PROVINCE OF NEW BRUNSWICK

ENVIRONMENTAL TRUST FUND (ETF)

FINAL REPORT: Project No.: 140223

Developing new wet-areas mapping tools for hydrological risk assessments and planning

We continued assisting the Province and wet-areas mapping (WAM) partners in assessing and classifying potential hydrological risks (coastal and inland flooding, erosion) to soils and infrastructure using provincial and local data layers. This is to be done using hydrographically corrected digital elevation data including LiDAR point cloud data where available. At this stage, we:

- Built a province-wide wet-areas mapping database across New Brunswick, at 10 m resolution. Some of the results were submitted to NB Environment as part of the wetland delineation mapping effort as part of the NB-wide wetland mapping process. This new map places all known wetland locations into their local hydro-topographic locations and flow connections. The outcome is a wetland layer that shows the wetland to upland gradations at all locations, and defines the watershed area and flow channels associated with each wetland. The latter information is important to know how much water is flowing through the wetland in relation to specific high-flow weather events.
- Presented our mapping results at several wetland-focus and flood risk assessment sessions with NBELG and other wet-areas mapping partners.
    - Sept. 29. 2014 Meeting to discuss wet areas mapping and flood hazard mapping.
    - Sept. 24, 2014. Meeting to discuss wet areas mapping and flood hazard mapping from Sussex Corner, NB.
    - July 24, 2014: Beta Map - Validate use of UNB's Potential Wetland layers.
    - July 10, 201: Wetland Delineations this summer - Verification Documents.
    - June 23. 2014: ETF Project: Visualizing Hydrographical Relationships between Wetlands and Urban Structures using LiDAR-based Wet Area Mapping.
    - Oct. 28. 2014: ESRI User Conference, Fredericton (see abstracts below).

- **We revised our existing wet-areas maps for Fredericton, Moncton, Memramcook, Miramichi, Sussex Corner, Bathurst and Quispamsis** due to (i) new advances in wet-areas mapping (truer delineation of flow channels and depth-to-water in flat areas), and (ii) provision of hydrological infrastructure data layers (storm water system, culvert locations wetland delineations). The information of this infrastructure varies from highly detailed, as for Fredericton and Moncton, to acquiring (Sussex Corner, Memramcook, Bathurst), to absent. Information like this is being retrieved through further ETF funded wetland delineation and ground verification by way of the ETF-funded projects with NB City Association, Sussex Corner.

- **Our LiDAR-based mapping process was further improved to achieve greater local accuracy and precision through:** (i) improved tracking of wetland borders across wetlands, (ii) polygonization of wetlands within the stream-wetland continuum, (iii) fine-tuning LiDAR-based road recognition, (iv) breaching flow across flow blockages, e.g., roads, and data artifacts along flow channels, (v) added hydrological connectivity among stream segments across LiDAR tile borders. Our processes involve extracting and deriving the following data layers from LiDAR point clouds: (i) bare-ground elevation, (ii) vegetation height, (iii) cartographic depth-to-water below the soil surface, (iv) seasonally expanding and shrinking flow-channel networks based on varying the minimal upland contributing area for flow initiation within the flow channels, (v) slope, depressions, toe slopes, seepage areas and topographic indices. With these data layers, the mapping effort expands by addressing
    - i. habitat and habitat connectivity,
    - ii. vegetation distribution in and around wetlands,
    - iii. vegetation moisture preferences across landscapes,
    - iv. treed and non-treed vegetation and green spaces in urban areas,
    - v. soil trafficability;
    - vi. routing water flow and natural flow channels and ditches based on local hydrological infrastructure specification and related inland and coastal flooding potentials.

