A Conservation Blueprint for the Poultney River watershed, VT using the Active River Area conservation framework

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Executive Summary

The Vermont Chapter of The Nature Conservancy (TNC) worked with conservation partners in the Poultney River watershed in Rutland County, Vermont, to develop a 'blueprint' to address the most pressing conservation needs for river conservation using the *Active River Area* framework. This framework defines river system components that are collectively responsible for forming and maintaining aquatic habitat and allowing natural disturbance-driven river processes to take place. This analysis was conducted in a data-rich environment, as detailed conservation assessments and plans already exist for the Poultney watershed. Accordingly, we oriented our ARA analysis on the Poultney to partner input on conservation needs and the capabilities of ARA GIS modeling tools developed by TNC. The result was a synthesis of new ARA-based analyses with existing information on the Poultney River. We characterized of landcover and quantified riparian wetlands within the floodplain component of the ARA assessment framework. We also developed ARA-derived measures for floodplains associated on floodwater attenuation potential, ranked river reaches based on this measure, and with existing assessment data, characterized our analysis results in terms of functionality of floodplain connectivity, geomorphic condition, and geomorphic sensitivity to disturbance. This information was synthesized to produce conservation priorities for the river. While limitations were encountered due to analysis scale and data accuracy, the ARA framework and associated GIS-based assessment work provided a unique lens through which to prioritize conservation in the Poultney River.

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Introduction

Towards meeting the challenge of developing conservation plans that take into account a river's key physical and ecological processes, the Vermont Chapter of The Nature Conservancy worked to develop a 'blueprint' for river conservation on the Poultney River using the *Active River Area* framework. The Active River Area (ARA) framework is based on geomorphology and fluvial dynamics, and consists of five components: (1) headwaters and other material contribution areas, (2) the channel and meander belt, (3) floodplains, (4) riparian wetlands, and (5) terraces, and is more fully described in Smith et al (2008). These river system components are collectively responsible for forming and maintaining aquatic habitat and allowing natural disturbance-driven river processes to take place. As such, this blueprint seeks to address river system conservation from an aquatic biodiversity perspective.

This collaborative project was organized by the Vermont Chapter of The Nature Conservancy, and involved a number of partners that are interested or engaged in Poultney River conservation work, chiefly, the Poultney Mettawee Watershed Partnership and the Vermont Department of Environmental Conservation. Project collaboration was organized via a series of 2 meetings, where the information needs for conservation were gathered by TNC from the project partners. Partners also assisted with interpretation of Active River Area analysis results, helped TNC understand the most pressing conservation needs, and provided feedback on the identification of priorities for conservation.

The project was initiated by describing the ARA framework to partners, and then consensus was achieved among the partnership on the conservation needs in the Poultney for each of the Active River Area components. We oriented our ARA analysis in accordance with feedback from project partners, within the capabilities of the available ARA GIS assessment tools. The result was a synthesis of new ARA-based analyses with existing information and conservation plans for the river, most notably, the Poultney River Geomorphic Assessment and River Corridor Plan (Poultney Mettawee NRCD 2006), the Poultney Mettawee Basin Plan (PMWP 2004), and The Nature Conservancy's Conservation Action Plan for the Poultney River (2007). This analysis focused on the ARA components that were most valuable in terms of filling information gaps in existing Poultney River conservation plans and able to be adequately characterized with existing GIS assessment tools: the floodplain and riparian wetland ARA components.

The Poultney River Watershed

The Poultney River is a small to medium-sized river that flows from the headwaters of the Taconic highlands in Vermont in Rutland County and empties into the southern end of Lake Champlain. Its watershed encompasses 262 square miles in Rutland County, VT and Washington County, NY. The watershed consists of three major tributaries: The Poultney River mainstem, the Castleton River, and the Hubbardton River (Figure 1), as well as numerous smaller tributaries, the most significant of which are Coggman Creek, Mud Brook, Lewis Brook, Finel Hollow Brook, Laverly Brook, and South Brook. The mean of daily mean flow values for 81 years of record is 264 cfs (USGS) in the lower portion of the watershed.

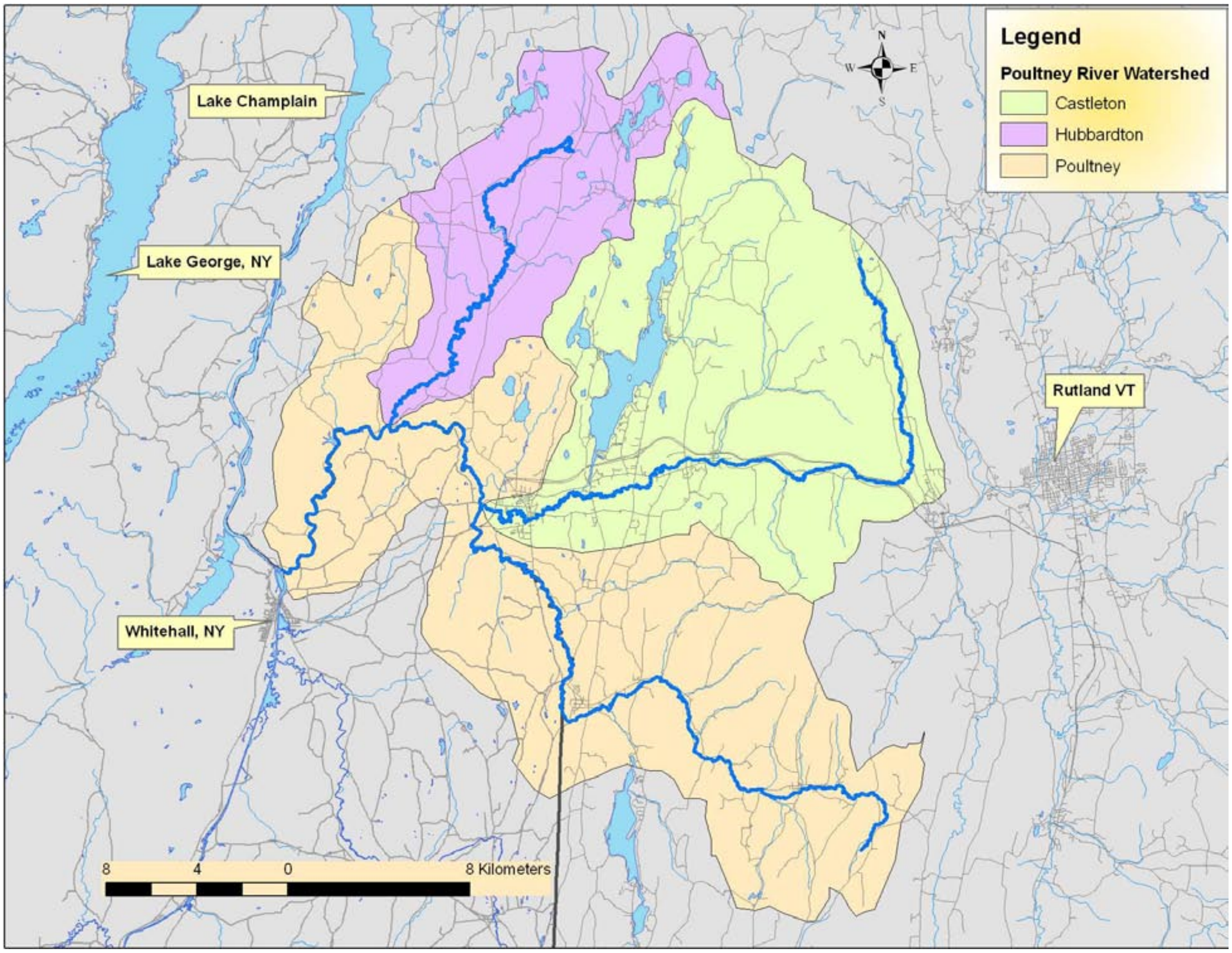

Figure 1: Poultney River watershed in Rutland County, Vermont and Washington County, NY.

The lower Poultney River is designated a Vermont Outstanding Resource Water because of its exceptional natural, cultural, and scenic values. Upper reaches of the Poultney mainstem and the Castleton River flows out of the Taconic hills in southwestern (Rutland County) Vermont, and are characterized by high gradients and confined river valleys. This portion of the watershed supports a typical cold water fishery. In the lower parts of the watershed, the Poultney River straddles northern Washington County, New York, and western Rutland County, Vermont. The river here is lower in gradient, traverses broader river valleys and is more turbid due to the predominance of clay-rich soils. The water is warm, and slow moving, and merges into a freshwater estuary with the waters of Lake Champlain.

Forty-three species of fish and 12 species of freshwater mussels are documented in the Poultney River. The globally rare eastern sand darter (*Ammocrypta pellucida*, G3) is threatened in both New York and Vermont, and the channel darter (*Percina copelandi* ,a fish), black sandshell (*Ligumia recta*), giant floater (*Pyganodon grandis*), fragile papershell (*Leptodea fragilis*), pink heelsplitter (*Potamilus alatus*), pocketbook (*Lampsilis ovata*), and fluted-shell mussels (*Lasmigona costata*) (all native mussels) are threatened or endangered in Vermont. All of the species listed as rare or endangered exist in the lower warm-water portions of the river between the first major fall line at Carvers Falls and Lake Champlain. Because of the regional significance of its rare fauna, The Nature Conservancy (TNC) has made the Poultney River watershed a priority for its conservation work, and has invested much to protect the biodiversity of the river.

Much of the 12-mile lower stretch of the Poultney River below Carvers Falls has been conserved via land protection. Almost 60% of the riverbanks and riparian area on the lower Poultney in Vermont and New York are owned by The Nature Conservancy. Indeed, the lower Poultney consists of a remarkably intact natural landscape, with an abundance of protected lands, no building encroachments in the riparian zone, and an impressive riparian wetland complex. While the lower Poultney River once supported some small scale agriculture, only a few farms remain. However, farther upstream, there is little in the way of conserved lands. Broader valleys are predominantly agricultural, and narrower river valleys have more of a mixed land use, with intensive agriculture in suitable locations mixed in with wetlands and forests and scattered development.

The Poultney River is a well studied river system (Table 1). A series of studies and assessments starting in 2000 culminated in a full geomorphic assessment and river corridor plan (Poultney Mettawee NRCD 2006). That work, in addition to the Poultney-Mettawee Watershed Basin Plan and a Conservation Action Plan developed by The Nature Conservancy and other conservation partners in 2007, provides a wealth of information that includes assessments of riparian wetlands, natural communities, bank erosion, riparian buffers, dams and culverts impairing aquatic organism passage, ranks of hydrologic and sediment regime stressors, and development of short-term and long-term conservation objectives, strategies, and projects. Of particular importance are results from the 2006 Stream Corridor Plan (Poultney Mettawee NRCD 2006) that included a field-based assessment of valley walls that delineate riparian areas subject to flooding. The present ARA project, therefore, benefits from having a field-based demarcation of a physical feature (the “valley wall”) that our project seeks to estimate via ARA GIS modeling.

In addition to the assessment work and conservation planning done in the basin, this project relied on a number of other data sources: 1) a wetland restoration plan that identifies restoration priorities in the Lake Champlain Basin in Vermont (VTDEC 2007); 2) A detailed land-cover data set created by the University of Vermont (UVM Spatial Analysis Lab, 2006) by digitizing orthophotos. This data set is superior to existing National Landcover Dataset information that is more typically used for land-cover analyses, and has a resolution for land cover classes down to 0.01 acre. This dataset, however, is only available for a portion of the Poultney watershed: 800m buffers around the mainstems of the Poultney and Hubbardton Rivers.

Due to the abundance of conservation-oriented data on the Poultney Watershed, entering into this project, conservation partners had a detailed understanding of the existing physical and biological processes, location of rare fauna, existing threats, and had developed a set of conservation priorities based on this understanding. Since the essence of our charge for this project was conservation planning within a specific river assessment framework, our analysis was therefore oriented towards testing for corroboration between ARA based results and existing river assessment efforts and related conservation priorities on the Poultney River. Also, we made decisions at the outset on which ARA framework components to focus our analyses. Criteria for deciding on framework components to focus on were 1) components that would help define characteristics and metrics that fill gaps within the current body of understanding about the Poultney Watershed; and 2) components with specially designed GIS modeling tools that were likely to yield results that were useful, informative, and/or novel.

Table 1: Recent conservation assessment and planning projects for the Poultney River watershed

2001 - A Wetland and Riparian Habitat Assessment of the Poultney River Watershed (TNC)

2002 - Floodplain history and associated impacts on channel morphology at the Lower Poultney River Preserve (Harrison Tract) (TNC)

2005 - Fluvial Geomorphology Assessment of the Poultney River and Hubbardton River, Vermont (TNC)

2004 - Conservation Action Plan for the Southern Lake Champlain Valley (TNC)

2004 - Poultney Mettawee Watershed Basin Plan (Poultney Mettawee NRCD)

2006 - Poultney River Geomorphic Assessment and Stream Corridor Plan (Poultney Mettawee NRCD)

2008 –Phase 2 Stream Geomorphic Assessment, Castleton River Watershed (South Mtn. Research and Consulting)

Accordingly, our efforts only directly encompassed a subset of the full suite of ARA components: the floodplain and riparian wetlands. ARA assessment tools were also able to indirectly encompass the meander belt component. We were unable to adequately characterize the terrace ARA component, for reasons described later. For the headwater streams/material contribution area component, headwater streams were perceived to have outstanding landscape context and were heavily vegetated, so limited resources for assessment analysis effort were focused elsewhere. Finally, modeling tools for the material contribution areas component (GIS buffer functions) was judged to be less likely to produce analysis that would provide partners with novel perspectives on river conservation.

By targeting our efforts at a subset of components, we were able to develop a unique ARA framework-based lens to assess the overall systemic health of the Poultney Watershed that was tailored to the existing data/information environment.

