Beaver-driven dynamics of a peatland ecotone: Identification of landscape features with Lidar and geomorphon analysis

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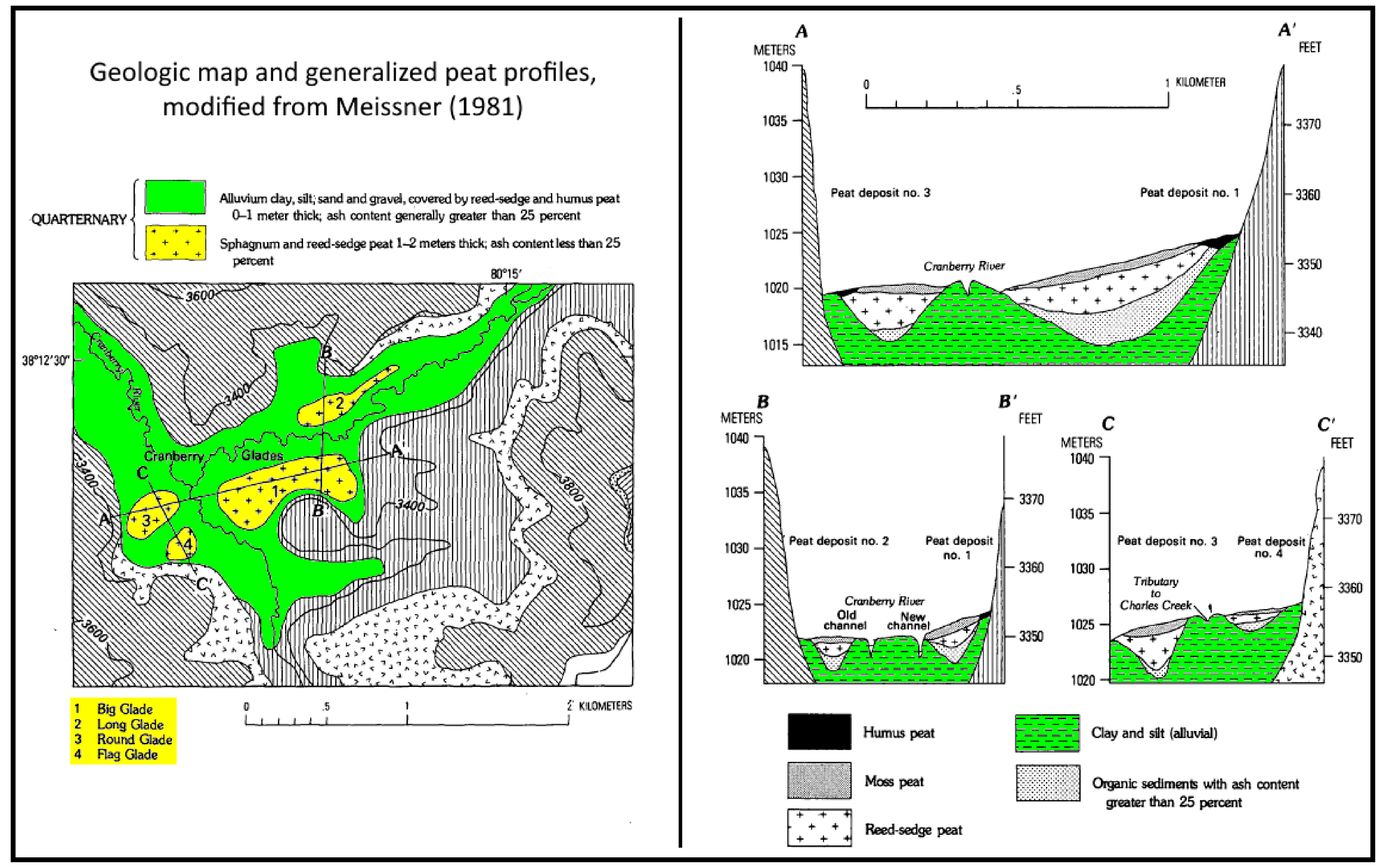
Project Summary

