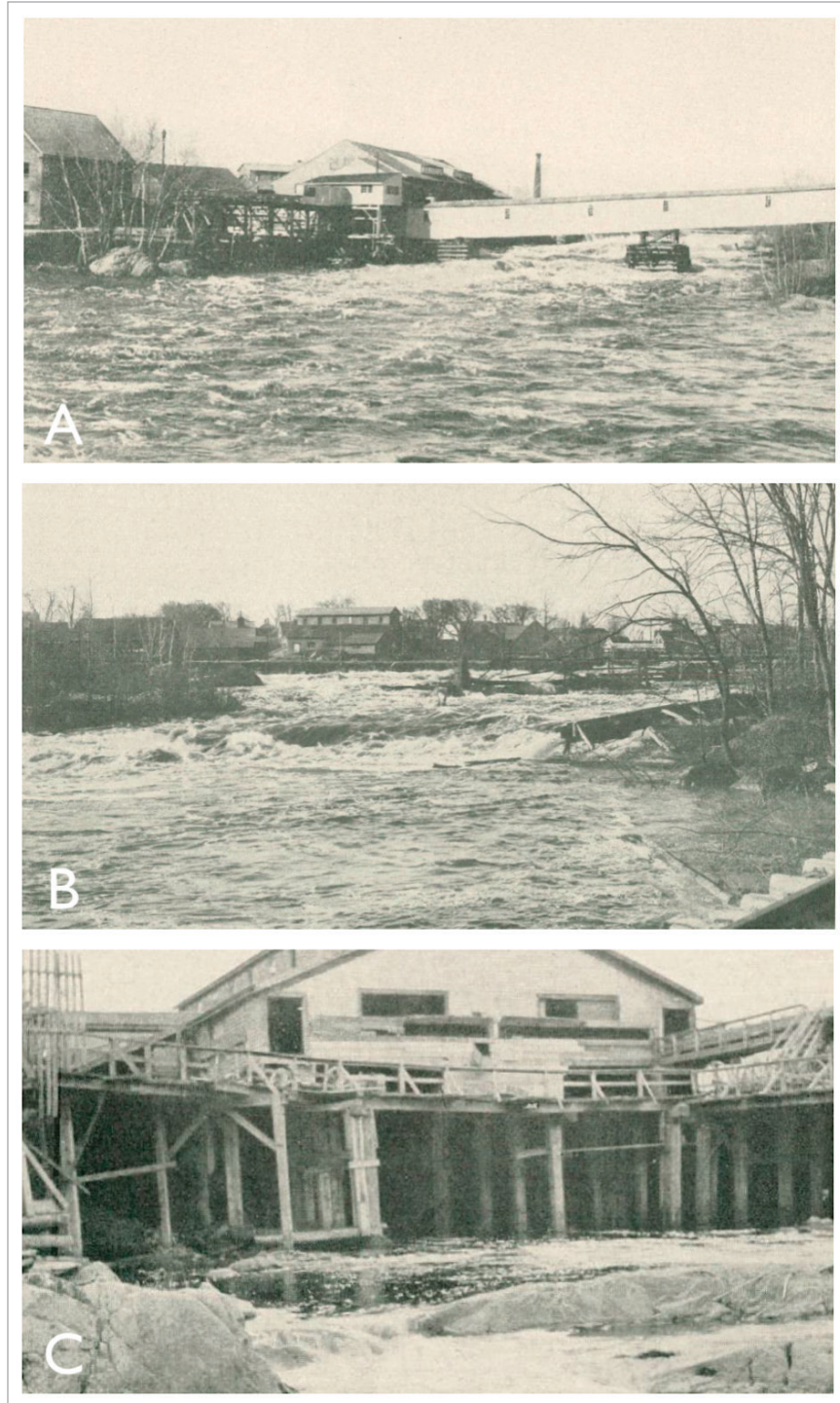


Figure 4. Ground-based photographs of sawmill operations and river flow conditions around Todd Island during high water (A, B) in 1920 and low-water (C) in 1918. The locations of the three photos are indicated in Figure 2. Photo A shows the channel eventually designated as the main channel on the IBC boundary map. Photo B shows the channel along the western side of the Island. Photo C illustrates the difficulty of obtaining hydrological measurements at Todd Island since part of the secondary channel was occupied by a Canadian sawmill operation on wooden pylons. (Source of photography: IBC 1934 St Croix Boundary Report)