We were:

- **Engaged with Communities through workshops**: Sussex Corner, and Fredericton presentations through workshop presentation, and further communicated with community representatives and NGOs in southwest New Brunswick (St. Stephen, St. Andrews, Sussex Corner, Miramichi, Bathurst, Moncton, Acadian Peninsula, Sackville, and the Upper Saint John Valley (c/o M. McLeod, Sussex Corner; D. Roussel, City Association).
- **Developed a comprehensive NB road vulnerability risk index** with regard to inland and coastal flooding from a climate change adaptation perspective. This work still needs to be summarized in terms of road vulnerability, with specifications pertaining to the lengths and types of roads that would be subject to coastal inundation as well as related wear and tear in relation to coastal vicinity and elevation. This project also builds a foundation for a larger analysis which seeks to address the impact of climate change on the optimal scheduling of the maintenance, repair and replacement of provincial transportation infrastructure. This analysis will feed into the NB Department of Transportation and Infrastructure's (DTI) Asset Management Planning Tool, in communication with NB DTI, and NB DELG.
- **Continued building user-friendly ArcMap tools** that will allow GIS specialists and resources planners to take advantage of the newly developed datalayers in view of some of the above mapping themes. The tools that are becoming available refer to the following items (c/o UNB WAM team).
    - **BLOCK.** An emergency response visualization / planning tool to assess likely flood levels if storm water is blocked (i) upslope of roads due to culvert blockade or insufficient flow capacity, (ii) upslope of stream and rivers if blocked by ice jams, or other structures. Current stage: user specifies xy location of blockage, computer zooms to this location, and gathers the needed map layers (DEM, flow accumulation, depth-to-water, etc.), (iii) user blocks the flow digitally across the locations, (iv) computer maps and quantifies the extent and amount of water building up above the blocked location.

- **SPILL**. An emergency response visualization / planning tool to determine likely contaminant spill path and access planning towards spill containment sites at surface, due to (a) train derailments, (b) container over turn along transport routes. Current stage: user specifies xy location of spill, computer zooms to this location, and gathers the needed map layers (DEM, flow accumulation, depth-to-water, etc.), (c) computer traces likely flow path, and estimates time of spill progression; spill progressions depends, e.g., on slope, channel width, volume of depressions to be encountered, etc. User would interpret the outcome and decides on best locations to contain and trap contaminant.
- **TRAIL.** A visualization / planning tool to decide on the best route for trails or roads by avoiding flow channels, wet areas, steep slopes, etc. within the added constraints of ownership, terrain conditions, and user-stated constraints. Current stage: user specifies area of interest as well as start and end of desired route, computer zooms to this location, and gathers the needed map layers (DEM, flow accumulation, depth-to-water, etc.), (c) computer traces likely route based on user-stated preferences and risk avoidance levels, (d) user repeats the process by varying the preference and avoidance levels, (e) computer stores all the results and provides an .xls table profiling each route to enable route-to-route comparisons and final route selection.
- **NB-WAM**. A database that provides the essential data frame for the above tools, by including: NB-wide data layers re. hydro-graphically correct DEM, flow-accumulation, flow channels (starting with 4 ha as flow initiation), cartographic depth-to-water later . New layers to be added involve, all at 10 m resolution: NB-wide floodplains, hydrographically corrected soil map, wetland map with flow connections and catchment areas above wetland outlets, provincial road map with catchment areas above road-stream crossings; a vegetation community index map by soil moisture preference (developed for parts of Alberta by Doug Hiltz, MScF UNB, to be applied to NB).
- Added map interpretations regarding soil wetness, and related distributions of plant communities by soil moisture regime preferences.

Much of this work was done by two GIS analysts (Jae Ogilvie, Mark Castonguay; part-time), one GIS Programmer (Hua Kim Wen), one specialist in programming ArcMAP user interfaces, and 3 graduate students involved with LiDAR wet areas mapping and related field work as follows:

- wetland and vegetation occurrence mapping (Monique Goguen, MScF candidate, UNB)
- soil trafficability, trail routing, and soil erosion along roads (Mary-France Jutras, PhD candidate, UNB)
- inland and coastal flood risk mapping, with and without local hydrological infra-structure in place (Shane Furze, PhD candidate, UNB)
- municipal wetland delineations (Tanner Segouspe, MEM candidate, UNB)
- This work was further be assisted by 3 summer students (Friedrich Wuthrich, Matthew Bolton, Clara Dennis). The summer students assisted with GIS work and related image and field verifications re. tool parametrization (verification of tree heights, soil conditions along trails, flow channel parameters, flooding extents).