The process for this project was as follows:

1. Convene kickoff meeting in December 2009 with project partners to solicit input on which components of the ARA framework would be the most valuable.
2. Conduct analysis focused on these components.
3. Use existing spatial and geomorphic data from the Poultney watershed to assess/validate the results of ARA analysis.
4. Produce spatial information on the Poultney River through new TNC-developed GIS analysis tools that characterize the components of the Active River Area framework that would be most likely to add new perspectives to conservation priorities within the watershed.
5. Solicit feedback on initial analysis results from partners, and finalize analysis results to provide to characterize conservation priorities through the lens of the ARA framework.

Methods

We defined a “floodzone” for the river by deciding on cost-surface (a spatially explicit measure of the “cost” that water encounters as it leaves the channel and enters the floodplain in terms of elevation and distance, see Appendix A) derived “thresholds” to demarcate the floodzone. Decisions on determining the threshold were made by comparing the spatial distribution of cost surface values away from the river channel with the location of field-derived valley wall designations (Poultney Mettawee NRCD 2006) (Figures 2a and 2b) and personal knowledge of the physical elevation floodplain features. Once a threshold was decided upon that best approximated the location of RMP valley walls, the thresholds were used to spatially define ARA floodzones along the Poultney, Castleton, and Hubbardton Rivers. The floodzone was then longitudinally divided along the river valley according to the location of RMP geomorphic reache breaks, resulting in a GIS layer of discrete *floodzone reach*es, consisting of a series of polygons bounded by floodzone lines and RMP reach breaks (Figure 3). The resulting floodzone reaches represent sub-divisions of the ARA floodzone that possess specific fluvial geomorphic attributes and functions. Floodzone reaches were named according to the corresponding reach naming protocol used by the VTDEC (Table 2).

These polygons together formed the analysis units that were used to “clip” land cover data, deriving land-cover metrics for each floodzone reach. Where available, land-cover data from the UVM Spatial Analysis Lab (2006) was used (Table 3). NLCD (2001) data was used for reaches not covered by the UVM dataset. Land-cover from both datasets was generalized into the following categories: agriculture, “natural cover”, wetlands, forested, and developed (Table 4), and used to quantitatively characterize each floodzone reach. Where alternative datasets were available, we compared the different data sources against each other and against our knowledge of field conditions, and selected what we thought to be the most accurate data source to use (Table 5).

Floodzone reaches were developed for all reaches upstream of M3. Below M3, the backwaters of Lake Champlain influences fluvial dynamics, making demarcation of landscape features that predictably

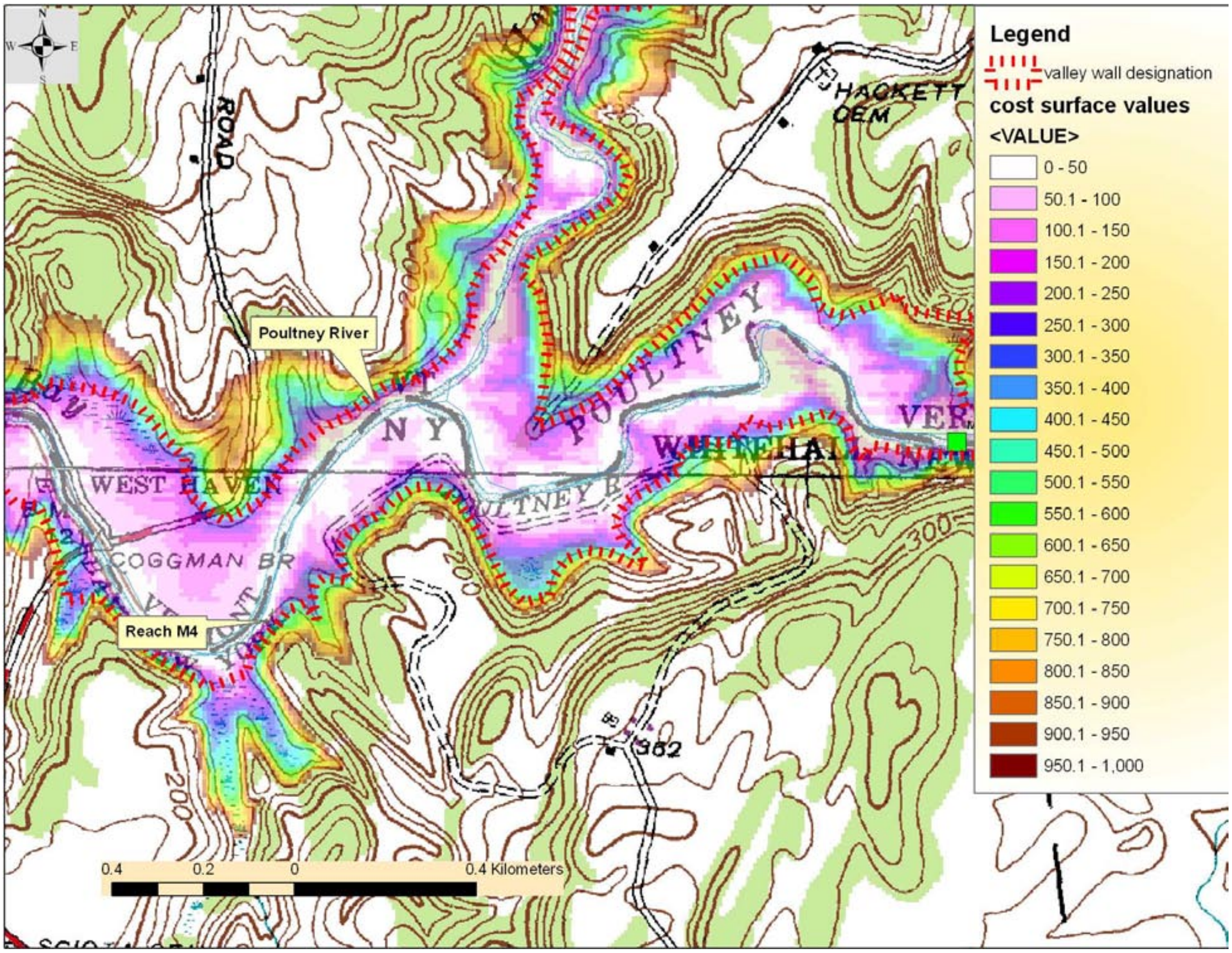

Figure 2a: Comparison of Floodzone cost surface values and VTDEC RMP valley wall designation, o define threshold for determining the ARA floodzones on reach M4. Floodzone threshold was decided to be 180.

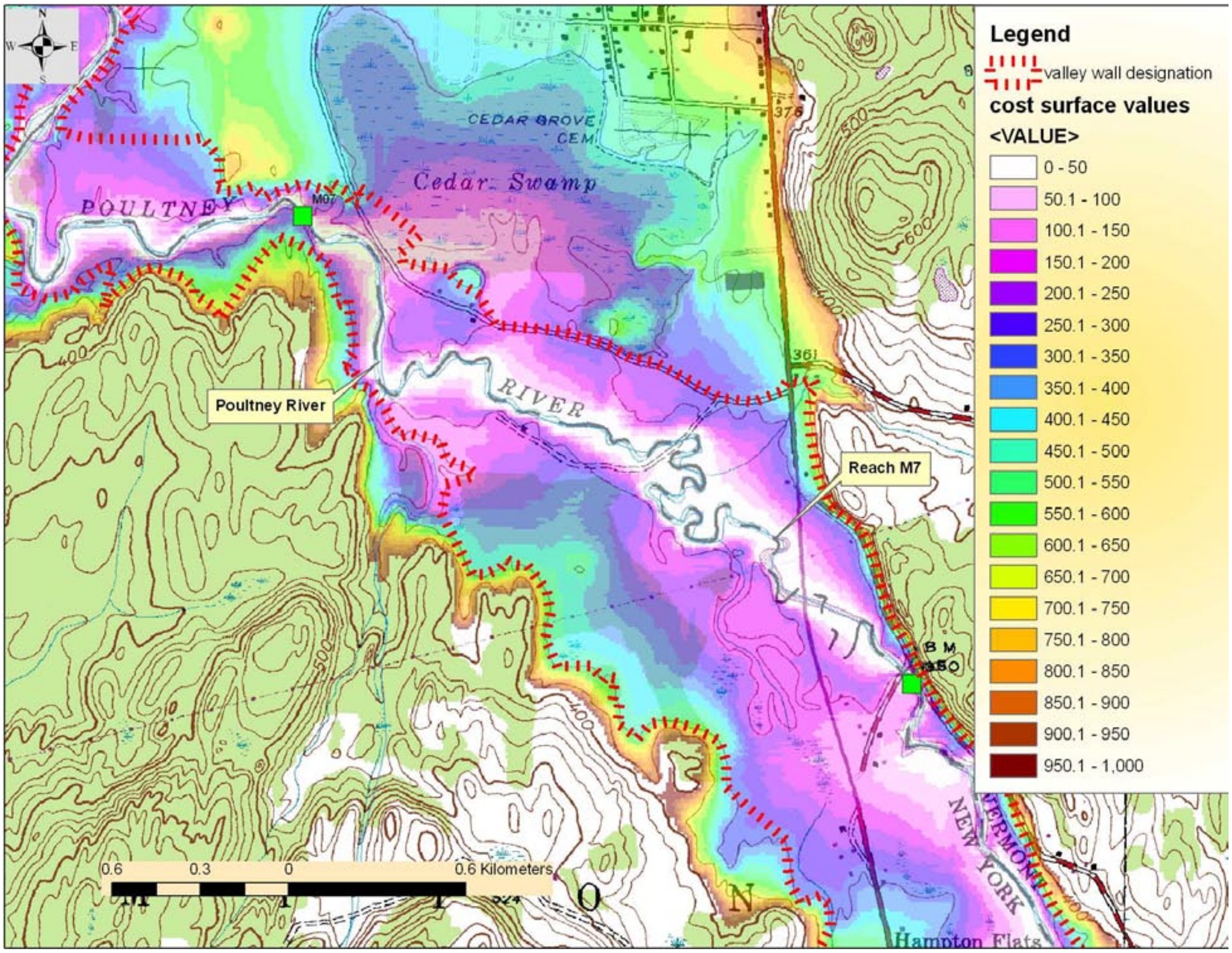

Figure 2b: Comparison of Floodzone cost surface values and VTDEC RMP valley wall designation, o define threshold for determining the ARA floodzones on reach M7. Floodzone threshold was decided to be 370 for this reach.

Table 2: Naming conventions used for floodzone reaches.

Sub - watershed	Floodzone reach designation
Poultney River	M3 – M16
Hubbardton River	T1.01 – T1.10
Castleton River	T2.01 – T2.15

Table 3. Landcover data sources used for project analysis.

Landcover Data used for analysis	River reaches
UVM Spatial Analysis Lab (2006)	M03 – M09; T1.01 – T1.10; T2.10 – T2.03
NLCD (2001)	T2.04 – T2.15 M10 – M15

Table 4. The composition of land cover categories used for analysis with ARA GIS tools.

NLCD 2001	Landcover class (UVM Spatial Analysis Lab 2006)	Land cover categories				
		Devel-oped	natural cover	forested	wetland	Ag.
deciduous forest	deciduous forest		■	■		
mixed forest	mixed forest		■	■		
evergreen forest	coniferous forest		■	■		
woody wetlands	forested wetland		■	■	■	
emergent wetlands	emergent wetland		■		■	
	scrub/shrub wetland		■		■	
shrubland	brush		■			
high/low intensity residential; commercial/industrial/ transportation	developed	■				
field/pasture	field/pasture					■
row crops	ag/general					■
orchard	orchard					■
open water	water					

Table 5. Data used for analysis with ARA GIS tools, and alternative data sources not selected for analysis.