respect to conventional ground-based methods, including rapid data collection and detailed photographic results. In addition, the stereoscopic record encapsulated another potential store of information: the three-dimensional model of photographed terrain, vegetation cover, and buildings. The principle of photo stereoscopy was well understood at the time, but not fully exploited for topographic map-making.¹⁸ Yet, stereoscopy can still convey three-dimensional spatial information for portions of the St Croix air photo set to an observer today, even though many of the industrial buildings and installations have since disappeared on the ground (**Fig. 6**).

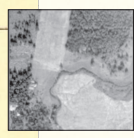



A set of black-and-white contact paper prints of the 20 air photos eventually found its way into the National Air Photo Library (NAPL). NAPL was instituted by Canada in the 1920s as a public archive of indexed federal aerial photography and repository of related historical records, such as the legacy photography of the Canada Air Board of the early 1920s. The 1921 St Croix air photos were catalogued under Roll Number K3, one of the earliest on record at the NAPL. A hand-written note on the storage canister indicates that the original silver-nitrate film negatives of the roll no longer exist¹⁹ The surviving, second-generation contact prints are of remarkable quality and devoid of any markings of detached emulsion, crackling, pin pricking or fading, which suggests that they have not been used for stereoscopic analysis procedures or open display for any length of time. Together with the Halifax air survey conducted in Nova Scotia during March 1921, the St Croix boundary survey later that year constitutes one of the earliest air-photo missions in the Maritimes.²⁰

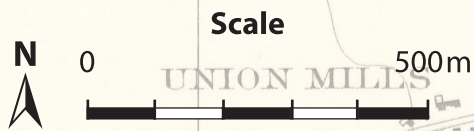
The NAPL acquisition also changed the status of the St Croix photographs. It was no longer solely an experimental set of vertical air photos acquired at the behest of a government institution in support of international boundary surveying, but a photographic record accessible to the public-at-large. By the same token, the original focus of attention on the Todd Island locale faded; even the original scope for acquiring the air photo set became obscure, as there was no ancillary information added to the photography itself, other than a penciled note “St Croix. N.B.” and an alpha-numeric code for the purpose of archival indexing.²¹ In order to obtain an overview of the aerial survey and the objects of its photography, it is necessary to reconstitute the individual air photos in mosaic form. This allows for detailed inspection and comparison of thematic content, for stereoscopic analysis of pairs of overlapping photos, and for attaining a synoptic view, or *vue d'ensemble*, of the St Croix riverine landscape.²²

During the nineteenth and early twentieth centuries, the St Croix became the home of an important and unique *inter*-national community that relied historically on the rich forest and water resources of the watershed. Residents on either side of the river established a common and interdependent waterway culture. Economic capacity and civic pride found visual representation during the late 1870s in the form of a detailed, panoramic bird's eye view of the main manufacturing district between Calais-St Stephen-Milltown.²³ The development and management of early railroad lines, wharf and shipping facilities, a large cotton mill, numerous sawmills, and other lumber-industry infrastructure along the river were, in large part, international efforts. They involved multiple levels of government and private industrial interests on both sides of the Canada-United States border.²⁴ Covering essentially the same area, the air photo

Reassembled Mosaic of the 1921 St Croix River Air Photo Mission

Air Photo Interpretation Key

-  **Land cover, land use**
Wooded areas
Agricultural fields
Small water course
-  **Town, rural settlement**
Homesteads
Road network, traffic
Trees and green spaces
-  **Waterfront**
Wharfs, warehouses
Sailing vessels at dockside
IBC Turning Point (in red)
-  **Infrastructure**
Water power generation,
Rail yard, roundhouse
Maintenance buildings
-  **Manufacturing industry**
Cotton mill, factories
Power generation plant
River, floating timber
-  **Lumber industry**
Saw mill operations
Log rafts along the river
Lumber yard and rail line