The GIS programmers and specialists assist in finalizing the above-mentioned GIS tools, including tool descriptions. The tools will become available to the general public through license agreements. The students assisted in building NB-WAM as outlined above and the NB road vulnerability risk index. Students and GIS analysts also assist in workshop presentations and delivery.

The above mapping activities have been identified as useful contributions to currently on-going planning activities from urban to rural settings, and from various perspectives: forest, park and wildlife management, urban developments, conservation of natural resources, increasing potential for outdoor recreation while minimizing environmental damage, and climate change adaptation. The project therefore continues assisting provincial, municipal authorities and NGO's as well as others to scope, evaluate, classify, plan and determine extent of hydrological risks in view of pending threats ranging from coastal and inland flooding to slope instabilities. The maps also serve to visualize and evaluate the extent of areas affected by local flooding, contaminant dispersal, and other hazards. At the same time, the geomatics and science of producing these maps and related tools further advance through research and feedback from partner-conducted surveys and tool use. In summary, the project will assist provincial, municipal authorities to scope and evaluate hydrological risks at 1 m resolution in view of

- existing or contemplated developments,
- LiDAR improved GIS-based wetland delineations and wet-area mapping in general,
- assessing and evaluating pending environmental threats, ranging from coastal to inland flooding to local slope instabilities.

Participation at Esri Canada User Conference – Fredericton, Oct. 28, 2014.

Furze, S. UNB PhD Candidate: Improving the province-wide DEM for New Brunswick

Abstract: This presentation focusses on improving New Brunswick's provincial digital elevation model (DEM) by using several DEM coverages for the province (geoNB elevation, SRTM, ASTER, CD_DEM) and using LiDAR-generated DEMS for selected areas as elevation reference. The quality, resolution and accuracy of the non-LiDAR DEMs vary with vertical errors in the range of ± 30m, but only ± 15 cm for open-area LiDAR-DEMs. The non-LiDAR errors were in part due to errors in (i) the vertical alignments of the original DEM tiles, (ii) the alignment of the original elevation points along straight lines, and (iii) the fact that the photogrammetric elevation delineations reflect canopy height rather than bare ground elevations. Through various DEM weightings, we were able to improve the vertical accuracy of the resulting NB-wide DEM to within 2 m of the LiDAR DEM.

Jones, M.F. Creating a Temporal and Spatial Soil Hydrothermal and Operations Model

Abstract: This presentation deals with the current integration of a temporal and spatial model to create an all-inclusive modeling tool which could visualize soil hydrothermal and forest operation risk maps. The temporal variations are modeled at daily resolution based on air temperature and precipitation (rain, snow) data via the Forest Hydrology Model (ForHyM). The spatial variations are derived from LiDAR-generated bare-ground elevation surfaces at 1 m resolution by way of the depth-to-water index (DTW). This project utilizes outputs from ForHyM as primary inputs for soil trafficability models created in ModelBuilder. The goal is to produce a temporal user-friendly ArcMap model to allow for geospatial forecasting based on specific soil conditions. Case study preliminary results focus on North-Western New Brunswick comparing model results with on the ground measurements.