Land use category	Source data	Alternative data not used
Natural Cover	UVM Spatial Analysis Lab, 2006; NLCD 2001	
Wetland	UVM Spatial Analysis Lab, 2006:	VSWI wetland data, “wet flat” ARA data, NWI data
Forested	UVM Spatial Analysis Lab, 2006; NLCD (2001)	

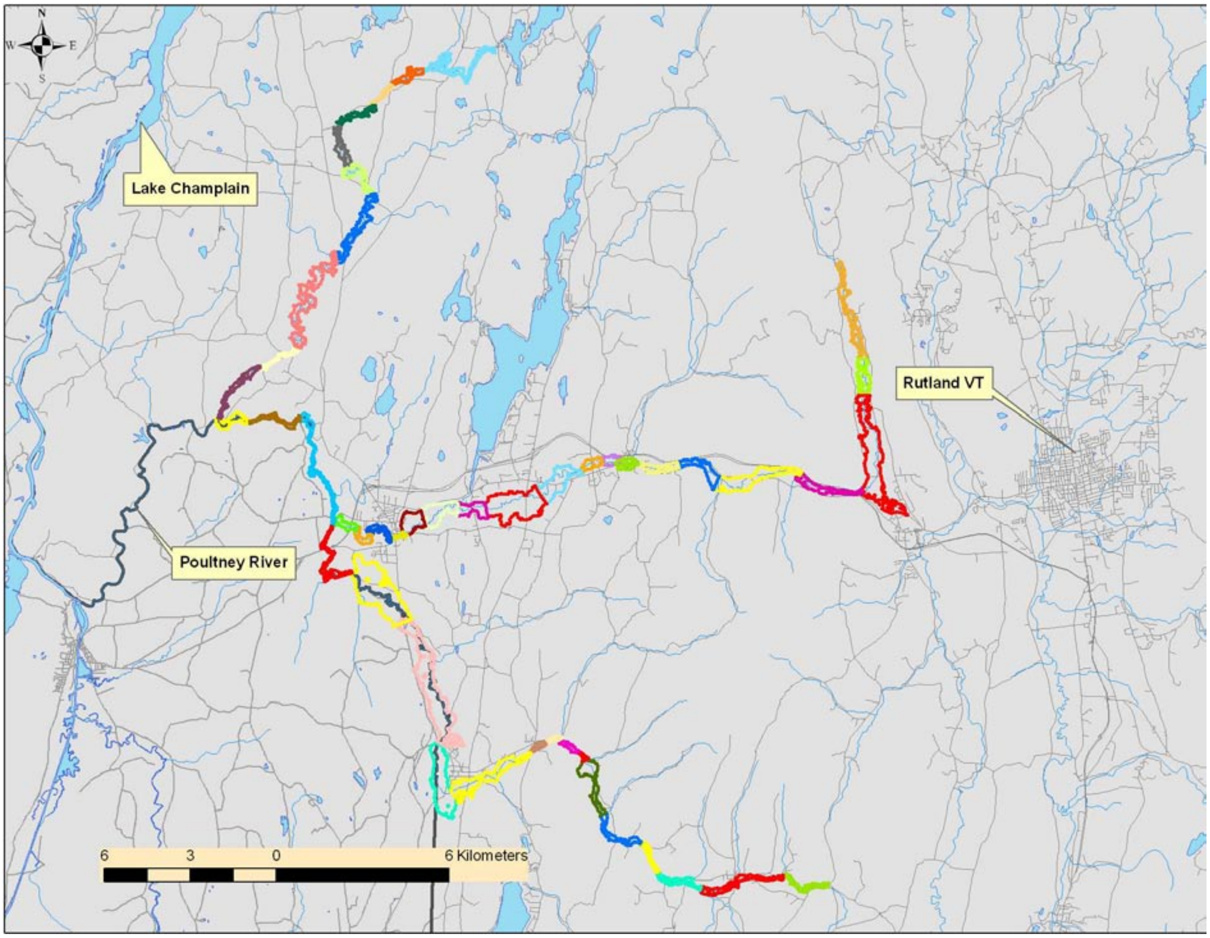

Figure 3. Map of all floodzone reaches used for the analysis on the Poultney, Castleton, and Hubbardton Rivers.

corresponds with fluvial processes such as flooding problematic, so reaches M1 – M3 were excluded from our analysis. Extreme upstream reaches along the Poultney, Castleton, and Hubbardton Rivers watershed and major sub-tributaries were not analyzed because of analysis resource limitations and anticipation of problems with issues likely to arise with this analysis at very small scales.

Results and Discussion

The floodzone reaches derived from ARA floodzones and RMP river reaches are depicted in Figure 3**.** When compared to the RMP valley wall designations (which served as a reference point for determining floodzone line locations from the cost surface), the floodzone demarcation lines were generally consistent with RMP valley walls (Figures 2a and 2b), with some notable deviations. Deviations were more pronounced in some reaches compared to others, and there appeared to be few consistent patterns to these deviations – in some cases the floodzone extended well beyond the valley wall, and in other cases, the converse was true. In a number of reaches, where discrepancies were most pronounced, we decided to use different cost surface thresholds to define the floodzone (Table 6).

Table 6. Floodzone cost surface threshold used for reaches in the Poultney watershed to define floodzones.

Reach	Floodzone cost surface threshold
M3-M6	180
M7	370
M8, M9	180
M10	180
M11 - M16	180
T01.01	180
T01.02 - T1.10	140
T02.01 - T02.112	180

In general, cost surface thresholds were set for most reaches at 180. On the Poultney mainstem, reach M7 differed substantially enough to warrant being set at 370, as the cost surface at 180 produced a floodzone that vastly understated the size of the riparian area when compared to the RMP valley wall designation (Fig 2b).

For the Hubbardton River, the RMP valley walls appeared to vastly overestimate areas which are flooded with any consistency, so instead of using the valley walls, we used our knowledge of actual field conditions (particularly on reaches T1.01 – T-1.04) to set the threshold at 140, with the exception of the T1.01, which appeared to fit much better with a threshold of 180. The entire mainstem of the Castleton River appeared well fitted to the 180 threshold.

Although we were careful to identify a threshold that corresponds as closely as possible with the "valley wall" designation that demarcates a 'reasonable" flooding frequency, the limitations of the resolution of the underlying 10m DEM likely provided a source of error into our floodzone area estimates. This degree of error is potentially large considering the scale of the DEM relative to the scale of the floodzones, which ranged approximately from 50m to 600m in width.

We were able to assess floodzone demarcation precision issues with results from a companion project on Lewis Creek. On Lewis Creek, we compared floodzones developed from the 10m DEM to floodzones developed from a LIDAR[1] derived cost-surface and RMP Valley Wall Designations. LIDAR-derived floodzones was vastly more precise than 10M DEM-derived floodzones on reach M15. Reach M15 on Lewis Creek features a low relief feature in the floodzone south of the channel not captured on USGS topo map that was used to demarcate the RMP valley wall as point of differentiation between active floodplain and a terrace (Figure 4). This feature was not picked up by the 10m DEM cost surface, and accordingly, the 10m DEM floodzone was substantially overestimated when compared to the valley wall designation. The LIDAR floodzone, however, was able to pick up on this low relief feature, and closely corresponded to the field-based valley wall demarcation.

This comparison suggests the limitations of 10m DEM data for fine-scaled analysis needed for small rivers such as Lewis Creek, which is comparable in size to the Poultney River. Moreover, it called into question our ability to adequately characterize the terrace ARA component with the floodzone analysis tool. It also suggests that LIDAR data may enable accurate and precise designations of valley walls and floodzone reaches with remotely sensed data. In Lewis Creek, the largest discrepancies between LIDAR derived floodzone reaches and the 10m DEM floodzone reaches were in reaches with broad floodzones with gradual topographic transitions between riparian zones and uplands (M15a, M15b, T4.01; Figure 5). LIDAR and 10m DEM-based floodzones among more confined reaches had greater degrees of corroboration (M14, M13, M16, M12; Figure 5). It should be noted that riparian areas in reaches with broader floodzones are likely more ecologically important, and also more important to demarcate accurately from conservation planning and fluvial erosion hazard assessment perspectives, suggesting that LIDAR based analyses are vastly superior in situations where increased data confidence is more important.

In general, we assumed that the floodzone produced from ARA GIS modeling tools is a landscape feature defined both by its elevation with respect to the river channel elevation, and physical landscape features that defines a "river valley", shaped by floodwaters of an unknown but consistent recurrence interval based on flow duration curves from the current geological period. Areas within the floodzone are assumed to be subject to inundation from floodwaters, and areas outside of the floodzone are assumed to be largely free from flooding inundation. Implicit in this working definition with respect to the ARA floodzone components are that floodplains are defined by the floodzone, and terraces that no longer flood are not.

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[1] Exceptionally fine GIS DEM layers can be derived from LIDAR data, with a resolution of 3.2 meters.

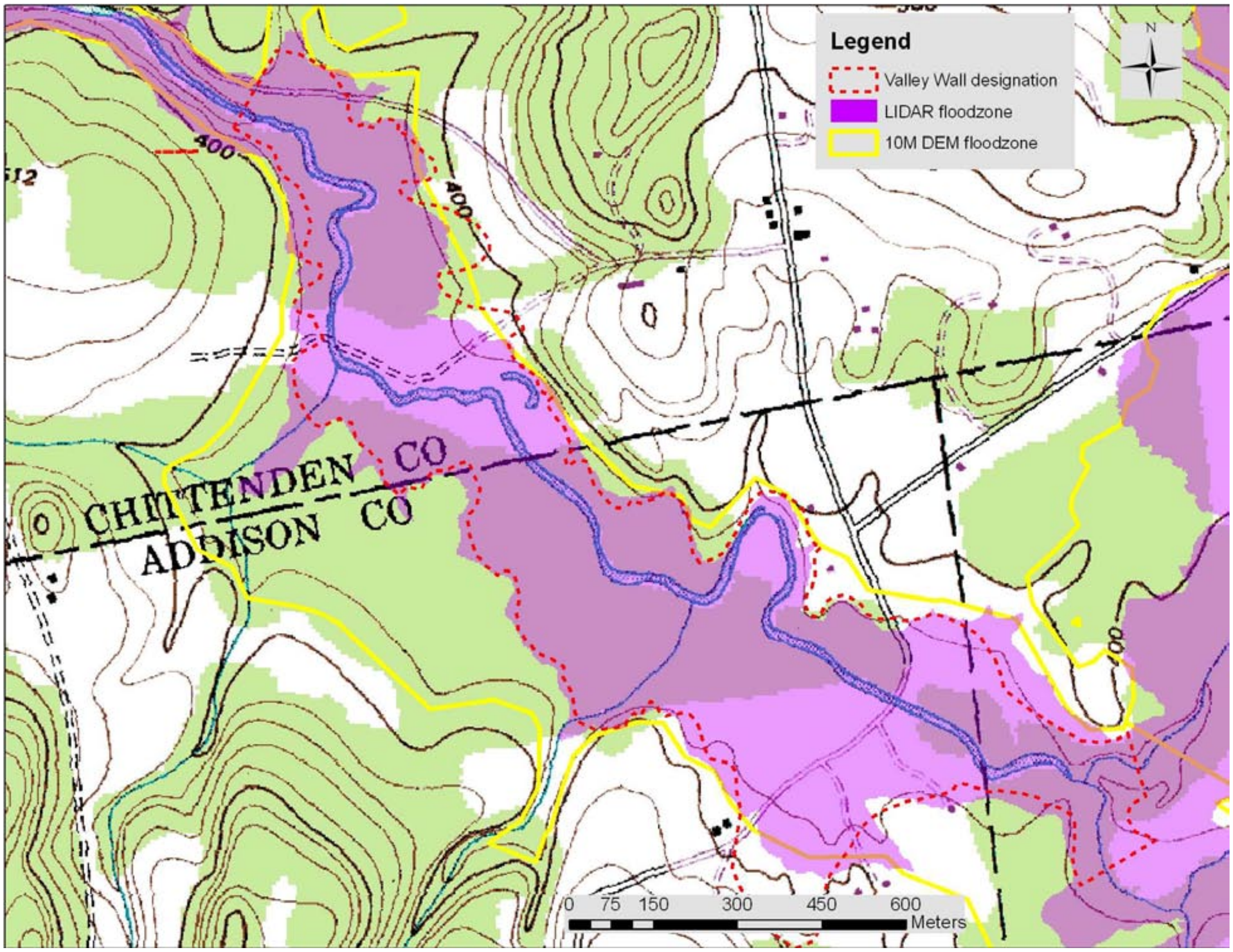

Figure 4: Comparison of LIDAR derived floodzone, 10m DEM floodzone, and VTDEC RMP valley wall designation on reach Lewis Creek M15. Note that the LIDAR derived floodzone closely corresponds to the RMP valley wall designation.

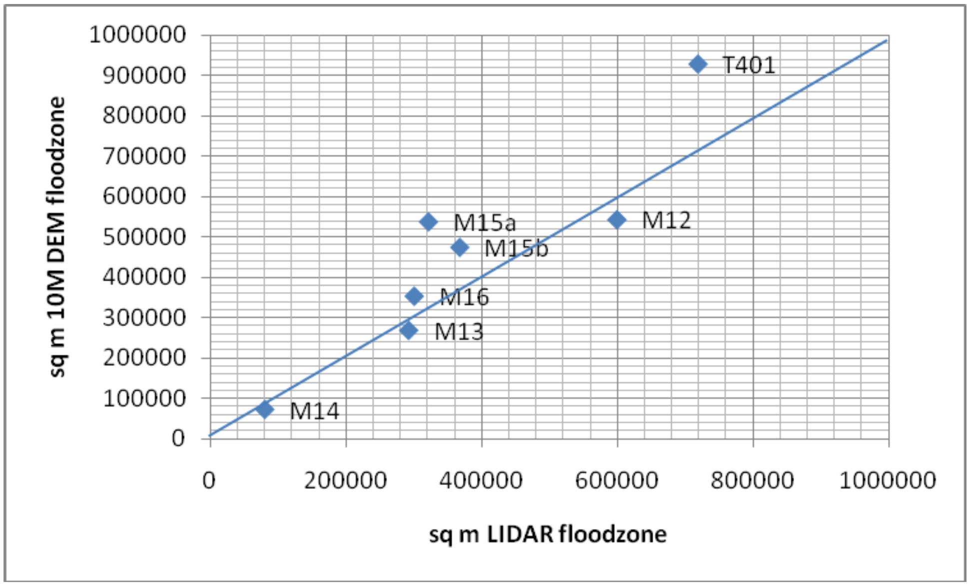

Figure 5: Scatter plot of the estimates of the area of floodzone reaches of LIDAR derived floodzones vs. 10m DEM floodzones on Lewis Creek. The line represents a 1 to 1 relationship, so the greater the distance from the line, the greater divergence of the 10m DEM floodzone reach area compared to the LIDAR floodzone reach area.

Floodzone area analysis (Floodplain ARA component):

We comparatively assessed the overall importance of individual floodzone reaches for potential floodwater attenuation by comparing the ratios of floodzone reach area/reach valley length (Figure 6).

This ratio can be used as a measure of *floodwater attenuation potential* (FAP), or the potential floodwater accommodation capacity of a floodzone, assuming equity among river channels between geomorphic reaches to convey floodwaters. Figure 6 indicates that the highest seven ranked reaches in terms of FAP are T2.04, T2.05, T2.07 and T2.08 in the Castleton, and M07, M09, and M08 in the Poultney watershed. None of the Hubbardton reaches ranked in the top 7, but the two highest ranked reaches within the watershed were T1.03 and T1.04. In general, these reaches have the greatest floodwater attenuation values in the watershed.