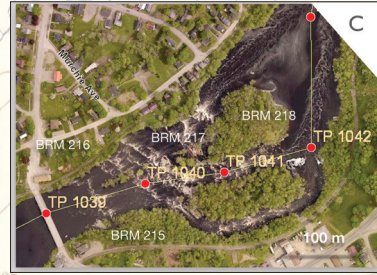


Sources of Geospatial Data

1934 boundary map and satellite imagery:
International Boundary Commission, IBC
www.internationalboundarycommission.org
Historical air photos K3 #1-20, 1921: National Air
Photo Library, NAPL (Canada)

Todd Island Boundary

- A 1921 Aerial photography
- B 1934 IBC map
- C 2015 GeoNB imagery and IBC Map



Sources: IBC, NAPL, GeoNB

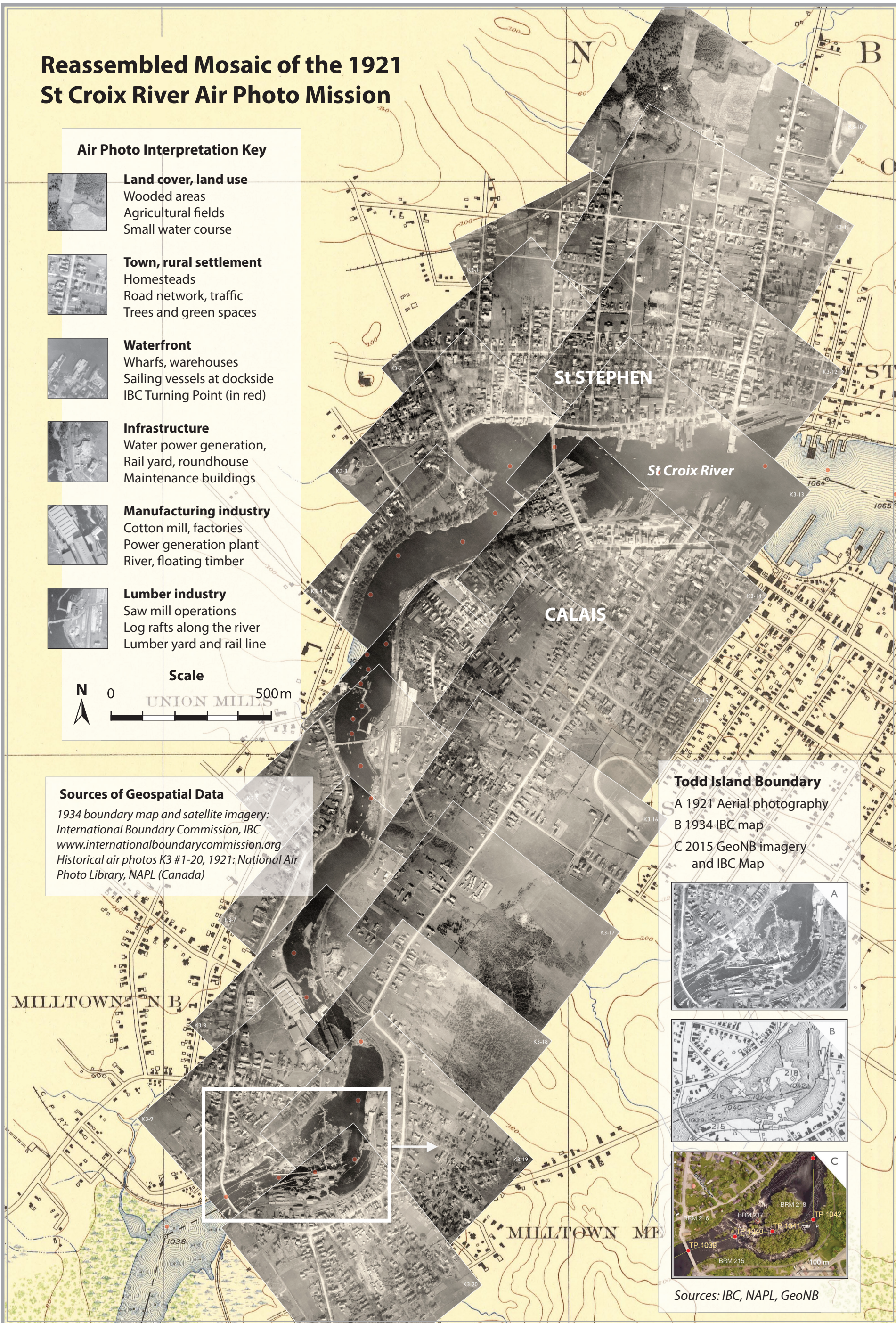


Figure 5. Digitally (re-)composed photo-mosaic of the 1921 St Croix air survey mission, with annotation, displayed against the 1934 IBC boundary map for the river section between Milltown and St Stephen in New Brunswick, Canada, and Milltown and Calais in Maine, United States. Boundary turning points are marked in red. Inserts A, B and C detail 1921 air photo, 1934 IBC boundary map and 2018 digital photography representations of the Todd Island area, respectively. Sources and Credits: NAPL (aerial photography, Roll K3, No.1-20) and IBC 1934 S., St Croix Boundary Report; research and composition by Dirk Werle



Figure 6. Stereopair of 1921 aerial photographs (left, centre) displaying a heavily industrialized section of the St Croix River near Union Mills, with log rafts (1), log booms and spillways (2), power generating facilities (3), railroad network and roundhouse construction (4), lumber yard (5) and lumber storage piles, and rural farmstead (8). The colour image (right) shows the same area in 2015; power generating facilities are still in place, with the addition of a transformer station (7). Source: NAPL (1921 air photos K3-7, K3-8) and IBC – Geo.NB (2015 colour image).

mosaic of the 1921 aerial survey, referenced against the 1934 IBC boundary map (**Fig. 5**), can be seen as a early twentieth-century photographic counterpart to the graphic 1879 panorama.

The mosaic displays in detail the main land-use and land-cover features within the heavily industrialized corridor along the river, the buildings and street network of the town centres, and individual homesteads of surrounding rural settlements. While the economic might of the community had passed its peak, the photography of the early 1920s still captured much of the extensive infrastructure dating back to the late nineteenth-century lumber boom. Examples include spillways and dams, electricity generation by means of waterpower, and railroad lines on both sides of the river, with maintenance yard and roundhouse on the American side (**Fig. 6**). Power grid and transportation networks connect the main installations of the manufacturing and lumber industries. They include large rectangular buildings of the cotton mill at Milltown, NB and a series of sawmill operations along the river. Large stockpiles of lumber and rail shipments provide evidence of the productivity of the latter (**Fig. 7**). The importance of lumber export and trans-shipment is captured in air photos of the waterfront at the border-towns of St Stephen and Calais, where a four-masted sailing vessel awaits