Goguen, M. MScF Candidate. Mapping dominant moss species distributions across NB

Abstract: Plant species composition is known to vary along environmental gradients. Bryophytes such as *Sphagnum* moss grow in abundance where water remains near the surface year-round, while others (ie.*Dicranum polysetum)* prefer mesic locations. This project makes use of a cartographic depth-to-water (DTW) index to model the potential distribution of common moss species in New Brunswick. The DTW raster depicts soil wetness at 1m resolution using LiDAR-derived digital elevation models; it is useful for emulating soil drainage variations, e.g. from very poor (DTW<10cm) to well drained sites (DTW>100cm). Moss species composition and relative abundance were measured along transects traversing the landscape, from wetlands to uplands. Multiple regression is being used in combination with ArcGIS to create habitat suitability maps which relate species composition to environmental variables such as DTW, forest cover, and microtopography, as well as predict the probability of species occurrence at unsampled locations. Comprehensive spatial information of this type could be valuable for agencies involved in biodiversity conservation, restoration, or regulatory efforts.

Wen, H.K. Tracing water flow and retention at road-stream crossings using LiDAR DEMs

Abstract: This presentation shows how LiDAR DEMs can be used to determine where streams should cross roads, and how much are above the roads would flood in case where the road blocks the flow of water. Doing this is critical for (i) producing hydrographically correct flow-channel and wet-area delineations, (ii) ensuring culverts are properly located and sized by upland flow-accumulation area, (iii) producing actual flow paths across sequences of ditch-drained roads, and (iv) setting priorities regarding road, culvert and ditch maintenance scheduling to avoid potential road washouts. Three DEM-generated flow channel networks are examined for three locations (a hilly forest area, flat agricultural terrain, coastal floodplain) as follows: (i) without road breaching at actual culvert locations; (ii) road breaching at all potential DEM-derived culvert locations; (iii) breaching only at known culvert locations.

Appendix

Enhancing Digital Elevation models for improved wet-areas mapping purposes across New Brunswick

At 10m resolution, the original and still used New Brunswick Digital Elevation Model (DEM) contains two major artifacts: "ridging" (straight lines) and faulty elevational tile registrations (rectangular depressions), which interfere with proper topographic and hydrographic delineations and analyses. Since topography is a dominant landscape and soil forming factor, these errors significantly limit the existing DEM's ability to analyze and map land attributes at high resolution. The existing New Brunswick DEM was re-examined in view of additional province-wide DEM coverages at varying resolutions: SRTM (90m), SRTM (30m), and CDED (22m). Due to varying resolutions and geographic coordinate systems, each DEM was recreated through projection and interpolation models.