Actual floodwater attenuation however, is also influenced by a number of other factors. One such factor is the storage capacity of the river channel itself. *Incision ratios (IR)*[2] offer a basis to compare this capacity between reaches, and these measures ranged from 1.0 to 3.65 (Poultney Mettawee NRCD

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[2] "low bank" height/bankfull height, where the "low bank" represents a terrace on the floodplain.

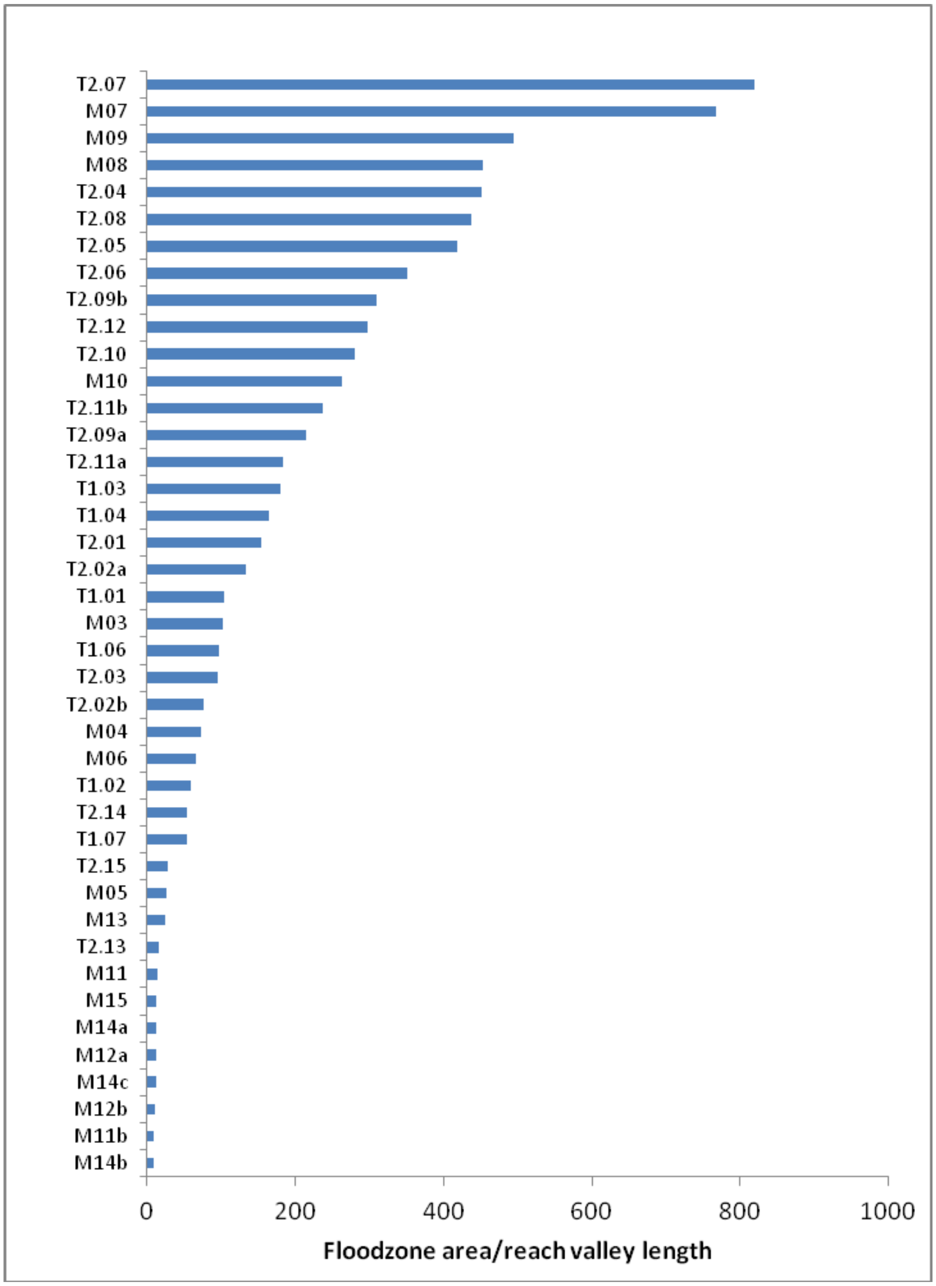

Figure 6: Comparison of the ration of floodzone area/reach valley length among all reaches in the watershed. Reaches with the highest ratio were considered to have the highest ranking for floodwater attenuation potential (FAP) in terms of the value of the floodzone for floodwater attenuation per unit of river valley length.

2006). When incision ratios were plotted against the ratio of floodzone area to valley length for each reach (Figure 7), we gained additional insights into how well connected floodzones are to the river channel in terms of floodwater attenuation in each reach. The IR in reaches with the highest FAP ranged from 1.0 to 1.85, and among the reaches ranked highest for FAP, reaches M7, M9, M10, and M13 appear to have the most impaired floodwater attenuation potential (note that incision ratios were not available for 11 reaches, listed in Figure 7).

A potential for error in ranking reaches based on our measures of floodwater attenuation potential stems from the coarseness of the 10m DEM floodzone analysis. The comparison of results from Lewis Creek between LIDAR and 10m DEM derived floodzones illustrates the limitations of estimates derived from 10m DEM-derived floodzones. Accordingly, it is reasonable to suspect that some features in the Poulntey Watershed within the 10m DEM-derived floodzone may be free from floodwater inundation.

Landcover metrics (Floodplain and Riparian wetland ARA components)

We developed landcover metrics for each floodzone reach by clipping landcover data in GIS by floodzone reach boundaries. With the metrics, we characterized and compared of floodzone reaches in terms of landuse and landcover. By summing up this data on a sub-watershed basis, we produced a comparison of landcover within floodzones among major tributaries. The Poultney River has the largest area of floodzone of the three rivers (Figure 8), which was slightly greater that the floodzone area of the Castleton River. The Castleton River by far featured the largest proportion of floodzone land classified as wetland (74%; Table 7), and lowest proportion of land in agriculture (4%). In contrast, the Poultney mainstem floodzone had the highest proportion of land in agriculture (44%), and the highest proportion of developed land (11%). The Hubbardton River had the smallest floodzone are of the three, and the lowest proportion of development (2%) (Table 7).

When comparing floodzone reaches both within and among sub-watersheds, the broader floodzone reaches of the Castleton River harbored most of the riparian wetlands in that tributary. Indeed, the three largest floodplain reaches (T2.07, T2.12, and T2.14) are predominantly composed of wetlands, and because wetlands are a component of the “natural cover” category, are predominantly in natural cover as well (Figure 9a and b).

The Hubbardton River also appears to possess a high degree of natural cover compared to the Poultney mainstem (Table 7). However, much of the Hubbardton River that is classified as wetland and natural cover is actually recovering old pasture and agricultural land. Up until 35 years ago, riparian habitats in the Hubbardton were intensively used for activities such as haying and grazing. While much of this “natural cover” is not in mature natural vegetation communities, the data do suggest that the landuse context for the Hubbardton floodplain is one that is mostly free of intensive human use and generally is in an early successional type of “natural cover”.

Overall in the Hubbardton River, reaches T1.03, T1.04, and T1.10 have the largest floodzones, and all feature a relatively high proportion of wetlands and natural cover (Figures 9c and d). In general, when compared to the Poultney mainstem and the Castleton, wetlands are less proportionally significant to the smaller, more confined reaches of the Hubbardton.

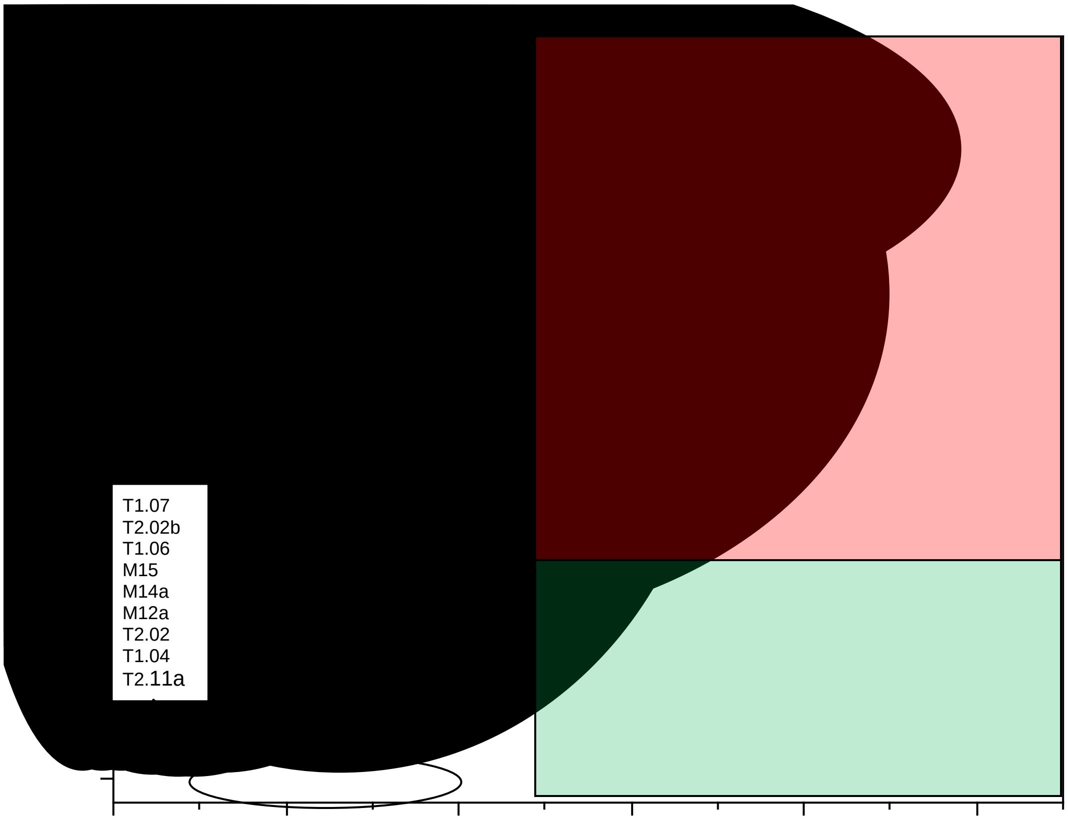

Figure 7: Plot of FAP (ratio of floodzone area/valley length) to Incision Ratio. Red box identifies reaches with high FAP that have impaired floodplain functionality (higher Incision Ratios). Green box identifies reaches with high FAP with more intact floodplain functionality (lower Incision Ratios). No Incision Ratios were available for T2.03, T2.04, T2.05, T2.07, T2.08, T2.09b, T2.13, T2.14, T2.15, M11b, M12b.

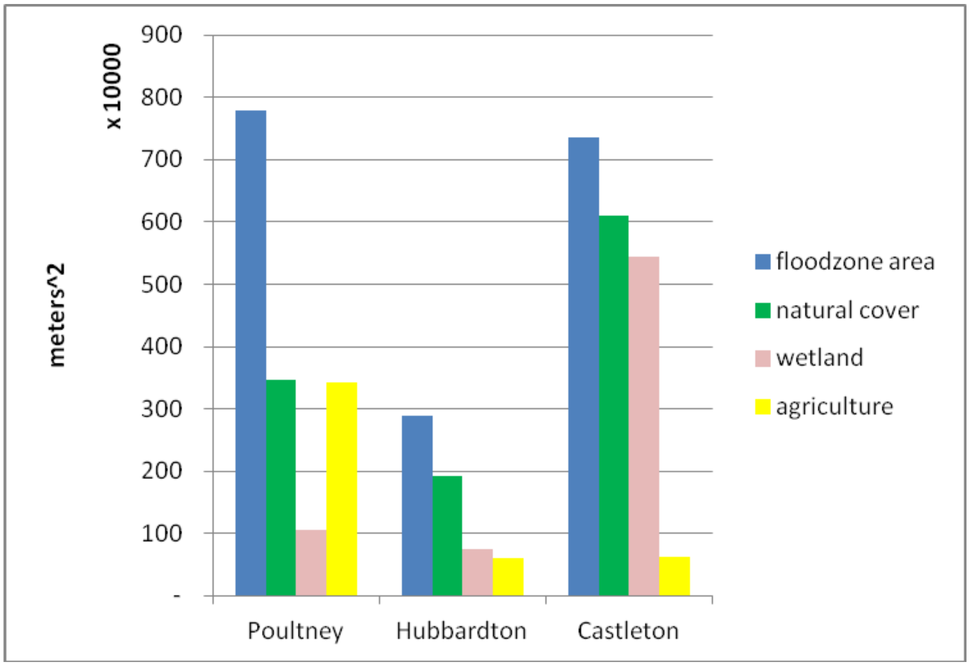

Figure 8. Landcover composition of the floodzones for the three major tributaries in the Poultney River watershed.

