6-2017

Developing 2015 High-Resolution Impervious Cover Estimates for the 52 Towns in the Piscataqua Region Estuaries Partnership: Final Report

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DEVELOPING 2015 HIGH-RESOLUTION IMPERVIOUS COVER ESTIMATES FOR THE 52 TOWNS IN THE PISCATAQUA REGION ESTUARIES PARTNERSHIP

A Final Report to

The Piscataqua Region Estuaries Partnership

Submitted by

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June, 2017

This report was funded in part by a grant from the Piscataqua Region Estuaries Partnership as authorized by the U.S. Environmental Protection Agency's National Estuary Program.

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Acknowledgements

Grateful thanks go to Amanda Cugno and Rebecca Bannon for their diligence and perseverance while digitizing and updating the impervious cover for the study area.

Project Summary

Estimates of 2015 impervious cover (IC) for the 52 towns of the Piscataqua Region Estuaries Partnership (PREP) were generated from 2015 1-foot imagery (for the 42 towns in NH) and 2015 1-meter NAIP imagery (for the 10 towns in Maine). The 2015 IC mapping updated previous high resolution mapping developed from 2010 (New Hampshire) and 2011 (Maine) orthophotography for the study area.

Impervious features covered 32,462 acres (5.8% of the land area) in the New Hampshire towns and 13,295 acres (5.3% of the land area) in the Maine towns, with a total of 46,634 (5.6% of the land area) acres mapped in the entire study area. The towns with the highest percent impervious cover in 2015 were in New Hampshire, and included Portsmouth (26.7%), New Castle (20.0%), and Seabrook (20.0%). The largest increases in IC between 2010 and 2015 occurred in Rochester, NH (122 acres), Wells, ME (64 acres), and Seabrook, NH (64 acres). Minimal amounts of IC increases occurred in most towns, with the least amounts in Madbury, NH (4 acres), New Castle, NH (2 acres), and Brookfield, NH (2 acres).

Methods

Data sets for the 52 town PREP footprint (see Figure 1) were assembled from the NH GRANIT Clearinghouse (granit.unh.edu) and the Maine Office of GIS (maine.gov/megis). The primary source data for the project comprised 2015 1-foot resolution, 4-band orthophotography in New Hampshire 2015 1-meter resolution, 3-band orthophotography in Maine, and existing 2010 impervious cover feature data sets. Older vintage orthophotography (2010 and 2005) was also used for reference.

The updated IC coverage was derived by displaying the 2010 impervious cover data sets for the project area, visually interpreting the 2015 source imagery, and manually digitizing new IC features visible in the imagery. Data were initially displayed at a minimum scale of 1:2,000 to identify features to be digitized. The scale was typically increased to 1:1,000 (or greater) when actively digitizing features.

In addition to mapping 2015 features, updates were made to the 2010 features to capture or delete IC as appropriate. Most of the updates addressed prior errors of omission (e.g. missing features). Typically, these errors occurred because features on the ground were at least partially obscured by tree canopy in the 2010 imagery but became visible in the 2015 imagery (see Figure 2). The errors were addressed by confirming their presence in the 2010 imagery, and then digitizing the features from the 2015 imagery. Errors of commission from the 2010 data, e.g. false positives, were also updated as appropriate. Figure 3 illustrates the range of updates that were incorporated into the 2015 data set.

After a comprehensive review of the data, the IC polygons were processed to derive the final data set for distribution. First, the vector polygons were converted to a 1-foot resolution raster. To fill any small gaps between features, the raster data set was expanded by 2 pixels and then contracted back by 2 pixels. Lastly, the raster was converted back to vector format, the IC polygons were generalized (using a maximum offset of 2 feet), and small features (less than 20 sq. ft.) were eliminated.

Results

The primary result of this project is a high resolution (HR) impervious cover data set capturing features for the year 2015 within the 52 town PREP footprint. Figure 4 displays the distribution of impervious cover mapped throughout the study area, while Figure 5 displays the data at a large scale for a small geography. There was a total of 46,634 acres of IC mapped for the 2015 time period. This represents an increase of 1,257 acres (2.7% increase or 0.2% of the land area) over the amount mapped from the 2010 orthophotography (45,377 acres) using the HR mapping approach. The data may also be visualized based on percent impervious cover by town, as shown in Figure 6.