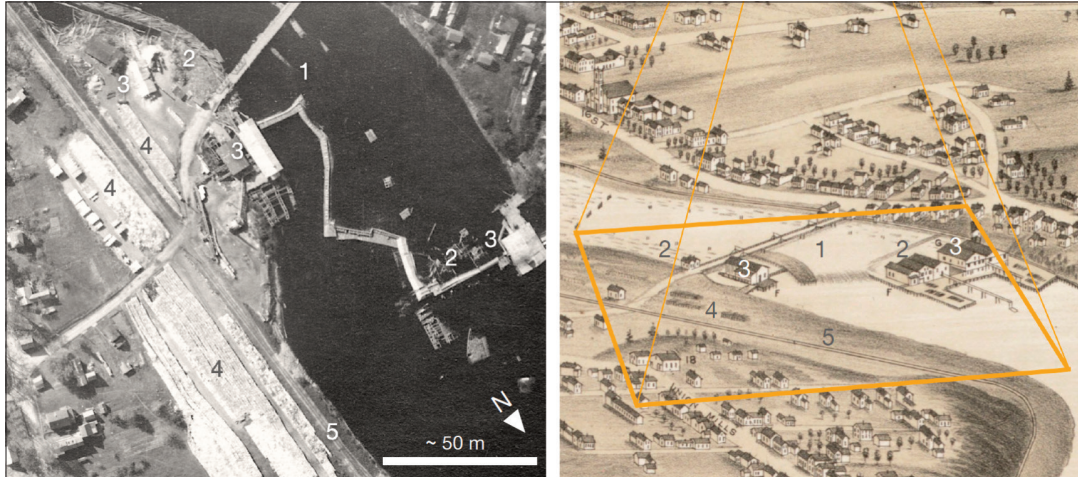


Figure 7. Detail of the 1921 aerial photography (left) and excerpt of the 1879 bird's eye view panorama (right), with footprint of the former indicated; both reveal American and Canadian lumber industry activities on either side of the St Croix River below Union Mill Bridge (1), including log rafts and booms (2), sawmill operations (3), extensive lumber storage yards (4), and railroad connection (5). Source: NAPL (1921 air photo K3-8) and Archival Collections of the Boston Public Library (1879 panorama).

loading at a major wharf complex that also serves as a multi-track rail terminus (**Fig. 8**). The mosaic captured industrial assemblages and river use features of the early twentieth century that no longer exist today.

Irrespective of the original intent to support the IBC activity of boundary *line* determination at Todd Island in 1921, the extended vertical air photo coverage of the St Croix represented a novel tool to assist with *area* mapping of the Canadian and American borderland. This quality apparently was of little immediate value to the IBC field survey crews for completing their assignments at the time. By the same token, there is no evidence to suggest that any analysis and interpretation of the Todd Island air photos had any influence on the IBC commissioners' determination in 1934; their discretionary agreement on crucial turning point locations effectively closed the case in Canada's favour with respect to the nationality of the island. Lacking official acknowledgment and documentation of their impact at the time, the experimental air photos were likely archived and rendered obscure for decades.

One hundred years later, the episode of the 1921 aerial-survey mission and the recovered photography of the St Croix boundary gain significance as a pioneering activity and status as a legacy dataset. Looking back at the technological and institutional development of vertical aerial photography and its surveying and mapping applications, Canadian experiments for mapping the country during the early 1920s established practices and standards that persisted throughout the twentieth century. Aside from their historical value, the air photos also retain practical usefulness on account of their downward-looking perspective, stereoscopic-modelling option, and map-like representation. Similar to the appraisal of century-old photo-topographic plates and recent imagery from the Rocky Mountain Repeat Photography Project,²⁵ the St Croix air photos can be re-composed into photo-mosaics, scaled and compared to equivalent sets acquired decades later. However, the process of their composition, analysis and image



Figure 8. Vertical aerial view of the St Stephen (1) and Calais (2) waterfront area along the St Croix River (3) showing past and present locations of wharf installations (4), berthed vessels (5) and tidewater levels toward the International Bridge (6). The semi-transparent renditions of the 1921 and 2015 imagery are overlaid digitally on the 1934 IBC boundary map of the area. Sources: NAPL (1921 air photo K3-13), IBC (1934 St Croix Boundary Map Sheet 13), IBC – Geo.NB 2015 (Digital Ortho Image St Stephen 24383E73546N)

interpretations is inherently complex, and the scientific approach to repeat photography requires careful consideration of the original intentions of the photographs.²⁶ For the St Croix boundary area, vertical air photos dating back to the mid-1930s, 1940s, and early 1970s are accessible at Canada’s NAPL, albeit at smaller scales.²⁷ In 2015, the Government of New Brunswick commissioned high-resolution digital remote-sensing images for the area (**Figs. 4 and 6**).²⁸ Remarkably, this set also serves as the current geospatial reference for the IBC’s official delineation of the Canada-United States boundary on the St Croix, thus acknowledging the importance and value of modern remote-sensing techniques and geospatial products for border demarcation and maintenance.²⁹

The remotely sensed nature of the air photos taken during the 1921 mission signified a departure from the ground-based, labour-intensive surveying method of the day in yet another way. The IBC’s official report of the St Croix boundary survey singled out one debilitating event in 1918, when the field season and surveying work came to a sudden end. Several members had become infected with the Spanish Flu virus, which “crippled the work so completely that on October 15 the party was disbanded, and the outfit was stored for the winter.”³⁰ In 1921, with engine troubles under control, Ambrose Shearer’s small crew of the HS-2L flying boat completed their pioneering aerial survey in a very short time and safely returned to base, without encountering the perils and deprivations that can afflict survey parties working on location for many months.