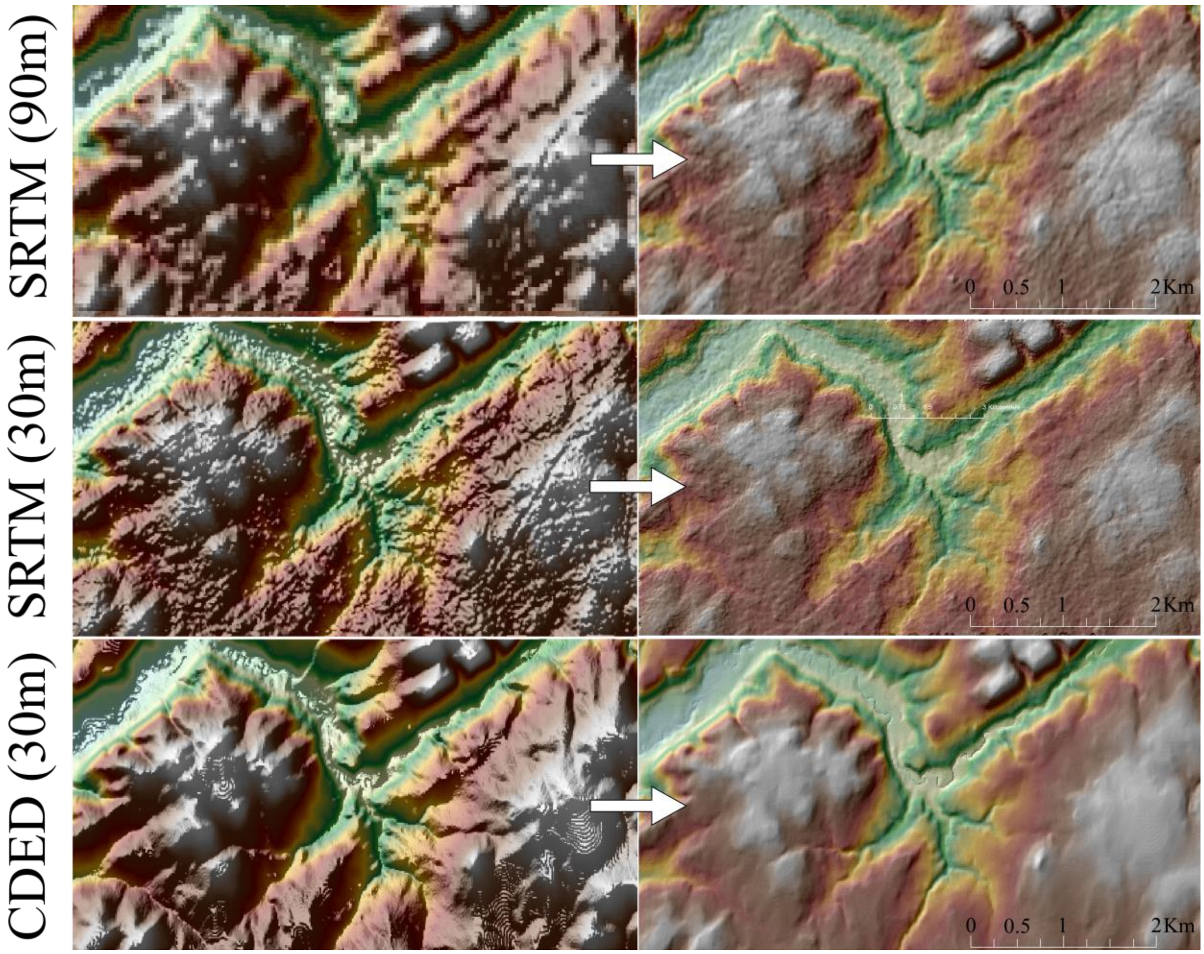

Fig.1. Converting original DEMs (left) into enhanced DEMs (right), and combining these based on select LiDAR-DEM cross-referencing and regression-type calibrations across New Brunswick.

Applying the wet-area mapping concept to the revised DEM produced significant improvements in NB wide wet-area Fig. 2), wetland and floodplain delineations (Fig, 3)