Tables 1 and 2 summarize the impervious cover by town and subwatershed. Portsmouth (26.7%), New Castle (20.0%), and Seabrook (20.0%) in New Hampshire contained the highest percent IC by land area. As expected, the towns in Maine with the highest percent IC by land area included Kittery (11.7%), Sanford (8.1%), and York (6.3%). In Maine, the least percent of IC by land area was found in the towns of Lebanon (3.0%), Acton (3.1%), and North Berwick (3.2%) while in New Hampshire, Brookfield (0.9%), Strafford (1.8%), and New Durham (2.0%) contained the smallest percentages of IC. Additionally, towns experiencing the greatest amount of IC acreage increase in Maine were Wells (64 acres), York (42), and Sanford (39), while in New Hampshire, Rochester (122 acres), Seabrook (64), and Dover (56) saw the highest additions of IC acreage.

For the subwatersheds, the greatest IC percentages of mapped land area were found in the Piscataqua River-Frontal Portsmouth Harbor (18.9%), Hampton River (15.0%), and Lower Cocheco River (12.0%) units. Conversely, the smallest IC percentages were found in the Pawtuckaway Pond (1.5%), Long Pond (1.8%), and Nippo Brook-Isinglass River (2.0%) subwatersheds (as calculated by mapped land area). While the previously mentioned subwatersheds were the lowest by percent, many of the units were separated by only tenths of a percent and many were less than 5% impervious by mapped land area.

Final deliverables for the project include an impervious cover shapefile covering the study area and the associated FGDC-compliant metadata. The data are available for download from NH GRANIT.

Discussion and Conclusions

In some locations, there was a visible shift of the roadways and angle of building lean (as well as other features) between the 2010 high resolution imagery and the 2015 iteration. This is to be expected, given the 5-year gap in the image collection cycle, the different sensors that were used, the different processing techniques, etc. As a result, there are instances of 2010 IS features that do not appear to overlay precisely on the 2015 imagery, which were left intact for the 2015 iteration.

This project represents the first iteration of mapping the entire 52-town PREP footprint utilizing high resolution (HR), 1-foot orthoimagery. In prior years, the PREP IC mapping relied on medium resolution (MR), 30-meter satellite imagery[1]. As noted in an earlier report (Justice and Rubin, 2015), there are marked differences between impervious cover estimates generated by the two approaches. This is in part due to the significant difference in the resolution of the source data (1-foot vs. 30-meter, respectively), and in part due to the different processing methodologies used (screen interpretation vs. subpixel automated classification, respectively).

The current study supports the earlier findings as we see large differences between the IC mapped by the HR approach versus the acreage mapped by the MR approach for the 2010 date. For example, the MR approach estimated 77,850 IC acres for the 52-town region while the HR method yielded an estimate of 45,377 acres, a 32,473 acre difference. At the town level, the acreage difference between the approaches ranged from 107 in New Castle, to 2,183 in Rochester (2010 MR acreages subset from tables in Justice and Rubin, 2011).

With baseline impervious cover now generated at the HR scale, future updates will require only the addition of new development to the impervious layer. It is anticipated that orthophoto data sources such as regularly

[1] See Justice, D. and Rubin, F., 2011, for a description of the 2011 data development methodology

acquired NAIP imagery (1-meter resolution) can be used as base data from which to delineate new features. While these data are acquired during the summer months and therefore some leaf canopy will be present, it is expected that new development will be sufficiently apparent to allow for the impervious cover to be adequately captured.

Figure 1. Project study area.