Table 7. Statistics for landcover within floodzones of each of the major tributaries.

	floodzone area (ha)	natural cover	wetland	agriculture	developed	forested
Poultney	779.0	44%	14%	44%	11%	23%
Hubbardton	289.1	67%	26%	21%	2%	41%
Castleton	734.8	83%	74%	9%	5%	5%

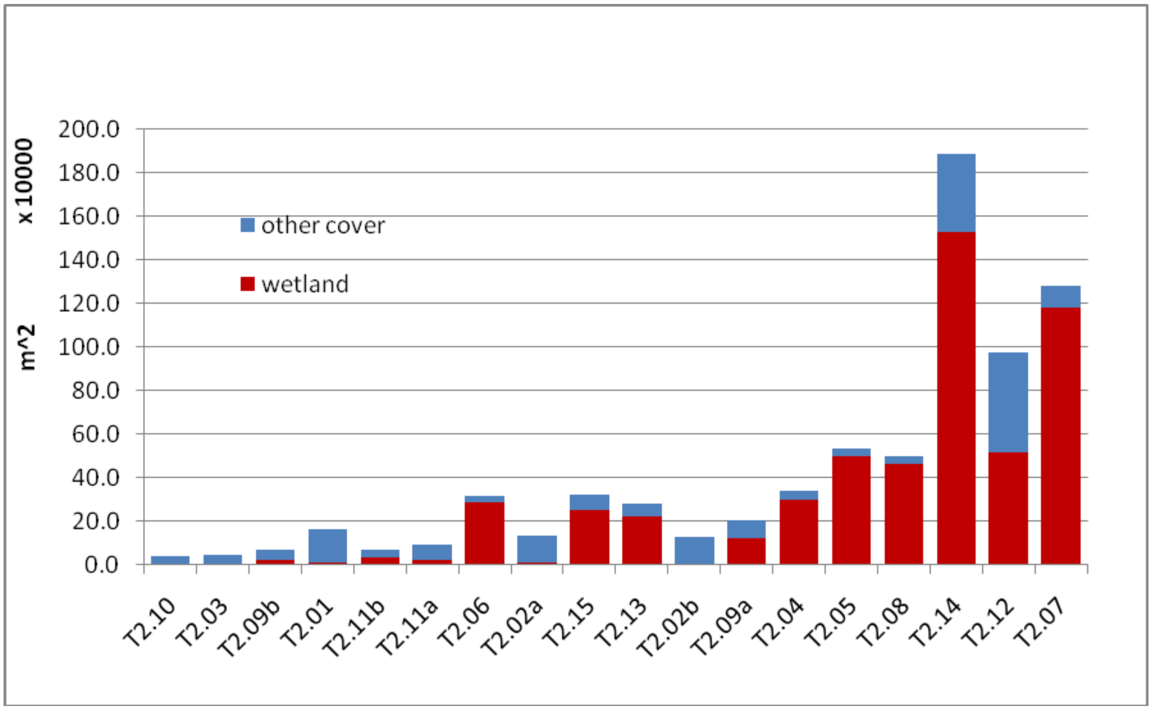

Figure 9a: Wetland landcover and total area for each of the Castleton River mainstem floodzone reaches, sorted by FAP (lowest to highest).

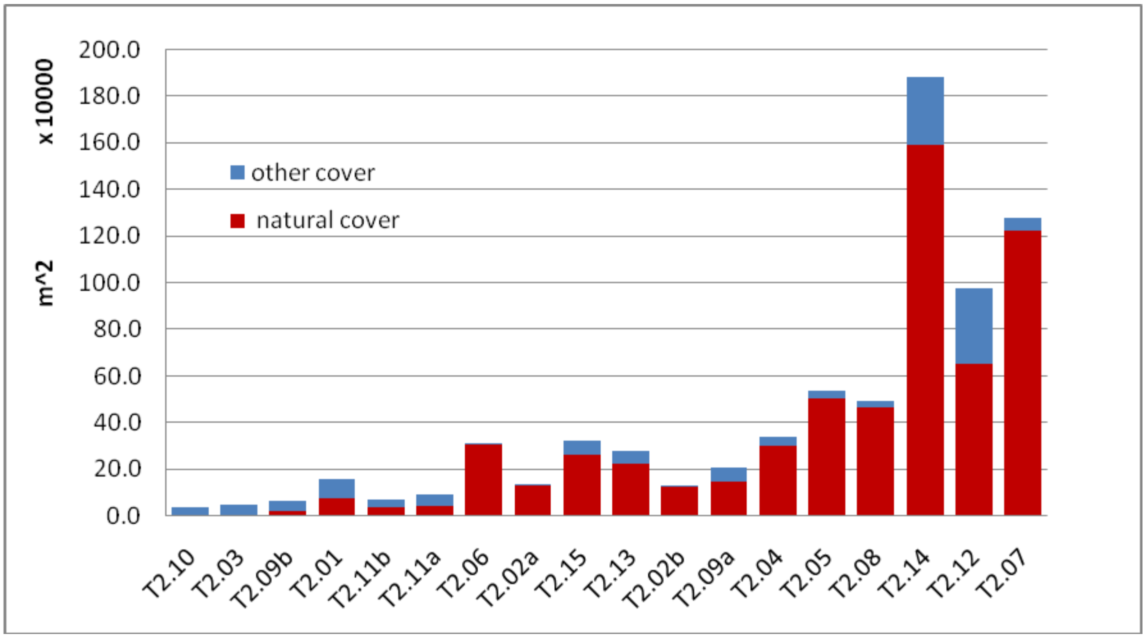

Figure 9b: Natural cover landcover and total area for each of the Castleton River mainstem floodzone reaches, sorted by FAP (lowest to highest).

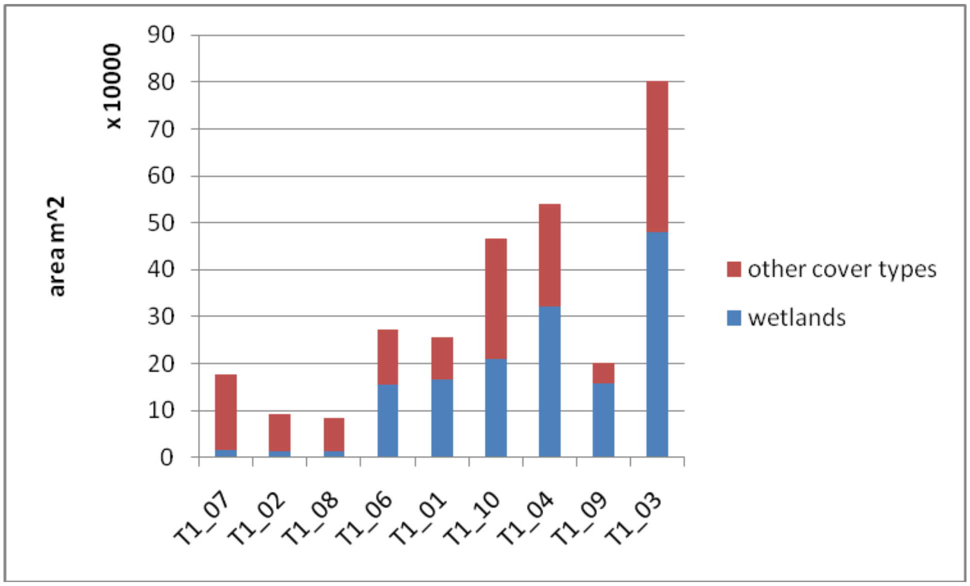

Figure 9c: Wetland landcover and total area for each of the Hubbardton mainstem floodzone reaches, sorted by the FAP (lowest to highest).

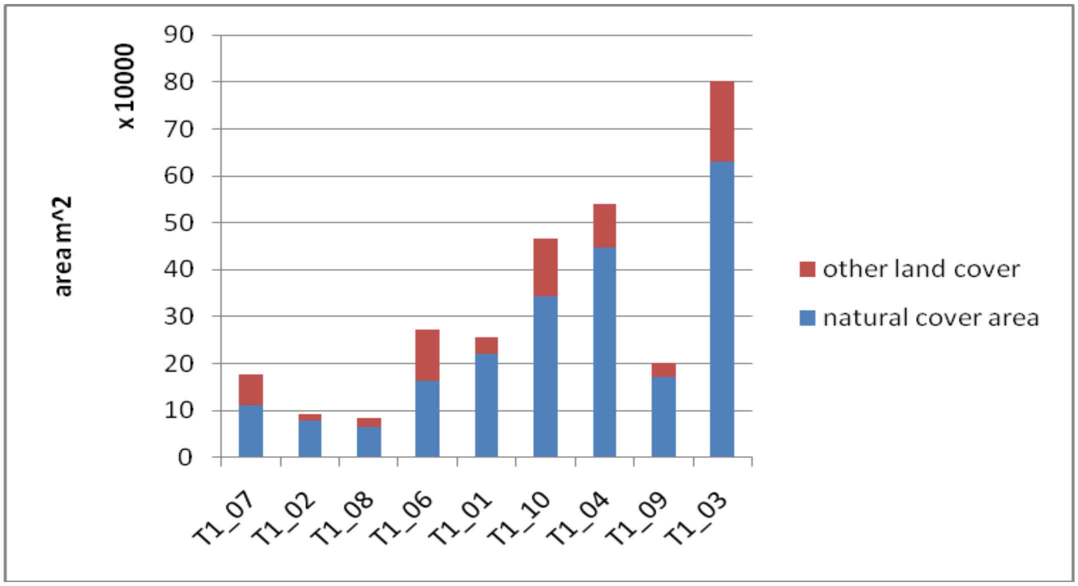

Figure 9d: Natural cover landcover and total area for each of the Hubbardton mainstem floodzone reaches, sorted by the FAP (lowest to highest).

There are four large, broad floodzone reaches (M7 – M10) in the Poultney River have few wetlands, are highly ranked in terms of FAP (Figure 9e), and are predominantly in agriculture. These reaches together constitute 64% of the entire floodzone area of the entire Poultney mainstem, and also host 71% of all the agricultural use in the watershed's floodzone. This concurs with the simple observation that these floodzone reaches have soils that are suitable for agriculture, and are intensively used for that purpose.

In general, in the Poultney mainstem, the floodzone reaches with the highest proportion of natural cover were in confined, narrow river valleys. These reaches had the smallest overall spatial area compared to reaches that had lower proportions of natural cover (Figure 9f). Of the 4 larger, broader floodzone reaches in the Poultney mainstem, M7 had the most natural cover, in part due to a large wetland that is north of a road that likely impairs the hydrologic connection between the wetland from the river.

Generally, ARA floodzone reach landuse metrics revealed a distinction between floodzone reaches that ranked higher vs. lower for FAP (Figure 9 b, d, and f). For broad, unconfined river valleys in particular (reaches ranking high in FAP), where conditions are suitable for agricultural development, floodzones had low metrics for natural cover and wetlands, while more confined reaches in narrower valleys with steeper gradients (lower FAP) tended to have higher metrics for natural cover. The Poultney River mainstem can be generally described in this way (Figure 9f). However, in broad river valleys with areas unsuitable for agriculture or agricultural conversion, wetlands dominated broad floodzone reaches. The Castleton River mainstem can be characterized in this way (Figure 9a). Moreover, the Castleton reaches with greater wetlands abundance tended to have floodplains with greater functionality, as indicated by the Incision Ratios in Figure 7. In contrast to the broad floodzone reaches on the Poultney, these reaches on the Castleton should be considered closer to a "reference" condition in terms of the function that is defined within the ARA framework for the floodplain ARA component.

It should be noted that while we are able to identify wetlands within floodzones in this analysis, we lack more detailed information of how well these wetlands are functioning, whether or not they are hydrologically connected to the river, or are otherwise separated by fragmenting features such as roads and/or railroads.

Where we had pre-existing knowledge of features that impair the hydrologic connectivity between wetlands within floodzones and river channels, we were able to estimate the spatial value of potential projects to restore these connections. Reaches M10 and T2.12 feature a channel-spanning rail bridge and an old trolley line, respectively, which have been identified as hydrologic connectivity-impairing features (Poultney Mettawee NRCD 2007). With the estimates of active floodplain provided by the floodzone reach demarcation, we were able to identify and quantify the area of wetlands that would benefit from connectivity restoration projects (Figures 10a and 10b). A project aimed at eliminating the constriction in flow caused by the rail bridge over the Poultney mainstem on reach M10 would increase the hydrologic connectivity of the floodzone downstream of the bridge on approximately 6.8% of the floodzone in that reach. In the floodzone on reach T2.12, removal of all or parts of the old trolley line would increase/improve hydrologic connectivity to wetlands on 11.3% of the floodzone in the reach.

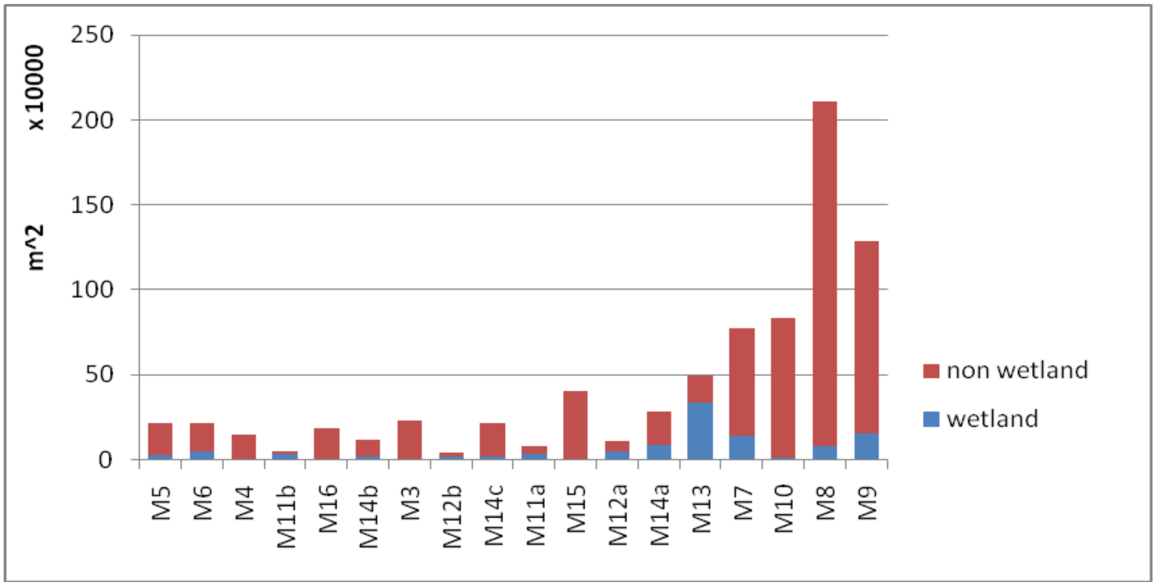

Figure 9e: Wetland landcover and total area for each of the Poultney River mainstem floodzone reaches, sorted by FAP (lowest to highest).