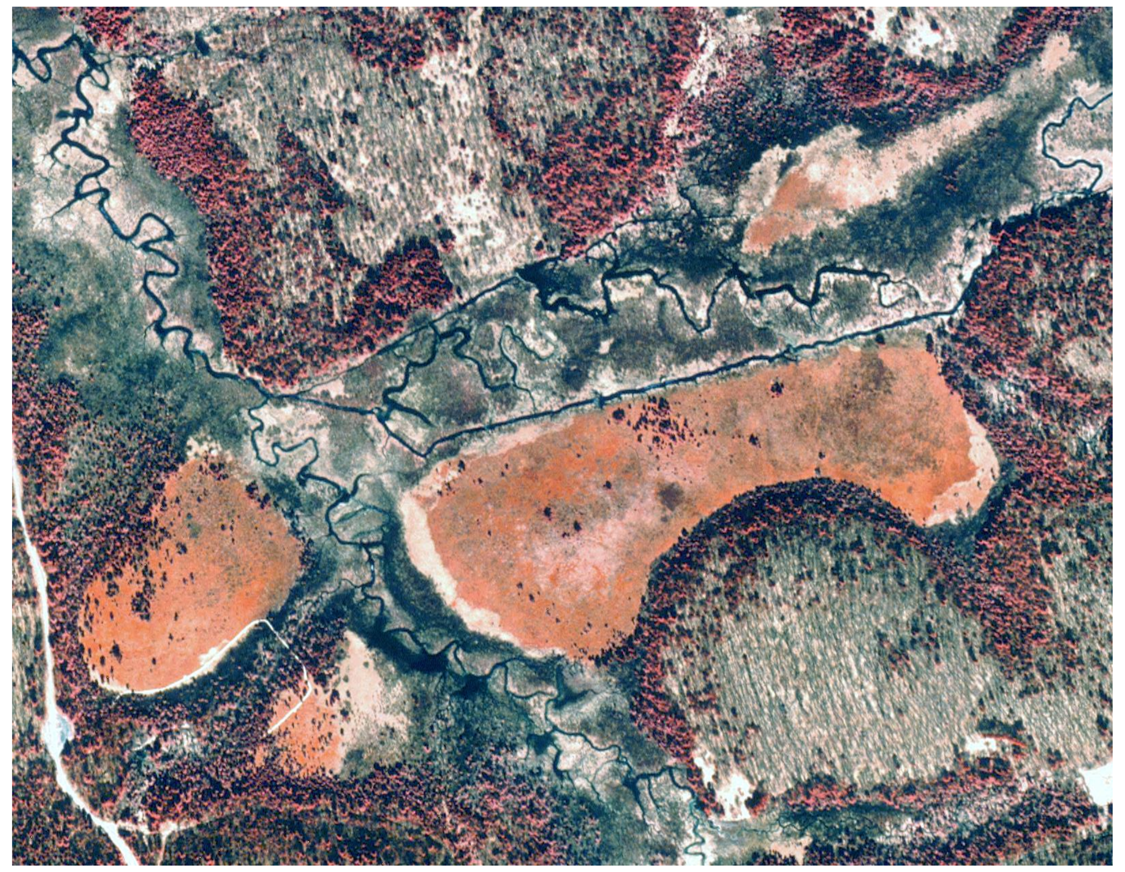
Beaver are renowned for their role as ecosystem engineers. Their ponds and vegetation consumption can greatly alter local hydrology and ratios of meadow to woodland. Beavers also actively buffer their environments against drought and wildfire susceptibility, and influence important climate parameters like carbon retention and methanogenesis (Rozhkova-Timina et al. 2018).