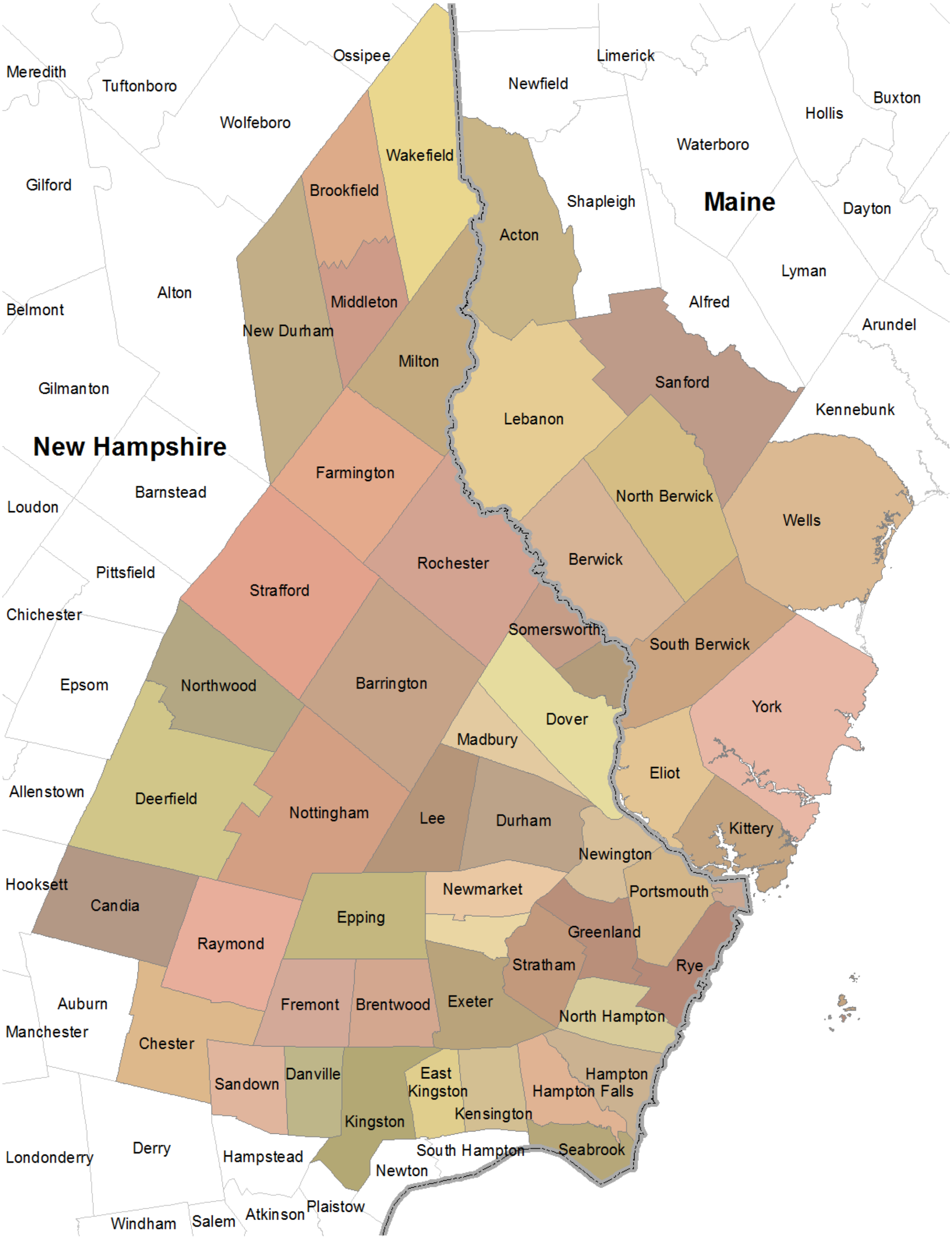

Figure 2. Example of feature obscured by tree canopy in 2010; visible in 2015.

Figure 3. Examples of impervious cover change between 2010 and 2015.

Figure 4. Distribution of 2015 impervious cover in the project study area. Impervious features displayed in purple.