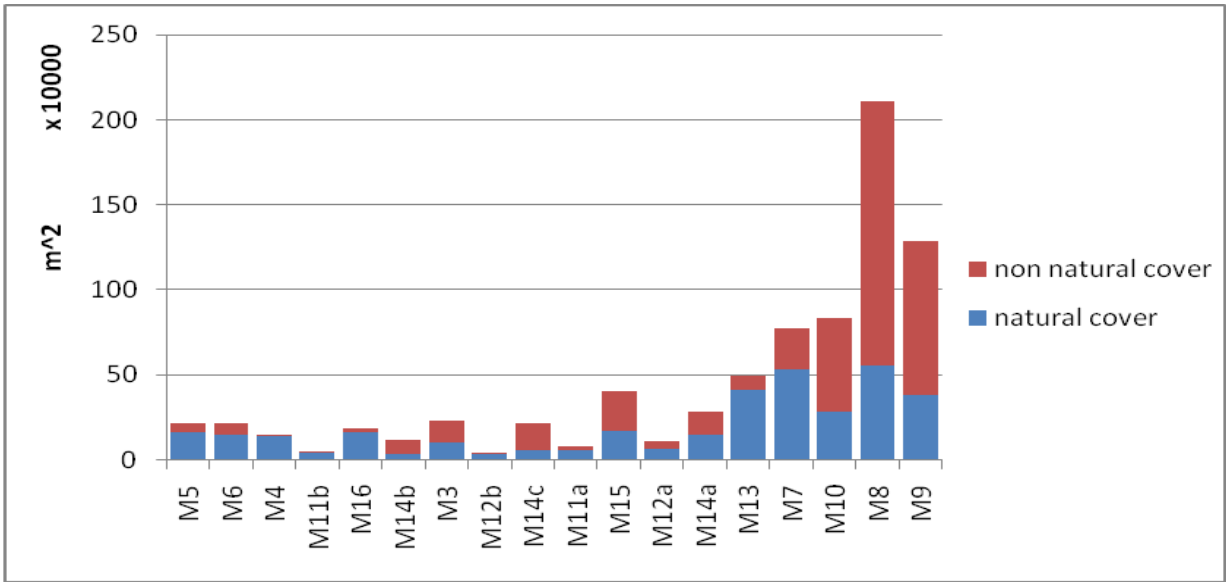

Figure 9f: Natural cover landcover and total area for each of the Poultney mainstem floodzone reaches, sorted by FAP (lowest to highest)

This information may be invaluable for proposals seeking restoration funding for implementing strategies to improve hydrologic connectivity around these features.

Floodzone Wetland Analysis (Riparian Wetland ARA component)

A wetflat ARA analysis tool developed by TNC was applied to delineate predicted water accumulation areas (or “wetflats” on the landscape according to the underlying DEM. We compared the wetflat areas to existing information on wetland occurrence in floodzone areas to test whether this tool was a good predictor of either extant or historical (drained or otherwise altered) wetlands. A visual comparison between 10M DEM wetflat tool outputs to existing spatial information on wetlands (UVM Spatial Analysis Lab 2006 data; Figure 11) yielded very little corroboration between the wet flat data and wetland landcover throughout the floodzone on the mainstems of the three major sub-watersheds. This non-corroboration was sufficiently obvious to make the decision to not invest time into producing wetflat results for the Poultney Watershed, as it seemed likely to produce results that would be difficult to interpret.

In addition to the issues with the wet flat data, difficulties with the data quality of wetland spatial information were also encountered. In the Lewis Creek ARA analysis, The UVM data (UVM Spatial Analysis Lab, 2006) depicted more wetland coverage in floodzone reaches than VSWI data (Figure 12). And while not quantitatively compared, VSWI wetland data in turn appeared to be greater than National Wetland Inventory data coverage within floodzone reaches. For this analysis, we chose to use data extracted from UVM Spatial Analysis Lab 2006 to characterize wetland coverage within floodzones, because it was not subject to the minimum size thresholds that limits the comprehensiveness of the VSWI data set (which does not document wetlands <3 acres in size). For reaches where UVM data was unavailable, we quantified wetlands from NLCD (2001) data. In general, 2001 NLCD wetlands data appeared inferior to the UVM data in terms of resolution, wetland identification, and wetland classification (Figure 13a and b). We thus have lower confidence in the data from floodzone reaches that were characterized with NLCD data.

In general, wetland restoration projects within the floodzone will provide a number of benefits: increases in the floodwater storing potential of the floodzone and facilitation of passive geomorphic restoration by improving flood dynamics by increasing the flow and sediment attenuation role of the floodzone surrounding the river channel. However, identifying specific wetland restoration projects is difficult due to the limitations of underlying wetlands and soils data. Existing maps of hydric soils are limited by a resolution of 3 acres, and our wetflat analysis was not reliable enough to identify potential restoration sites. However, the Lake Champlain Wetland Restoration Plan used a modeling process to identify number of additional potential wetland restoration sites in the watershed, on reaches M7, T2.11a and b, T2.12, T.13, T2.14, T2.15, T2.16, T1.04, T1.09 floodzones. This process was designed to prioritize restoration sites on the basis of phosphorous removal potential.

Other ARA Components

One of the objectives of the VTDEC RMP is to explicitly identify meander belts along rivers for the purposes of accommodating the meanders and slope of a balanced or equilibrium river channel.

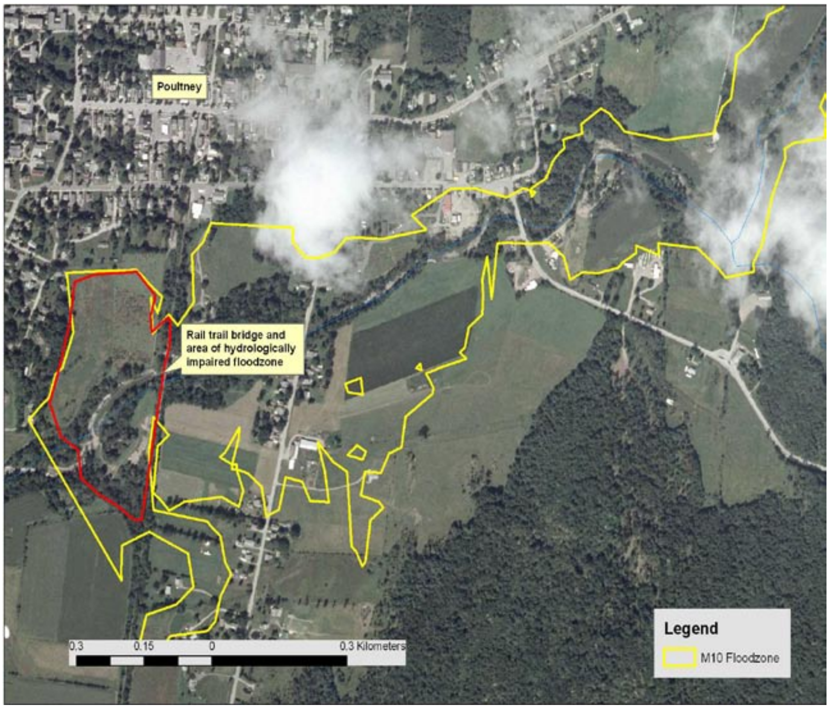

Figure 10a: Area of the floodzone with impaired hydrological connectivity downstream of the rail-trail bridge in Poultney, VT on floodzone reach M10.

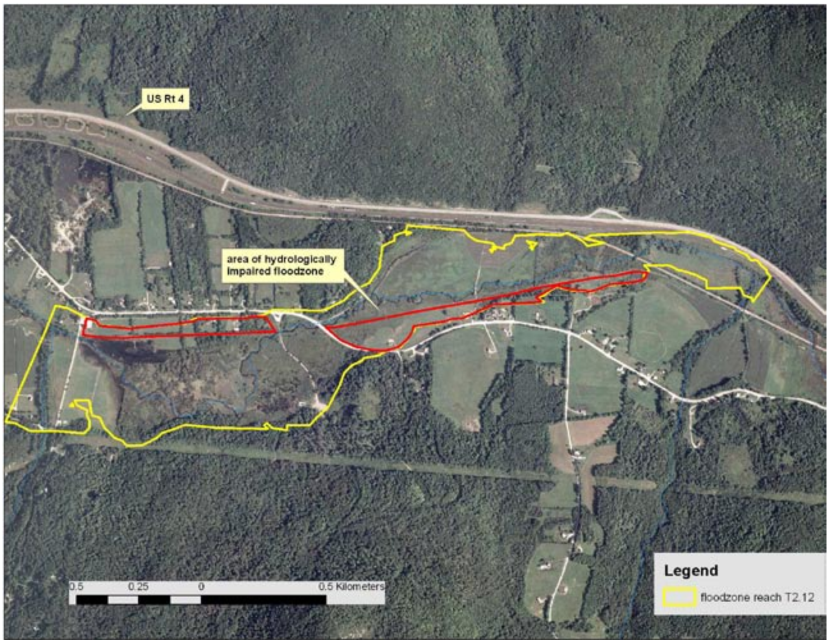

Figure 10b: Area of the floodzone with impaired hydrological connectivity imposed by old trolley line bed in reach T2.12 on the Castleton River.

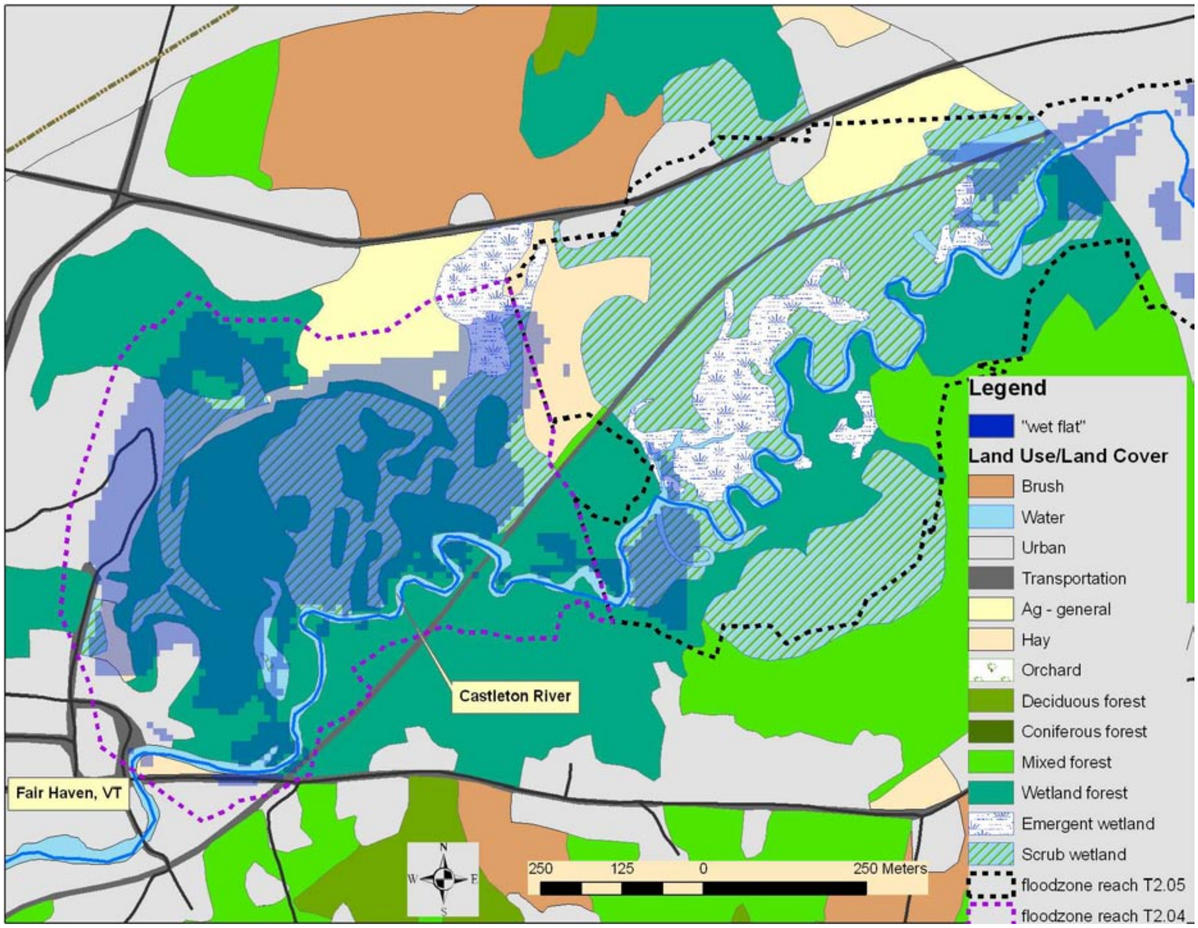

Figure 11: Comparison of modeled “wet flat” water accumulation areas within the floodzones ot T2.04 and T2.05, along with UVM landcover data depicting wetlands. The lack of correspondence between data layers in terms of wetlands led us to not use this tool for deriving wet flat metrics for each floodzone reaches.