By the time the twentieth century ended 80 years later, mission planners, pilots, and camera operators had added more than six-million air photos to Canada's National Air Photo Library in support of surveying, mapping, and monitoring programs across the entire country.

Dirk Werle studied geography and remote sensing at Universität Trier, Germany, and McGill University, Canada during the early 1980s. His career as a geoscientist with Ærde Environmental Research in Halifax, Nova Scotia has since focused on the application of modern satellite imagery for natural resource analysis and environmental monitoring.

Endnotes

- 1 S. Bernard Shaw, *Photographing Canada from Flying Canoes* (Burnstown, ON: GSPH, 2001).
- 2 Shaw, *Photographing Canada*, 24; Squadron Leader A.B. Shearer submitted weekly reports as Superintendent of the Dartmouth Air Station to his superiors at the Canada Air Board in Ottawa; copies are retained at the Shearwater Aviation Museum Library and Archives in Shearwater, NS.
- 3 Sean Seyer, "Walking the line – The international origins of civil aviation regulations in Canada," *Scientia Canadensis* 38, no. 2 (2015): 79-89, (<https://doi.org/10.7202/1037948ar>); William J. McAndrew, "The evolution of Canadian aviation policy following the First World War," *Journal of Canadian Studies* 16, no. 3/4 (1981): 86-99, (<https://doi.org/10.3138/jcs.16.3-4.86>).
- 4 The approach follows Joan M. Schwartz and James R. Ryan, eds., *Picturing Place: Photography and the Geographical Imagination* (London: I.B. Tauris, 2009).
- 5 Edouard Deville, *Photographic Surveying, Including the Elements of Descriptive Geometry and Perspective* (Ottawa: Government Printing Bureau, 1889); Ian S. MacLaren, with Eric Higgs and Gabrielle Zezulka-Mailloux, *Mapper of Mountains: M.P. Bridgland in the Canadian Rockies 1902-1930* (Edmonton: The University of Alberta Press, 2005).
- 6 Andrew Birrell, "The North American Boundary Commission: Three Photographic Expeditions, 1872-74," *History of Photography* 20 (1996):113-121; Andrew Birrell, "Survey Photography in British Columbia, 1858-1900," *BC Studies* 52 (Winter 1981-1982): 39-60; Christopher Petrakos, "William Ogilvie, the Klondike Borderlands and the Making of the Canadian West," *American Review of Canadian Studies* 46, no. 3 (2016): 362-379. James A. Eason, "When Narrative Fails: Context and Physical Evidence as Means of Understanding the Northwest Boundary Survey Photographs of 1857-1862," *Journal of Contemporary Archival Studies* 2 (2015), doi:10.1080/02722011.2016.1217895. For an account of aerial reconnaissance in the Rocky Mountains during the 1920s see Dan Smith, "Those magnificent men and their flying machines: Aerial reconnaissance in the Alberta Rocky Mountains during the 1920s," *Western Geography* 7 (1997): 73-96.
- 7 An illuminating examination of survey and geographic uses of high-altitude photographic images in Canada between the 1880s and 1960s is provided by Matt Dyce, "Canada between the Photograph and the Map: Aerial photography, Geographical vision and the State," *Journal of Historical Geography* 39 (2013): 69-84; a comprehensive historical account is contained in Don W. Thomson, *Men and Meridians: The History of Surveying and Mapping in Canada, Volume 3, 1917 to 1947*, (Ottawa: Department of Energy, Mines and Resources, 1969); see also Don W. Thomson, D.W. (1975) *Skyview Canada: A Story of Aerial Photography in Canada*. Ottawa: Department of Energy, Mines and Resources, 1975) and Shaw, *Photographing Canada*, 1.
- 8 Terrence Finnegan, *Shooting the Front: Allied Aerial Reconnaissance in the First World War*, (Stroud, UK: Spellmount /The Historic Press, 2011), 97-116.
- 9 Initial activities of the Board were documented in Air Board, *Report of the Air Board for the Year 1920*. (Ottawa: King's Printer, 1921) and Air Board, *Report of the Air Board for the Year 1921*. (Ottawa: King's Printer, 1922); other survey committee members included the Director of Forestry, the Commissioner of Dominion Parks and the Superintendent of the Geodetic Survey; correspondence in support of photographic survey activities are archived by the Directorate of History and Heritage (n.y.) *Royal Canadian Naval Air Service*, File # 77/58, Box 1, Vol. 3, Aerial Survey. For a review of aviation policy after the First World War, including aspects of survey photography, see MacAndrew, "Canadian aviation," 86-99.