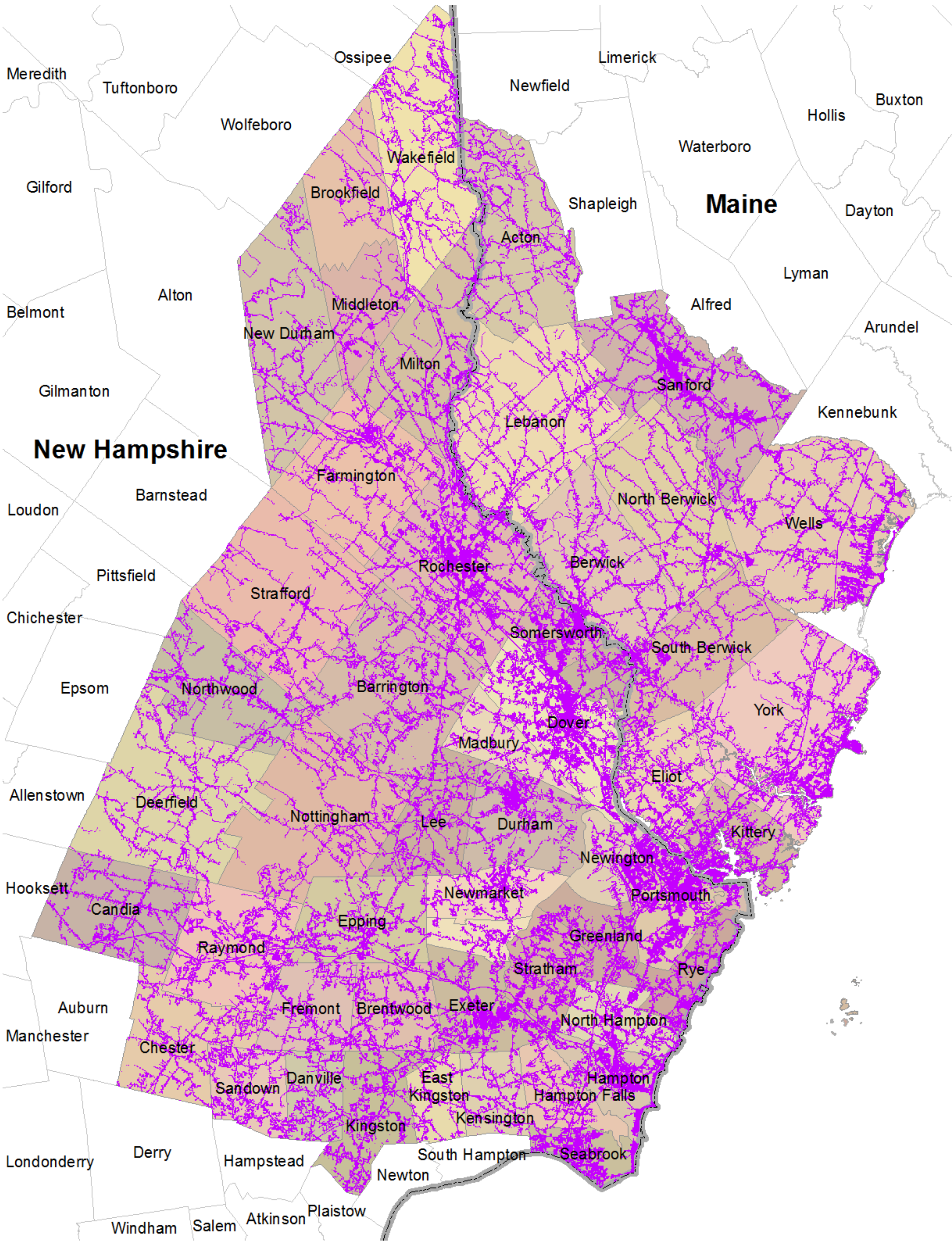

Figure 5. Impervious cover, 2015, for an area in Newmarket, NH.