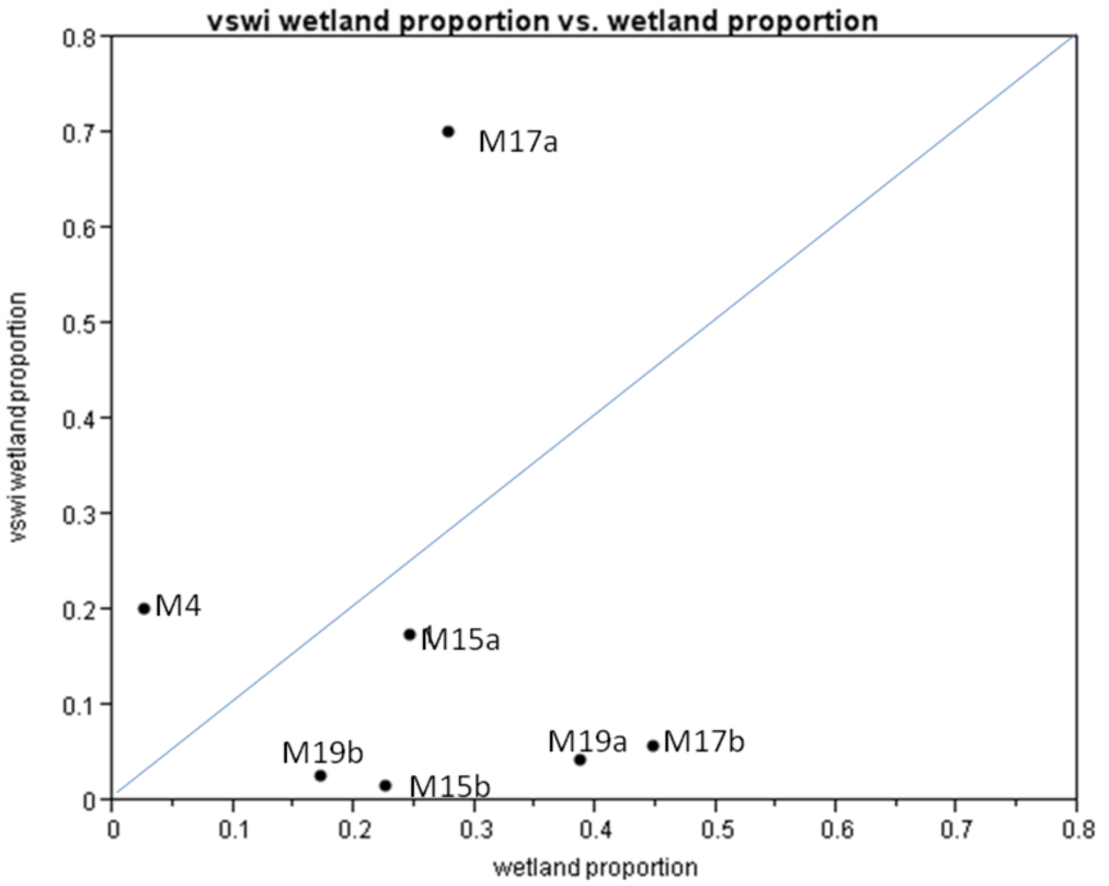

Figure 12. Comparison of VSWI Proportion of wetlands within floodzone reaches vs. UVM Spatial Data Analysis Lab (2006) for floodzone reaches in Lewis Creek. There is substantial scatter around the 1 to 1 relationship line, and UVM data depicts a much greater area of wetlands compared to VSWI data.

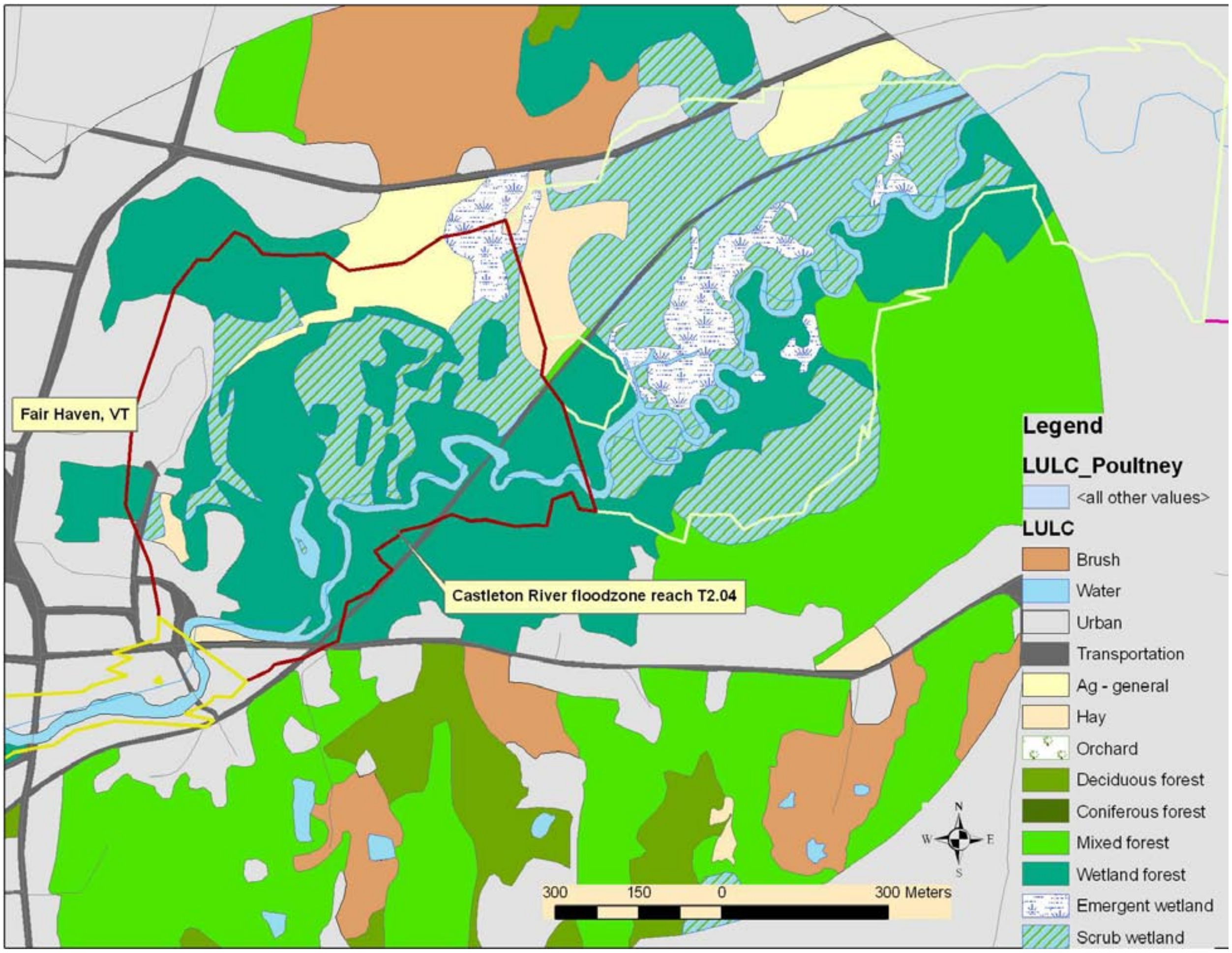

Figure 13a. UVM Spatial Analysis Landcover data (2006) for reach T2.04 and part of T2.05 on the Castleton River. Note the resolution in distinguishing between wetland landcover class-types within the floodzone reach.

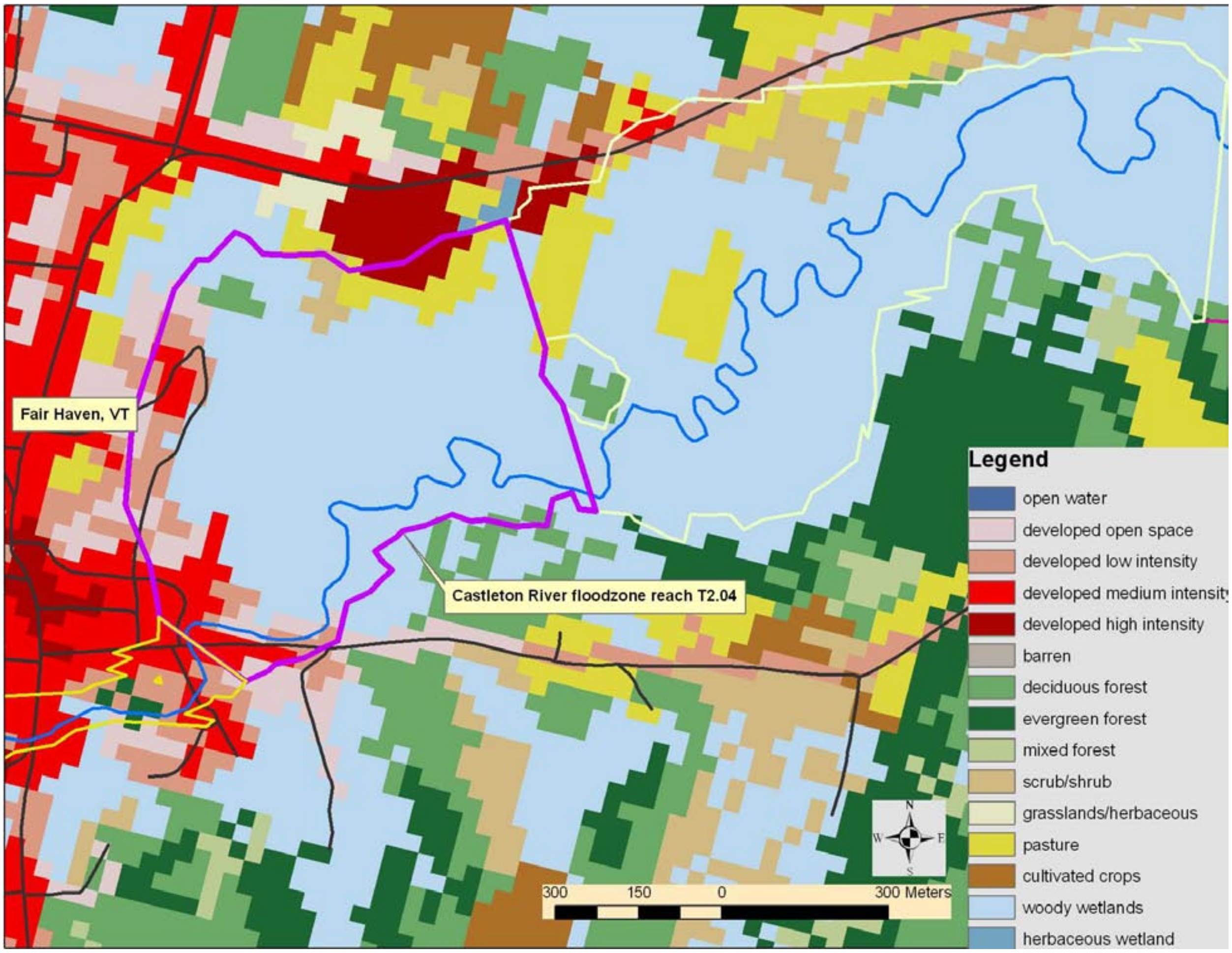

Figure 13b. NLCD (2001) landcover data for reach T2.04 and part of T2.05 on the Castleton River. Note the lack of resolution in distinguishing between wetland landcover class types within the floodzone reach compared to Fig 11a.

Meander belt designations serve as guides for fluvial erosion hazard assessment for land use planning, and also habitat management. VT ANR stream geomorphic assessments have in essence institutionalized the meander belt ARA component (VT ANR 2004), thereby encompassing additional ARA framework components (meander belt and river channel) into the existing body of information on the Poultney Watershed. Given that we did not have ARA related GIS assessment tools able to explicitly define and characterize meander belts, we did not make any effort to incorporate this component into this report.

In regards to the terraces ARA component, the coarseness of the 10m DEM floodzone analysis appeared to lack the resolution to be able to capture floodplain terraces with any confidence and differntiate between terraces and active floodplains. This was clearly illustrated in the comparison of 10m DEM floodzone vs. LIDAR derived floodzone for reach M15, as noted earlier. The 10m DEM floodzone incorporates what is likely a terrace that is seldom if ever flooded, while the LIDAR analysis is able to differentiate between terrace and active floodplain in this reach. Therefore, the terrace component will need to be more clearly demarcated if/when LIDAR data becomes available for the entire reach.

Prioritization of conservation in the Poultney watershed:

We prioritized floodzone reaches for conservation action from a synthesis of ARA-based analyses and existing geomorphic assessment data. We first culled the lowest ranked 29 reaches in terms of FAP (Figure 6) from the analysis, making exceptions for the two highest ranked Hubbardton River floodzone reaches, which were not among the highest ranked. This provided an initial list of 14 priority floodzone reaches. We then characterized these reaches in terms of landcover metrics and the intactness of floodplain functionality, and used these characterizations to classify these reaches terms of their conservation need (protection – high natural cover/wetlands/good floodplain functionality vs. restoration – low natural cover/wetlands/impaired floodplain functionality). Overall conservation priority ranks were determined on the basis of 1) FAP rank; 2) overall size of floodzone reach area (smaller reaches = lower priority); 3) Importance to a specific subwatershed in terms of FAP; and 4) Importance of geomorphic function (Poultney Mettawee NRCD 2006) (Table 8).

We were also able to cross reference results from landcover/floodzone reach analysis with geomorphic condition metrics by comparing landcover metrics in floodzone/geomorphic reach based analysis units to geomorphic assessment results from the Corridor Plan (Poultney Mettawee NRCD 2006): Reach Geomorphic Assessment rating (RGA) and the reach geomorphic Sensitivity rating. Results identified reaches that featured both the most compromised geomorphic conditions, reaches most sensitive to geomorphic disturbance, and reaches featuring with low metrics for attributes such as floodzone natural cover (Figure 14). Results from this analysis provide an additional ARA-based lens for framing conservation priorities in the basin. For example, reaches having low metrics of natural cover and/or wetlands, along with impaired geomorphic assessment conditions and high sensitivity rank as the highest priorities for restoration work, as restoration activities that included floodzone re-vegetation (restoration of floodplain forests and/or riparian buffers) and wetland restoration would provide material contribution (woody debris) and floodwater attenuation enhancement that would facilitate the passive restoration of geomorphic equilibrium. In Figure 14, reaches M10 and T2.09b overall had the highest ratings for sensitivity and impaired geomorphic condition, and the lowest ratings for natural vegetation cover in the floodzone. Therefore restoration efforts in terms of riparian buffer and/or forest restoration in the floodzone would be highest conservation priorities in this reach.