- 10 Following Douglas M. Johnston, *The Theory and History of Ocean Boundary Making*, (Kingston and Montreal: McGill-Queen's University Press, 1988), the term "boundary issue" is used here, as it relates directly to the basis of allocation or the specific criteria to be applied to the act of delimitation.
- 11 "Treaty between the United States of America and the United Kingdom Concerning the Boundary Between the United States and the Dominion of Canada from the Atlantic Ocean to the Pacific Ocean." Signed at Washington, April 11, 1908; Article II "The Boundary from the mouth to the source of the St Croix River".
- 12 International Boundary Commission, *Source of the St Croix River to the Atlantic Ocean*, (Washington: US Government Printing Office, 1934) Sectional report and original record of the boundary survey under the treaty of 1908; it was published following the acceptance of the survey of each section by the respective Governments.
- 13 IBC, *Source of the St Croix River*, 59
- 14 Michael O'Sullivan, "The Work and Value of International Boundary Commissions: The American Experience," *IBRU Boundary and Security Bulletin*, 9, no. 3 (2001): 86-93. In the past, the United States and Canadian IBC commissioners managed to eliminate issues or anomalies from the boundary description by agreement on three occasions, Todd Island included, before a case could lead to dispute.
- 15 IBC, *Source of the St Croix River*, 59 and 66.
- 16 N. C. Stewart, "Surveying from the Air," *Journal of the Royal Astronomical Society of Canada* 25, no. 4 (1931): 153-165. Regarding early development of aerial photography in Canada, Stewart noted that "every scheme with the slightest chance of success was tried out," 158.
- 17 The staggered footprints of the air photos are indicative of a significant amount of crosswind from a westerly direction during flight, for which the pilot had to compensate by pointing the aircraft slightly into the wind in order to follow the designated flight lines. As the camera mount was in fixed alignment with the aircraft fuselage, the actual drift angle at the instant of photo exposure is manifested in the "crabbing" pattern of the St Croix air photo coverage. There is a small drift-related coverage gap of the river at Union Mills, approximately half-way through the first flight line.
- 18 For further discussion of the Canadian experience see Dyce, "Canada between the Photograph and the Map,": 8-80. For a discussion of stereoscopy as medium and metaphor of knowledge see Christoph Ernst and Jens Schroeter, "Die Stereoscopie als Medium und Metapher des Wissens," *Augenblick – Konstanzer Hefte zur Medienwissenschaft* 62/63 (2015): 58-71.
- 19 The air photos of the St Croix survey of 1921 are catalogued under Roll Number K3, photos 1-20 (NTS map sheet 21G3) at NAPL from where high-precision 300dpi scans of the photos were ordered and utilized to produce an uncontrolled digital mosaic; as of 2020, there was no entry of the 1921 St Croix air photos in the Government of Canada's Earth Observation Data Management System (EODMS) that offers online access to the metadata of half of the six-million air photos at NAPL (https://www.eodms-sgdot.nrcan-rncan.gc.ca/index_en.jsp); for further detail on NAPL see Kim Carbonetto, "The National Air Photo Library," *Urban History Review / Revue d'histoire urbaine* 12, no. 1 (1983): 67-72. <https://doi.org/10.7202/1018997ar>.
- 20 Dirk Werle, "Early aerial photography and contributions to Digital Earth — The case of the 1921 Halifax air survey mission in Canada," *IOP Conference Series: Earth and Environmental Science* 34 (2016): 012039, <https://doi.org/10.1088/1755-1315/34/1/012039>; Dirk Werle, "Historical air photo missions in the Maritimes during the early 1920s: Coverage, thematic scope, and utility 100 years later," *Proceedings Nova Scotia Institute of Science* 51, no.1 (2021): 145-167, <https://doi.org/10.15273/pnsis.v51i1.10780>.
- 21 Generally, the analog practice of archiving an entire set of air photos frame-by-frame in affects its spatial cohesiveness, but index maps and modern tools, such as online geographic information system (GIS) technology, can assist in visualizing both the fragmented nature and the general outline of vertical air-photo coverage.
- 22 During the First World War, French reconnaissance experts used air photo mosaics to attain a comprehensive view, the coveted *vue d'ensemble*, for an area or region of interest. Their air photo analysis approach involved interdisciplinary teams whose methods, techniques and documentation were recognized as the standard among Allied military surveillance personnel; after the war, geographers, surveyors, and photo interpreters continued to play a prominent role in shaping thematic directions and practice of aerial photography. See Jeanne Haffner, *The View from Above—The Science of Social Space*, (Cambridge and London: MIT Press, 2013); Marie-Claire Robic, "From the sky to the ground: The aerial view and the ideal of the *vue raisonnée* in