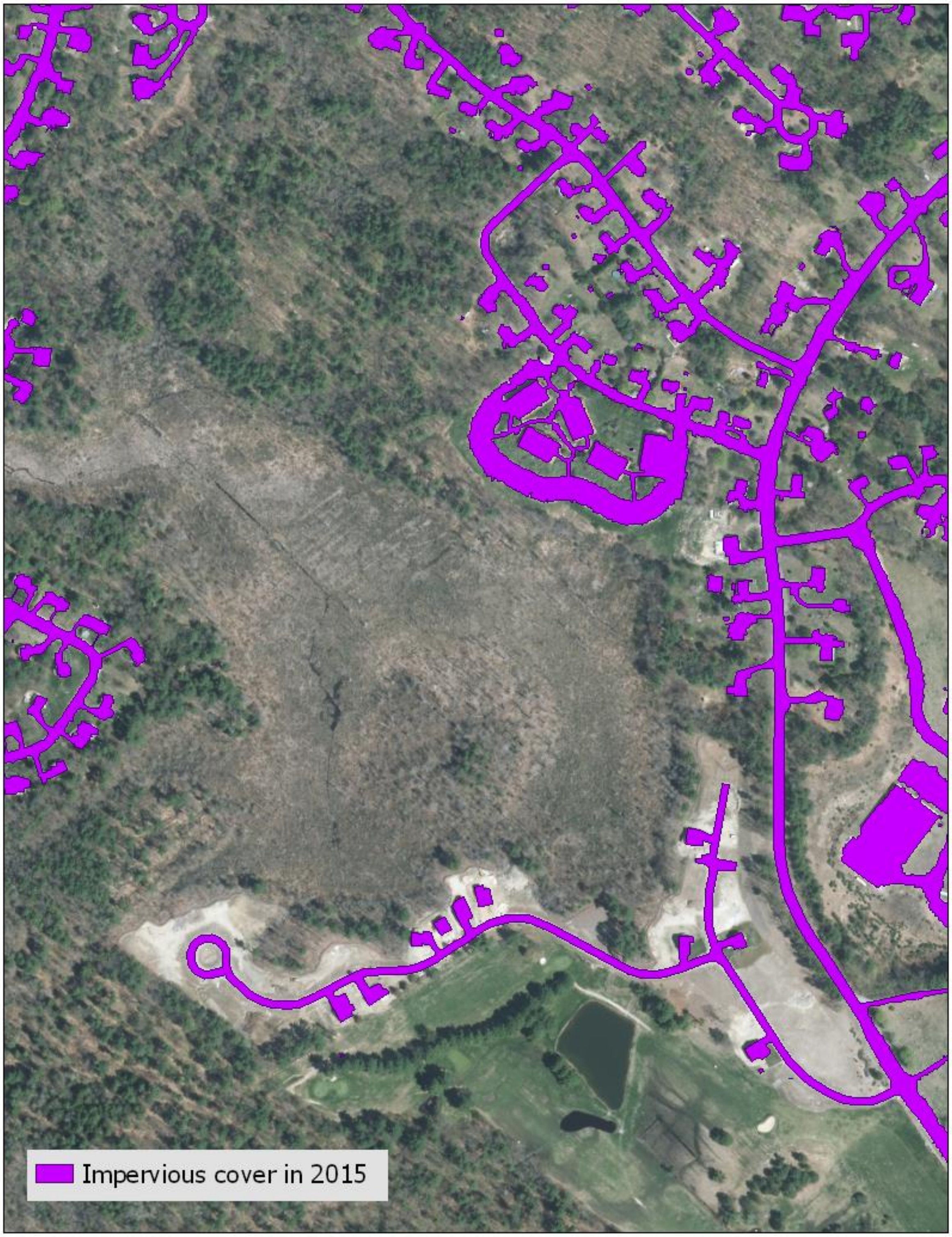

Figure 6. Percent impervious cover by town, 2015.