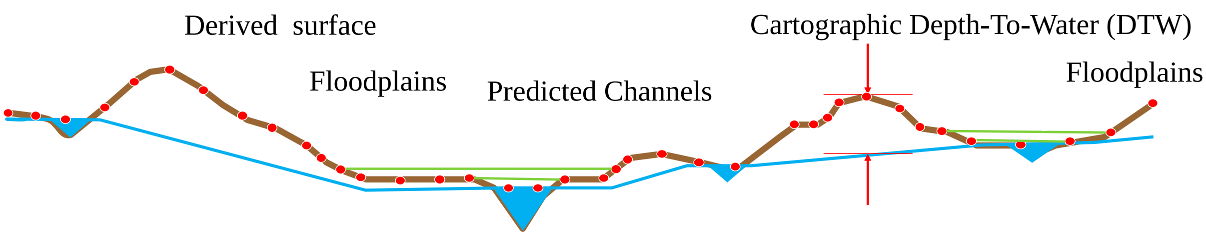

Fig. 2. Wet-areas mapping concept

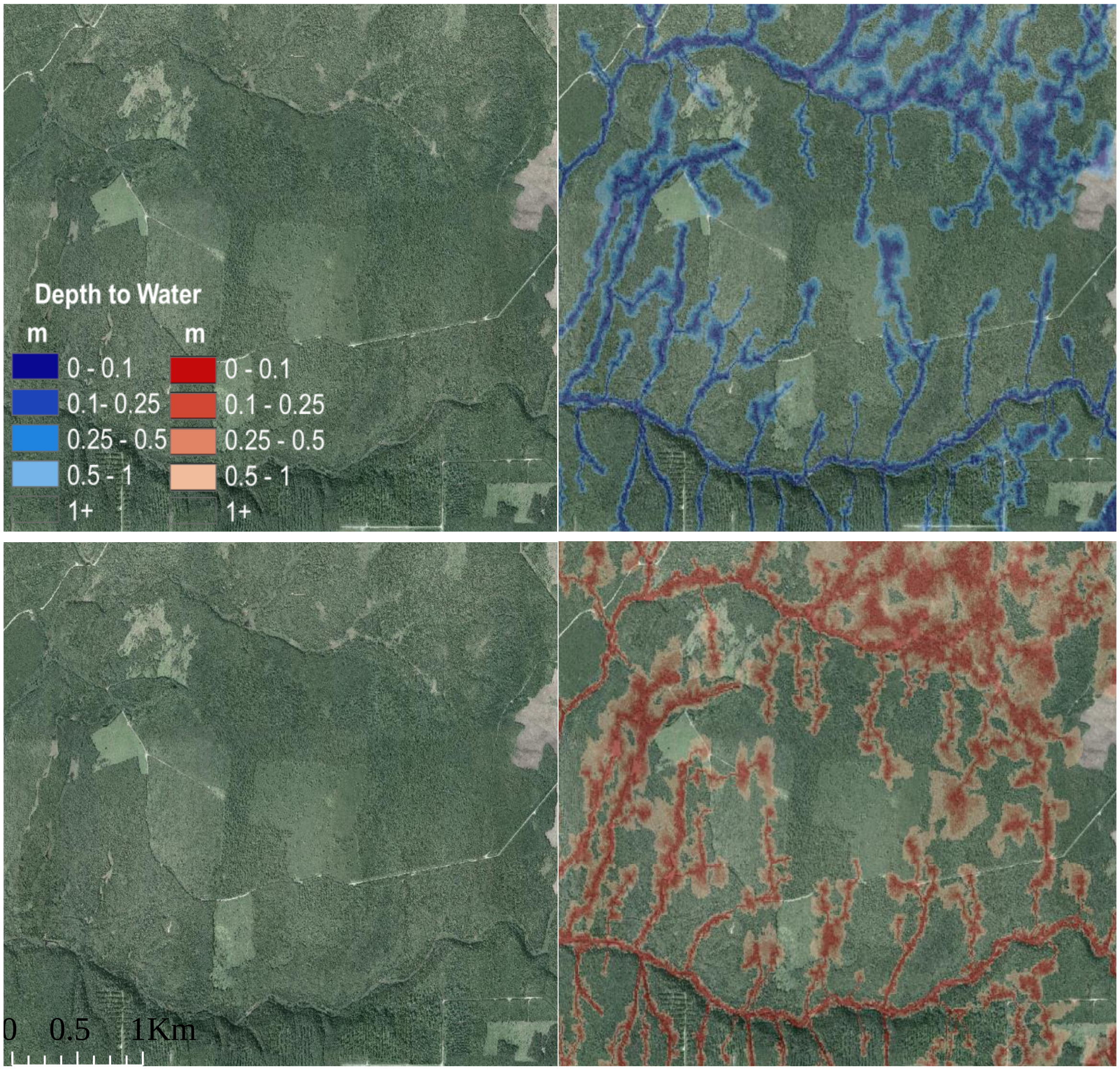

Fig. 3. Comparing the wet-areas mapping results based on the newly revised (top) and the original NB DEM (bottom).