geography during the 1920s,” in Mark Dorrian, and Frédéric Pousin, eds. *Seeing from Above – The Aerial View in Visual Culture*, (London and New York: I.B. Tauris, 2013) 163-187; Serge Reubi, “Die Entzauberung der Welt? Luftfotographie und die Sozialwissenschaften im Frankreich der Zwischen-kriegszeit,” in *Geschichte der Sozialwissenschaften im 19. und 20. Jahrhundert*, eds. F. Link and U. Dörk, (Berlin: Duncker & Humblot, 2019); and Finnegan, *Shooting the Front*, 7.

- 23 “Panoramic View of the City of Calais, St Stephen, and Milltown 1879” (Madison: J.J. Stoner,); 46 cm x 67 cm.
- 24 Harold A. Davis, *An International Community on the St Croix (1604-1930)*, (Orono: University of Maine Press, 1974); see also St Croix International Waterway Commission, *St Croix International Waterway: A Heritage — A Future Plan for Long-term Cooperative Management of the St Croix International Waterway*, (St Stephen and Calais: St Croix International Waterway Commission, 1993).
- 25 MacLaren, *Mapper of Mountains*, 211-263.
- 26 Karla McManus, “Objective landscapes: The mediated evidence of repeat photography,” *Intermedialité/ Intermediality* 17 (2011): 105-118.
- 27 Canada’s NAPL and EODMS have archived vertical air photos for the Milltown – St Stephen – Calais area under Roll Nr. A5090 #58-60 for 1935; Roll Nr. A8363, #10-11 for 1945, and Roll Nr. A23858, #250.
- 28 The Province of New Brunswick provides access to orthorectified digital aerial imagery through its GeoNB Map Viewer at <https://geonb.snb.ca/nbimagery/index.html>.
- 29 The official website of the International Boundary Commission [internationalboundarycommission.org](http://www.internationalboundarycommission.org) contains a collection of geographical data in the form of boundary maps and coordinates; a digital boundary map of high-resolution satellite imagery and turning point markers of the Canada - United States border is available at http://www.internationalboundarycommission.org/mb/IBC_CFI-eng.php. The orthorectified digital aerial imagery of the Milltown-St Stephen area were acquired May 14, 2015 at a spatial resolution of less than 10 centimetres.
- 30 IBC, *Source of the St Croix River*, 59.

Note: All websites mentioned in the Endnotes were accessed in December 2020.