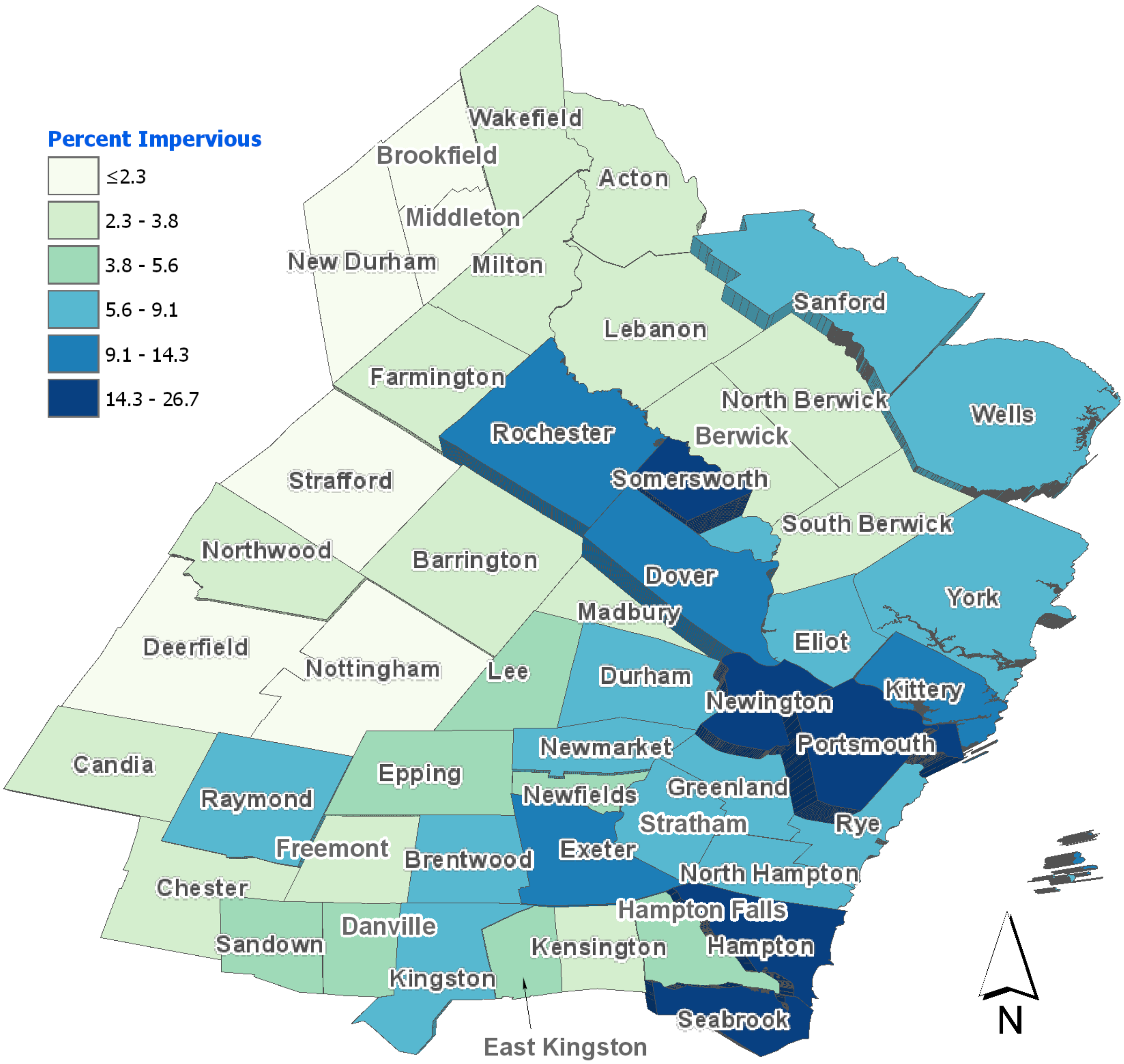

Table 1. High-resolution impervious cover by town, 2010-2015.

State	Town	**Total Area** (acres)			**IC** (acres)			**Percent IC** (Land Area)	
		Land	Inland Water	Total	2010	2015	Change	2010	2015
Maine	Acton	24,216.3	2,191.7	26,408.0	745.0	754.8	9.8	3.1%	3.1%
	Berwick	23,779.6	447.1	24,226.7	877.5	895.3	17.8	3.7%	3.8%
	Eliot	12,609.4	150.6	12,759.9	874.1	895.7	21.6	6.9%	7.1%
	Kittery[1]	11,548.0	168.2	11,716.1	1,304.2	1,315.8	11.5	11.3%	11.4%
	Lebanon	34,957.8	675.8	35,633.6	998.6	1,031.4	32.8	2.9%	3.0%
	North Berwick	24,265.1	157.6	24,422.7	737.8	765.1	27.3	3.0%	3.2%
	Sanford	30,314.8	890.3	31,205.1	2,427.9	2,466.7	38.7	8.0%	8.1%
	South Berwick	20,468.8	243.1	20,711.8	750.5	762.3	11.8	3.7%	3.7%
	Wells	36,427.3	125.1	36,552.3	2,134.3	2,198.4	64.1	5.9%	6.0%
	York	34,913.8	685.0	35,598.8	2,167.2	2,209.1	42.0	6.2%	6.3%
	Total	253,500.6	5,734.4	259,235.0	13,017.2	13,294.6	277.5	5.1%	5.2%
New Hampshire	Barrington	29,719.0	1,398.3	31,117.3	967.0	1,004.3	37.3	3.3%	3.4%
	Brentwood	10,728.1	134.9	10,863.0	636.8	672.6	35.8	5.9%	6.3%
	Brookfield	14,593.0	287.3	14,880.4	132.6	134.3	1.7	0.9%	0.9%
	Candia	19,328.9	228.2	19,557.2	621.6	642.9	21.3	3.2%	3.3%
	Chester	16,606.2	111.6	16,717.8	537.5	566.7	29.2	3.2%	3.4%
	Danville	7,438.7	130.7	7,569.4	390.8	402.0	11.2	5.3%	5.4%
	Deerfield	32,575.7	772.1	33,347.8	660.1	697.3	37.2	2.0%	2.1%
	Dover	17,036.9	1,555.2	18,592.1	2,388.9	2,445.4	56.5	14.0%	14.4%
	Durham	14,251.1	1,601.2	15,852.3	890.3	923.9	33.5	6.2%	6.5%
	East Kingston	6,318.0	62.8	6,380.8	265.8	274.1	8.3	4.2%	4.3%
	Epping	16,476.6	299.1	16,775.7	879.9	932.6	52.7	5.3%	5.7%
	Exeter	12,540.6	272.3	12,812.9	1,205.8	1,227.0	21.3	9.6%	9.8%
	Farmington	23,213.0	427.0	23,640.0	771.0	782.6	11.6	3.3%	3.4%
	Fremont	11,033.1	109.3	11,142.4	406.9	425.6	18.7	3.7%	3.9%
	Greenland	6,722.5	1,801.4	8,523.9	560.0	586.2	26.2	8.3%	8.7%