This investigation focuses on beaver impacts on the boreal peatland ecotones enmeshing Cranberry Glades Botanical Area (~300 ha, ~1000 masl), a National Natural Landmark in mountainous West Virginia. Beaver activity has been suggested (Stine et al. 2011) to have an important role in the formation and maintenance of peatland conditions at Cranberry Glades. Using Lidar, geomorphon analysis, and aerial imagery, we were able to identify and reconstruct shifting hydrological patterns associated with beaver dams and ponds. The three-year interval worked well, allowing time for widespread changes in beaver infrastructure while conserving utility of reference imagery.

Future work will include analysis of the most recent beaver activity, refinement of classification workflows, generation of more accurate physical models using drone-acquired Lidar and better ground filtering, and more complete incorporation of historical imagery.



Geologic map and generalized peat profiles, modified from Meissner (1981)

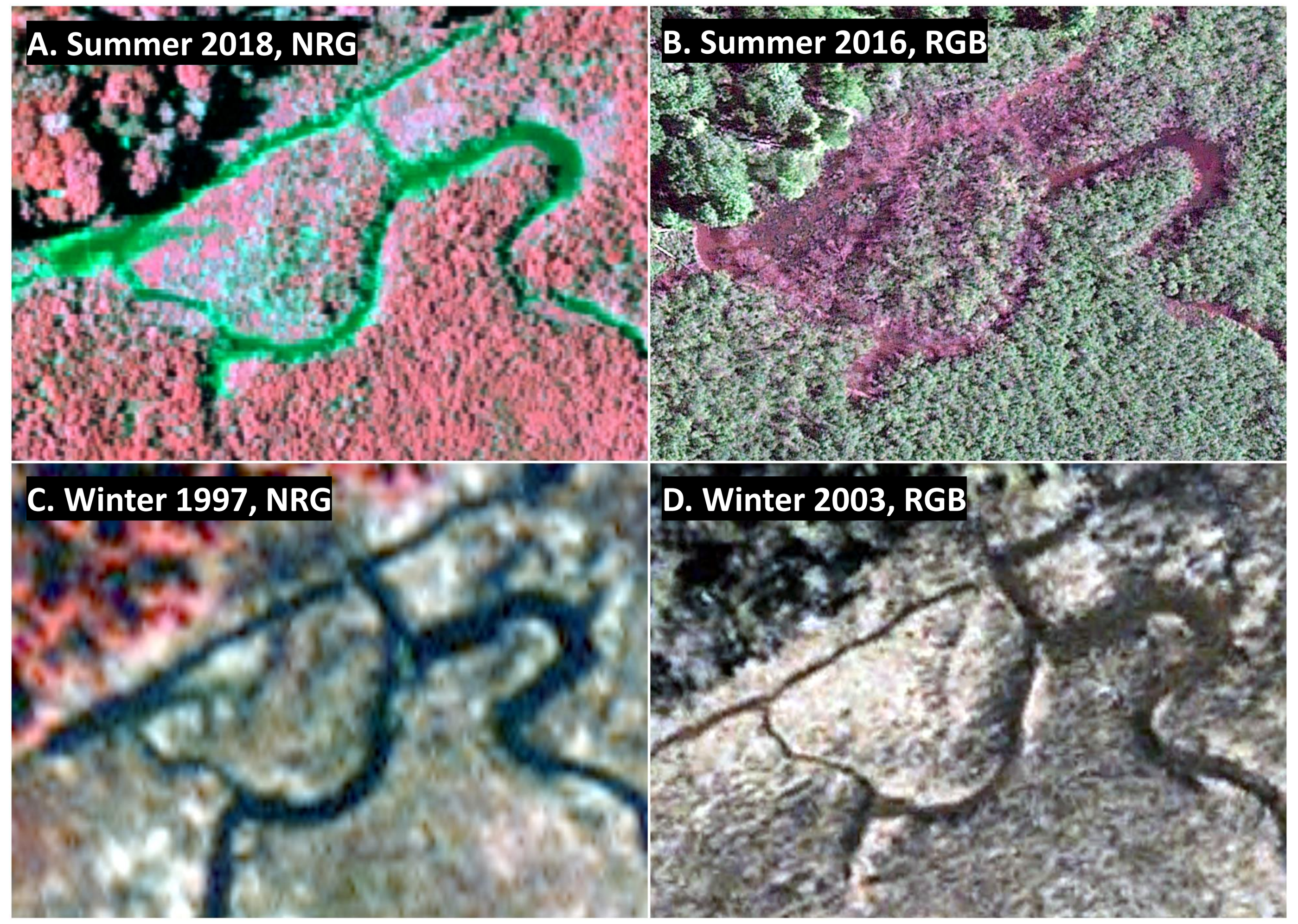


NAPP color-infrared aerial photo of Cranberry Glades, March 1997

Identification of ponds & dams in visible and near-infrared bands

Beaver impoundments often follow a multiyear cycle of construction, maintenance, degradation, and fallow. Flooding is the main agent of damage and even complete destruction; recently drained ponds show a high-contrast 'bathtub ring' of exposed sediments around the periphery. This photographic time series of multiple beaver impoundments reveals this dynamism over the course of 21 years in the heart of the Glades. The color (RGB) and color-infrared (NRG) aerial photo matrix offers complementary information in the search for beaver impoundments. Likewise for imagery gathered in a diversity of seasons.

NRG images, unlike RGB, show water in clear contrast to soils and emphasize spectral differences between coniferous and deciduous woody vegetation for both shrubs and trees (Figs. A, C). Summery leaf-on conditions allow discernment of woody vegetation killed by waterlogging (Figs. A, B). Winter offers better views of water contours due to leaf-off conditions, plus surface microtopography may be more apparent if light dustings of snow or low-angle lighting is available (Figs. C, D). A beaver dam is clearly visible (Fig. B) as a thin bright vertical crescent at far left.



A: NAIP; B,D: Google Earth; C: NAPP

Sidebar: anthropogenic intersection

A beaver impoundment intersects Cranberry Glades' perimeter trail TR253, ponding over the upstream stretch while overflowing down-trail into the heart of Cranberry Glades. Beavers are renowned for both their adaptability to local conditions and their capacity to modify their environment. This ecotonal editing has co-opted structures built by the Glades' other mammalian engineer of ecosystems: humans.