Likewise reach M7 had a rating of “poor” in terms of geomorphic condition and “very high” reach sensitivity. While landcover metrics were higher for this reach, additional efforts to restore wetlands and or landcover in this reach should be prioritized. Poultney reaches M8 and M9 had better geomorphic assessment rating (fair), but still were rated as “very high” in terms of sensitivity. Both reaches have low proportions of natural cover, so restoration activities could be considered somewhat less of a priority in these reaches compared to M7 and M10.

The results of this analysis suggest a set of specific priorities: Specifically, M10 ranks the highest for prioritization for restoration and protection work. Reach M10 has an important geomorphic role, being

Table 8. The characterization of conservation needs and classification of priorities for conservation among floodzone reaches in the watershed. Color codes are: Green=high; blue = medium; red = low/impaired.

Reach	FAP (Floodzone area/valley length ratio)	Floodplain functionality (Incision ratio)	Wetland proportion	Natural cover proportion	Conservation need	Priority
T2.07	High	NA	High	High	Protection	High
M07*	High	1.37	Medium	High	Protection	High
M09*	High	1.6	Medium	Medium	Restoration	High
M08*	High	1.26	Low	Low	Restoration	High
T2.08	High	NA	High	High	Protection	High
T2.05	High	NA	High	High	Protection	High
T2.06	High	1.0	High	High	Protection	Medium
T2.09b	High	1.0	Low	High	Protection	Medium
T2.12	High	1.3	Medium	Medium	Restoration	Medium
T2.10	High	1.3	Low	Low	Restoration	Low
M10	High	1.85	Low	Low	Restoration	High
T1.03	Medium	1.7	Medium	High	Protection	High
T1.04*	Medium	1.0	Medium	High	Protection	HIgh

*Reaches prioritized for riparian restoration by Field et al (2000).

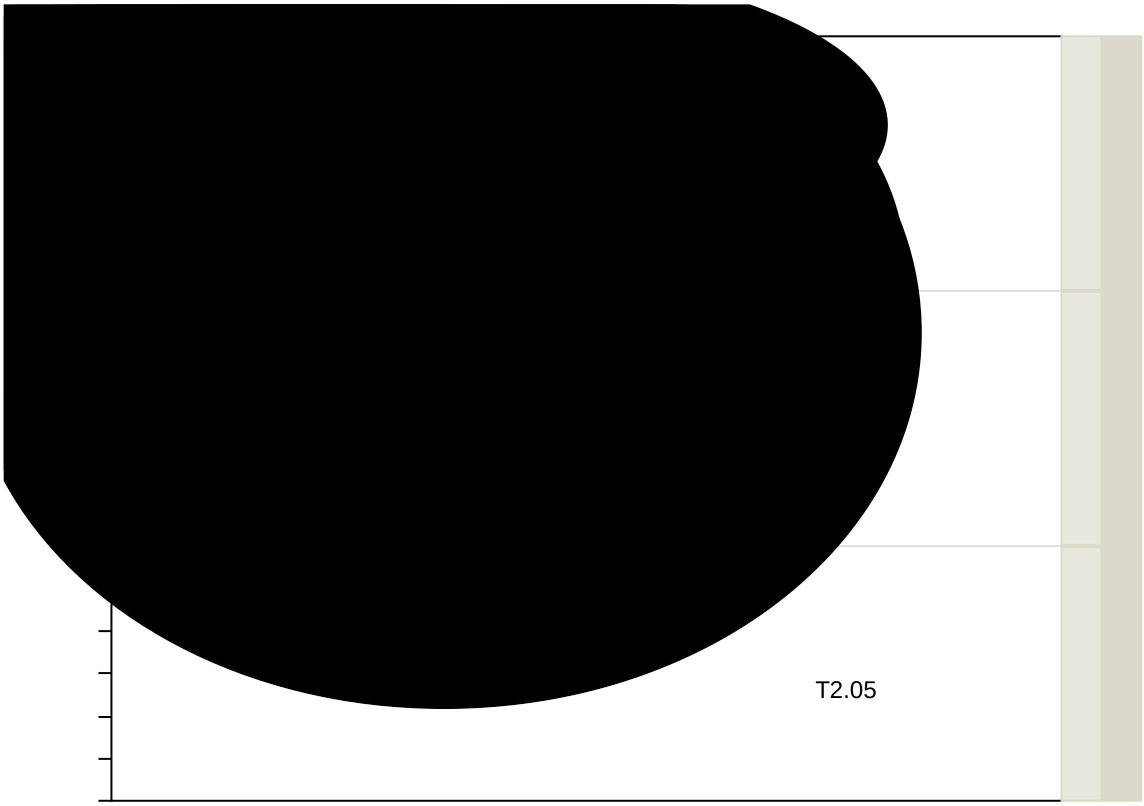

Figure 14: Floodzone natural cover % for largest reaches for each of the three main tributaries plotted against geomorphic assessment results. Note the geomorphic assessment results were unavailable for two of the larger reaches on the Castleton River (T2.07, T2.08, and T2.12).

the first reach the Poultney mainstem encounters as it transitions from a high-gradient system in confined river valleys to a lower gradient system in broader river valleys. As such it has a critical sediment and floodwater attenuation functions. It also has a “poor” geomorphic assessment rating (RGA), and an “extreme” rating in terms of its sensitivity to stressors that precipitate geomorphic adjustment. The reach had been straightened upstream of the rail bridge, thus exacerbating geomorphic degradation (Poultney Mettawee NRCD 2006). A greater degree of natural cover and wetlands in this reach would contribute to the improvement of these ratings, in addition to the flow restoration project mentioned previously. Reach M7 also is rated as “poor” in terms of geomorphology. It has a higher degree of natural cover, but only because, as noted before, of a large wetland complex that is separated from the river by a road on the north bank that is nevertheless in the floodzone. It also has been subject to channel straightening due to road construction and agricultural field maintenance (Poultney Mettawee NRCD 2006).

Reaches M8 and M9 also appear on Figure 14 as low in natural cover, fair geomorphic ratings, and very high sensitivity to geomorphic stressors. Both these reaches have large floodplain areas, low proportions of natural cover, and low proportions of wetlands within the floodzone (Figures 9e and f). On the basis of this characterization, these reaches can also be considered priorities for restoration-oriented actions such as land protection, riparian buffer re-vegetation, and wetland restoration. These reaches, however, provide distinct challenges to restoration, given that their current position in the floodzone (river channel hugging the east bank of the river valley in M8) has likely been created to maximize the use of river valley soils for agriculture. It is certain that agricultural uses of these reaches will continue to be valued land-uses by the local community, and as such, conservation initiatives will need to balance these priorities. Fortunately, emerging river conservation strategies are making advances in striking a balance between protecting conservation and agricultural values in terms of models for creating conservation easement language for use in river corridor land protection efforts. A way of balancing these needs may be to focus on opportunities to restore natural cover within river meander belts or wetlands with a direct hydrologic connection to the current river channel.

Restoration work on the reaches identified here can achieve multiple objectives: maximizing the value of natural habitats in the floodzone for both biodiversity conservation and contribution toward the restoration of geomorphic equilibrium conditions in terms of geomorphic processes.

Overall, relating ARA landcover and floodzone metrics to geomorphic assessment data provides a useful perspective for prioritization, but is also limited in that the dynamic processes governing fluvial geomorphic equilibrium on a reach basis are complex and multifaceted and are certainly not direct functions of landcover within floodzones. Nor, obviously, are floodzone reach landcover metrics even an indirect reflection of predominant geomorphic processes and adjustments. But we are able to use ARA floodzone metrics as an additional layer on top of geomorphic assessment data to provide a more complete reach-based characterization that combines ARA floodplain modeling, landcover, wetlands, and geomorphic assessment data.

Project analysis and the Active River Area framework

Overall, ARA analysis tools provided us with the ability to characterize landcover in two ARA assessment framework components: floodplains, and riparian wetlands within the floodplain. In addition, one of the objectives of the V DEC RMP is to explicitly identify an additional ARA component: meander belts along rivers for the purposes of fluvial erosion hazard assessment for land use planning. Our effort to characterize the Poultney watershed according to these ARA components provides a perspective that is not provided by any other conservation planning effort for the Poultney. Perhaps most significantly, the ARA framework adds a component of river systems to existing conservation assessments that did not previously exist: specifically, the function of riparian wetlands in terms of ecological habitat and potential floodwater storage/attenuation is overlooked in current conservation planning in the basin, other than being examined from the context of nutrient management in Lake Champlain. Unfortunately, inaccuracies in wetlands data limits the confidence terms of any conclusions we can reach. Nevertheless, this analysis provides a unique conservation perspective, and should be revisited whenever improvements in wetland datasets become available.

Conclusions

Despite the limitations of scale and data accuracy noted earlier, the ARA framework and associated GIS assessment provide a unique lens through which to assess and prioritize conservation in the Poulntey watershed. By deriving landcover metrics from units defined by floodzone reaches and incorporating data from existing geomorphic assessment work, we generated conservation priorities from a perspective informed by landcover metrics and geomorphic cohdition data among floodzone-based analysis units that are geomorphically distinct. This information alone is highly complementary to existing conservation assessments in the Poulntey wateshed. With this analysis, we were able to identify restoration and protection priorities for the major sub-watershed in the Poulntey, informed by the framework provided by the Active River Area. Significant refinements can be made by repeating this analysis with a LIDAR derived DEM for the entire watershed.

This project also illustrates the value and limitations of GIS-based analysis with ARA-oriented spatial assessment tools for characterizing and prioritizing for conservation components of rivers which for which there is less geomorphic, wetlands, and aquatic habitat assessment data. Analysis with the GIS tools demonstrated here can provide an initial characterization of river priorities, particularly when paired with other spatial analysis exercises such as the VTDEC Phase 1 SGA, which defines the geomorphcially unique river reaches that provided one of the foundations of this assessment. Analysis with ARA GIS assessment tools increases in value to the extent that LIDAR data is available for development of floodzone cost surfaces, and may be especially useful in smaller tributaries and streams, where the lack of resolution in 10M DEM data becomes increasingly problematic. In general, this project complements the existing Phase 1 SGA protocols, and ARA-based spatial analysis as demonstrated here can be streamlined and standardized to make this a cost effective approach for river assessment in less-data rich envrionments.

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Appendix A: GIS analysis methods

We used The Active River Area (ARA) Three-Stream Class Toolbox, a tool for ArcGIS created by TNC (TNC 2010), to create a raster data set that contains representations of most of the elements of the six components of the active river area. Input data for the tool included the 1/3-Arc Second National Elevation Dataset DEM (USGS 2009) with a horizontal resolution of 10m as a representation of topography and the Vermont Hydrography Dataset (VCGI 2008) for representations of streams and lakes.

The Vermont Hydrography Dataset (VHD) is based primarily on the Vermont Mapping Program (VMP) digital orthophotos and is the most detailed stream data available for Vermont. We used a combination of stream size classes from the Northeastern Aquatic Habitat Classification System (EPA, USGS, TNC, 2008) and stream orders from VHD to assign the stream and lake shapes to 4 different size classes. As the shapes in the Northeastern Aquatic Habitat Classification System (NAHCS) are extracted from a spatially coarser dataset, some stream segments in VHD are not represented in NAHCS. VHD streams with stream orders of 1 and 2 that are not represented in NAHCS make up the smallest stream class (size 0). VHD streams with stream orders of 3 and 4 that are represented in NAHCS and have watershed areas of 0 to 3.861 mi^2 make up the small stream class (size 1). Medium and large streams (size 2 and 3) have watershed areas of 3.861 to 38.61 mi^2 and 38.61 to 200 mi^2, respectively. Streams represented by polygons in VHD were treated the same way. VHD lakes that intersect with VHD streams were assigned a size class equivalent to the size class of the stream that it drains into. All of the components of the ARA, except the headwater watershed material contribution zone and the upper terraces, were created for stream sizes 1, 2, and 3. Only the riparian material contribution zone was created for stream size 0.

We used the ARA toolbox to create a cost distance grid (or *cost surface*) from the DEM and the classified stream input data. The cost distance grid is calculated from intermediate grids that are derived from the DEM: a slope grid, a flow direction grid, and a flow accumulation grid. The value of each cell in the cost distance grid is the cost distance for that location, when cost distance is defined as the relative cost of water to travel upslope out and away from the stream/river. The cost takes into account both the slope due to elevation change and the distance from the channel, with higher costs for greater slopes and distances from the stream/river (TNC 2010).

We identified areas in which wet areas adjacent to the streams would be included in the riparian wetland component of the ARA. These “wet flat grab zones” are areas defined by the doubled cost-distance thresholds for stream sizes 1, 2, and 3.

Wet flats “are areas that are likely to be wet as a result of high groundwater and overland runoff from adjacent uplands” (TNC 2010). We used the ARA toolbox to create a wet flat grid from the DEM.

Our first step in creating the wet flat grid was to create a moisture index grid derived from the slope grid and flow direction grid that were created in the process of calculating the cost distance grid. The resulting moisture index grid was then compared to wetland data, hydric soils, and topographic information in the wet flat grab zone in order to select values of the index that most consistently correspond to current and historical wet areas and areas likely to be wet based on topography. A wet flat grid was created by selecting cells in the moisture index grid that had values that were less than the chosen index value (wet flat threshold).