	Hampton	8,287.3	785.5	9,072.8	1,380.0	1,403.9	23.9	16.7%	16.9%
	Hampton Falls	7,719.6	358.4	8,078.0	395.2	402.9	7.7	5.1%	5.2%
	Kensington	7,616.4	51.4	7,667.8	279.8	288.1	8.2	3.7%	3.8%
	Kingston	12,494.3	955.9	13,450.3	764.5	784.5	20.0	6.1%	6.3%
	Lee	12,685.0	242.2	12,927.3	581.7	600.4	18.8	4.6%	4.7%
	Madbury	7,383.6	415.5	7,799.1	272.1	276.4	4.3	3.7%	3.7%
	Middleton	11,559.0	284.0	11,843.0	254.7	269.7	15.0	2.2%	2.3%
	Milton	21,088.6	847.3	21,935.9	670.1	694.8	24.6	3.2%	3.3%
	New Castle	506.2	841.4	1,347.6	99.9	101.5	1.6	19.7%	20.0%
	New Durham	26,345.5	1,708.5	28,054.0	524.1	533.7	9.6	2.0%	2.0%
	Newfields	4,540.8	105.9	4,646.7	208.8	213.6	4.7	4.6%	4.7%
	Newington	5,214.5	2,702.2	7,916.8	851.2	886.7	35.5	16.3%	17.0%
	Newmarket	8,034.5	1,045.8	9,080.3	571.1	579.3	8.3	7.1%	7.2%
	North Hampton	8,861.8	61.0	8,922.8	717.7	732.8	15.1	8.1%	8.3%
	Northwood	17,965.0	1,391.9	19,357.0	601.5	611.8	10.3	3.3%	3.4%
	Nottingham	29,839.7	1,157.0	30,996.7	640.3	657.0	16.7	2.1%	2.2%
	Portsmouth	10,003.5	759.9	10,763.4	2,657.8	2,674.4	16.6	26.6%	26.7%
	Raymond	18,438.3	505.2	18,943.6	1,121.2	1,142.5	21.3	6.1%	6.2%
	Rochester	28,329.2	751.5	29,080.7	2,736.8	2,858.5	121.7	9.7%	10.1%
	Rollinsford	4,681.3	161.5	4,842.8	275.7	281.3	5.6	5.9%	6.0%
	Rye[1]	8,464.7	411.3	8,876.0	650.3	663.4	13.0	7.7%	7.8%
	Sandown	8,888.5	343.3	9,231.8	475.0	500.1	25.0	5.3%	5.6%
	Seabrook	5,664.7	496.6	6,161.3	1,069.7	1,133.6	63.9	18.9%	20.0%
	Somersworth	6,219.2	179.1	6,398.3	996.9	1,015.6	18.7	16.0%	16.3%
	Strafford	31,151.8	1,627.1	32,778.9	545.2	563.3	18.1	1.8%	1.8%
	Stratham	9,655.1	246.5	9,901.6	849.0	874.4	25.4	8.8%	9.1%
	Wakefield	25,264.0	3,453.2	28,717.2	854.3	877.3	23.0	3.4%	3.5%
	Total	560,219.6	27,627.7	587,847.3	31,505.5	32,461.8	956.3	5.6%	5.8%
Study Total		838,984.2	36,815.3	875,799.5	45,376.9	46,633.7	1,256.8	5.4%	5.6%