Photo: T. Swift Oct 2020

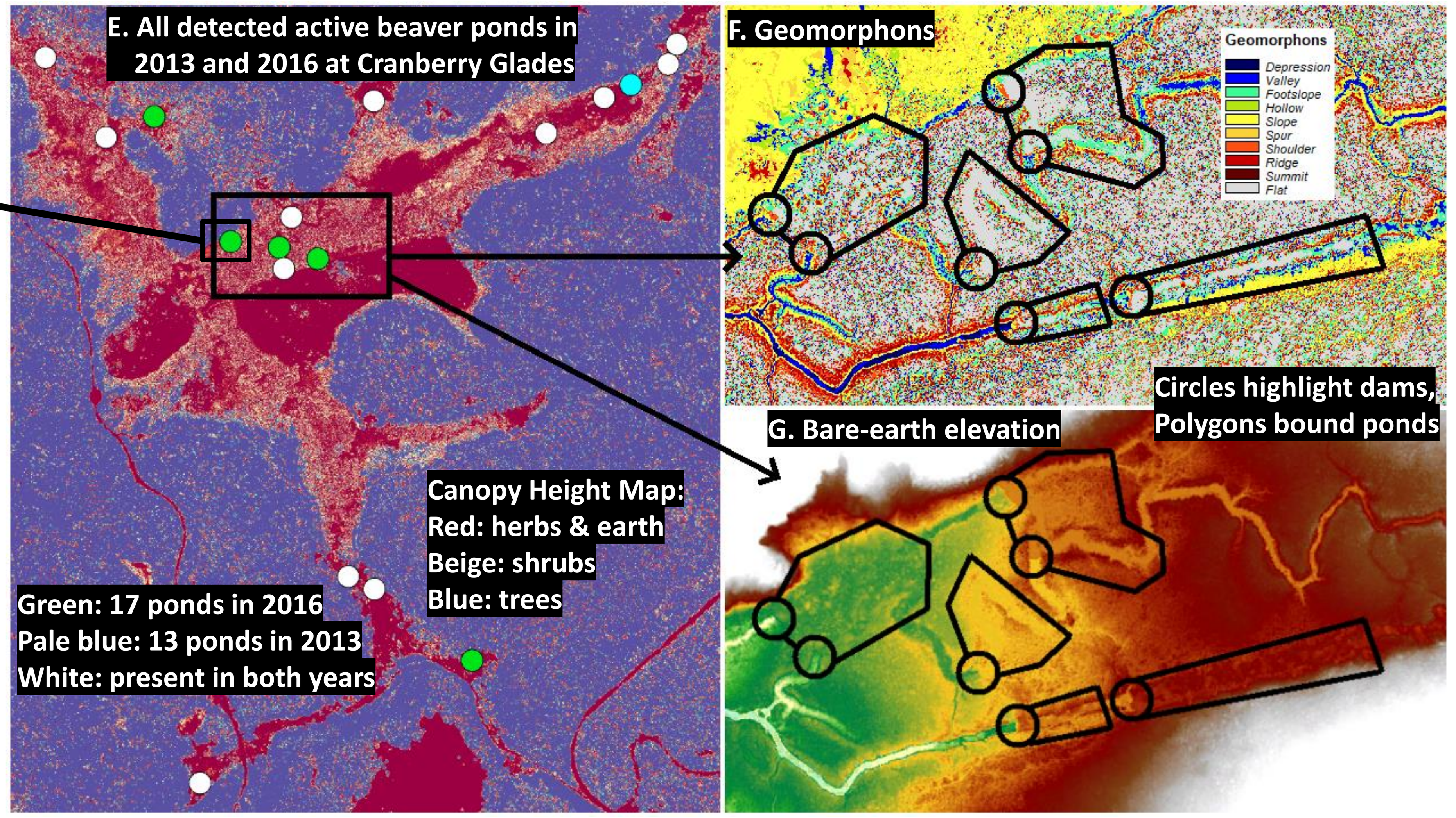
Lidar-based analysis and final inventory of active beaver ponds in 2013 and 2016

Aerial Lidar data has proven useful in the identification of beaver ponds. Basemaps (Figs. E, F, G) were derived at 1m resolution from a pre-classified Lidar point cloud obtained in late 2016. Candidate ponds for the years 2016 and 2013 were located by inspection of aerial photos and the Lidar-derived products (Figs. F, G).

Figure G is a digital terrain model (DTM) rasterized from 'ground'-classified Lidar points. The color scale was carefully tweaked to highlight microtopography down to the limit of vertical resolution at ~10cm. Looking along the intricate network of drainage channels passing between the glades, one sees sharp discontinuities in the interpolated water surface (black circles, Fig. G) at locations which correspond to dams in aerial photos. This works great for finding dams but cannot distinguish the extent of the impounded ponds.

The extent of upchannel ponding was determined using geomorphon analysis (Fig. F). Geomorphons are determined using 'openness' criteria for each pixel as determined within a terrain-appropriate radius; 25m was ideal for this streambank-specific analysis. Streambanks were chosen because in this ecotone free-flowing streams sit relatively low in their channels and thus appear geomorphometrically as 'valley' sandwiched between streambank 'ridges', whereas impounded water fills its banks and the pond becomes classified as 'flat' with no bounding ridges. These ponds are bounded by polygons (Figs. F, G); the dams are located at the sharp downstream geomorphon transitions (circles).

Finally, Figure E displays all detected active beaver ponds in the Cranberry Glades for 2013 and 2016. The basemap shows the Glades at upper-center at the convergence of the three major shrubby valleys.



2016 Lidar source: 3D Elevation Program, National Geospatial Program, U.S. Geological Survey

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