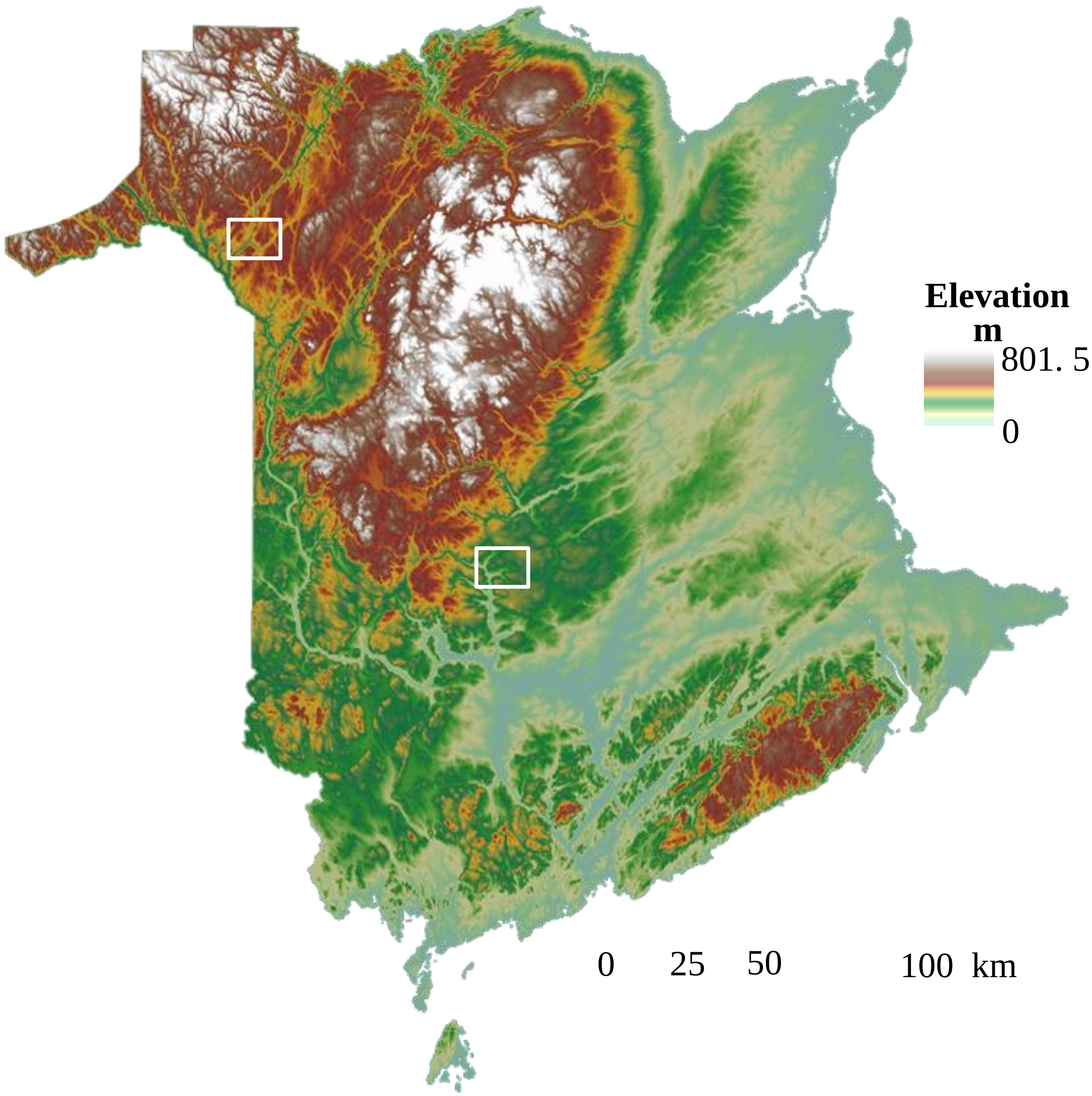

Fig. 4. Presenting the newly improved DEM for New Brunswick, at 10 m resolution, free of traditional artifacts. It forms a comprehensive base for assessing province-wide watershed areas and related flow accumulation areas.