[1]Acreage values for the towns of Kittery, ME and Rye, NH include the Isles of Shoals.

Table 2. High-resolution impervious cover by subwatershed, 2010-2015.

HUC 12 ID	HUC 12 Name	Total Area (acres)			Mapped Area (acres)			IC (acres)			Percent IC (Mapped Land Area)	
		Land	Inland Water	Total	Land	Inland Water	Total	2010	2015	Change	2010	2015
010600030602	Axe Handle Brook	7,028	369	7,397	7,028	369	7,397	246	256	11	3.5%	3.6%
010600030401	Bauneg Beg Pond-Great Works River	23,128	393	23,520	23,127	393	23,520	1,126	1,156	30	4.9%	5.0%
010600030705	Bean River-North River	14,796	276	15,072	14,796	276	15,072	368	371	4	2.5%	2.5%
010600030903	Bellamy River	20,335	1,277	21,612	20,335	1,277	21,612	1,423	1,455	33	7.0%	7.2%
010600031002	Berrys Brook-Frontal Rye Harbor	10,285	333	10,618	10,282	332	10,613	935	948	13	9.1%	9.2%
010600030505	Bog Brook-Little River	34,702	170	34,872	34,363	169	34,532	777	799	22	2.3%	2.3%
010600030604	Bow Lake	7,885	1,240	9,125	7,882	1,240	9,121	200	206	6	2.5%	2.6%
010600030502	Branch River	17,268	235	17,504	17,268	235	17,504	333	358	25	1.9%	2.1%
010600030805	Exeter River-Squamscott River	12,189	174	12,363	12,189	174	12,363	607	618	11	5.0%	5.1%
010600030904	Great Bay	13,103	6,121	19,224	13,103	6,121	19,224	1,083	1,112	28	8.3%	8.5%
010600031005	Hampton River	18,059	1,341	19,400	12,931	1,229	14,160	1,862	1,935	73	14.4%	15.0%
010600030501	Headwaters Branch River	17,543	840	18,383	17,101	840	17,941	391	398	8	2.3%	2.3%
010600030801	Headwaters Exeter River	20,209	202	20,411	18,875	197	19,072	796	844	49	4.2%	4.5%
010600030701	Headwaters Lamprey River	21,718	209	21,927	21,718	209	21,927	460	486	27	2.1%	2.2%
010600030503	Headwaters Salmon Falls River	15,178	2,556	17,734	15,179	2,556	17,735	424	432	9	2.8%	2.8%
010600030607	Isinglass River	10,289	438	10,727	10,289	438	10,727	483	498	15	4.7%	4.8%
010600030709	Lamprey River	12,789	402	13,191	12,788	402	13,191	610	614	4	4.8%	4.8%
010600030402	Leighs Mill Pond-Great Works River	31,670	270	31,940	31,670	270	31,940	1,020	1,050	30	3.2%	3.3%
010600030707	Little River	12,585	359	12,944	12,585	359	12,944	367	377	11	2.9%	3.0%
010600030606	Long Pond	9,801	351	10,153	9,801	351	10,153	173	179	6	1.8%	1.8%
010600030608	Lower Cocheco River	19,479	583	20,063	19,479	583	20,063	2,270	2,331	62	11.7%	12.0%
010600030507	Lower Salmon Falls River	13,299	567	13,866	13,299	380	13,679	955	968	13	7.2%	7.3%
010600030603	Middle Cocheco River	16,025	276	16,301	16,025	276	16,301	1,525	1,585	60	9.5%	9.9%
010600030506	Middle Salmon Falls River	37,430	790	38,220	37,430	787	38,217	2,083	2,155	72	5.6%	5.8%
010600030605	Nippo Brook-Isinglass River	17,116	273	17,389	17,116	273	17,389	330	342	12	1.9%	2.0%
010600030702	North Branch River	10,901	146	11,047	10,901	146	11,047	323	334	11	3.0%	3.1%
010600030706	North River	8,786	65	8,851	8,786	65	8,851	240	251	11	2.7%	2.9%
010600030902	Oyster River	19,317	542	19,860	19,317	542	19,860	1,305	1,358	53	6.8%	7.0%
010600030704	Pawtuckaway Pond	12,107	945	13,052	12,107	945	13,052	180	187	6	1.5%	1.5%
010600030703	Pawtuckaway River-Lamprey River	25,584	638	26,222	25,584	638	26,222	1,478	1,528	49	5.8%	6.0%
010600030708	Piscassic River	14,407	103	14,510	14,407	103	14,510	750	783	33	5.2%	5.4%
010600031001	Piscataqua R.-Frontal Portsmouth Harbor	25,020	5,383	30,404	25,018	2,652	27,670	4,660	4,736	76	18.6%	18.9%
010600030804	Scamen Brook-Little River	10,109	38	10,147	10,109	38	10,147	671	699	29	6.6%	6.9%
010600030803	Spruce Swamp-Exeter River	14,999	182	15,181	14,999	182	15,181	783	816	33	5.2%	5.4%
010600030806	Squamscott River	12,445	544	12,989	12,445	544	12,989	1,161	1,188	26	9.3%	9.5%
010600031003	Taylor River	14,374	282	14,655	14,374	282	14,655	1,444	1,475	30	10.0%	10.3%
010600030601	Upper Cocheco River	27,143	515	27,657	26,787	514	27,302	806	822	16	3.0%	3.1%
010600030504	Upper Salmon Falls River	13,692	1,174	14,866	13,693	1,177	14,869	416	422	6	3.0%	3.1%
010600030802	Watson Brook-Exeter River	10,452	123	10,575	10,452	123	10,575	396	404	9	3.8%	3.9%
010600030901	Winnicut River	11,052	99	11,151	11,052	99	11,151	908	942	34	8.2%	8.5%
Total		664,298	30,824	695,122	656,692	27,785	684,477	36,366	37,419	1,053	5.5%	5.7%

References

Justice, D. and Rubin, F. 2015. DEVELOPING 2010 HIGH-RESOLUTION IMPERVIOUS COVER ESTIMATES FOR SELECTED TOWNS IN THE PISCATAQUA REGION ESTUARIES PARTNERSHIP 15 p.

Justice, D. and Rubin, F. 2011. DEVELOPING 2010 IMPERVIOUS SURFACE ESTIMATES FOR THE PISCATAQUA REGION ESTUARIES PARTNERSHIP TOWNS. 27 p.