New York Forest Health Mapping Digitization, Analysis and Access

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Project Overview

The Vermont Monitoring Cooperative (VMC) collaborated with the New York Department of Environmental Conservation (DEC) on a forest health data pilot project. The goals of this project are to expand digital holdings of forest disturbance mapping back in time, and to demonstrate ways that that data could be integrated into the existing VMC holdings. There were three main components this project. The first task was to digitize historical forest tent caterpillar (FTC) aerial survey data, leading to scanned and georeferenced historical maps of forest tent caterpillar data, digital features extracted from each of these maps, an aggregated dataset of all historical damage and flown areas for each year, and yearly summary statistics. The second task was to catalog the larger set of historic forest health data and maps that could be digitized in the future, yielding a catalogue of available mapped data, its spatial and temporal extent and two scanned datasets. The third task was to ingest the digital New York forest health aerial survey data into the VMC database and generate summary spatial and temporal statistics for the overall dataset.

Task	Products

Task 1 Forest Tent Caterpillar Data Digitization	• Digital forest tent caterpillar maps for 1951-1955 and 1991-1994
	• Spreadsheet of spatial and temporal summary statistics
	• Geodatabase containing:
	  ○ Feature dataset of damage surveys with a feature class for each georeferenced map
	  ○ Feature dataset of areas flown with feature classes for each year of data
	  ○ Feature class of damage data aggregated across all years
	  ○ Feature class of flown/not flown data aggregated across all years

Task 2 Cataloging Available Disturbance Data	• Catalogue of undigitized disturbance maps • Scanning of some maps to flat images
Task 3 Analysis and Access to Data	• Preexisting digital aerial survey data (2006-2015) added to VMC database and portal • Summary statistics for aerial survey data spanning 2006 to 2015 • Maps of areas of repeated damage for four damage agents and two damage types • ArcGIS toolbox for assessing the intensity of repeated damages by type and agent

Task 1: Historical Aerial Survey Data Digitization

Yearly flights surveying New York's forests for damage due to pests and weather were conducted over much of the last century. These data were historically recorded on a variety of paper maps, making it difficult to analyze temporal trends in the data alongside more current digital data. To digitize these maps, they were first scanned as TIFF files. These files were then georectified using ArcMap. Due to the variability of the types of maps containing data - hand drawn, road maps, and USGS quadrangle maps – the georecitfication process was more accurate for some maps than others. Once georectified, feature classes were made from the drawn polygons on the historic maps. The scale of the maps varied greatly – from USGS quadrangle maps to maps of the entire state. Thus the precision and accuracy of the feature class digitization process varies from map to map (see Figure 1).

Figure 1. Sample of the variety of map types used for digitization.

Several of the maps labeled as FTC spray maps had only point features. Because all of the other spray maps and the damage maps contained only polygons and there was no additional indication as to whether the point maps contained survey plot data or actual damage data, these maps were not digitized (see Appendix B).

Once the maps were digitized they were merged into a single feature class (see **Error! Reference source not found.**) containing the forest tent caterpillar damage data for all years. This was also done with the

flown area feature classes to allow for calculations of statistics based on the area of surveyed land. Summary statistics were calculated for both the damage data and the area-flown data. These statistics were referenced against historical records[1] to ensure accuracy.

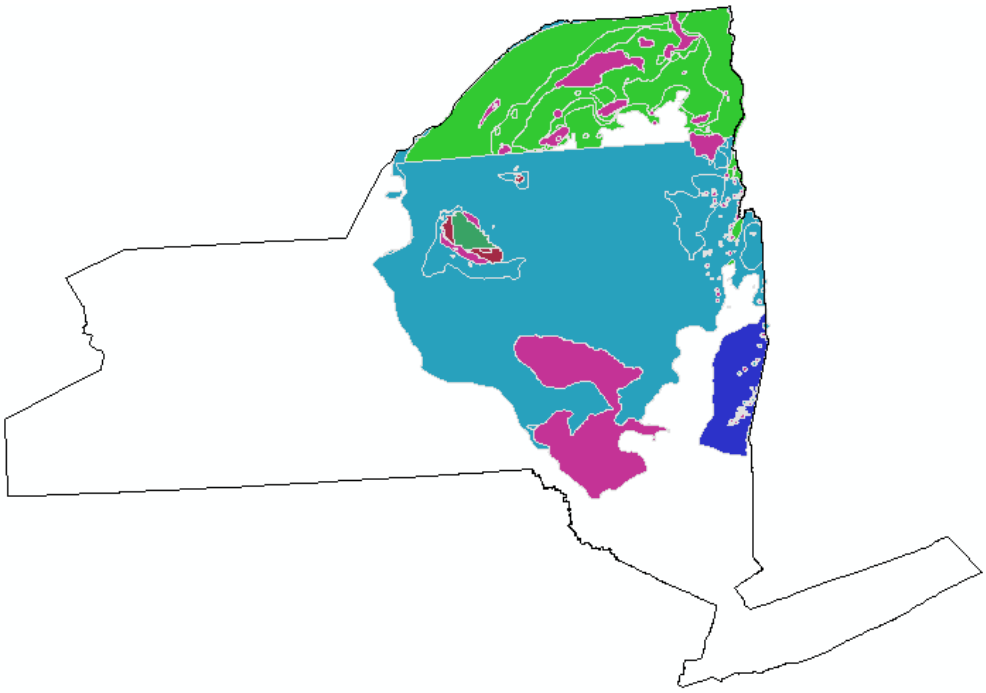

Figure 2. Aggregated historical forest tent caterpillar aerial survey data.

Table 1. Summary statistics of the digitized forest tent caterpillar aerial survey data.

Year	Total Acres Damaged (Acres)	Total Area Flown (Acres)	Percent of Area Flown with Damage	Average Polygon Size (Acres)	Number of Damage Polygons Mapped
1951	114,580	1,000,988	11%	14,323	8
1952	751,574	10,681,482	7%	25,052	30
1953	6,919,029	13,221,603	52%	172,976	40
1954	14,526,949	21,296,945	68%	234,306	62
1955	2,191,024	22,278,438	10%	20,670	106
1991	98,790	420,171	24%	32,930	3
1992	101,210	504,837	20%	3,163	32
1993	189,890	407,151	47%	63,297	3
1994	79,301	1,980,997	4%	11,329	7

[1] http://nysl.cloudapp.net/awweb/main.jsp?flag=browse&smd=1&awdid=1

The products of the historical forest tent caterpillar aerial survey data digitization effort include:

- Digital forest tent caterpillar maps for 1951-1955 and 1991-1994[2]
- A spreadsheet of spatial and temporal summary statistics
- A geodatabase containing:
    - Feature dataset of damage surveys with a feature class for each georeferenced map
    - Feature dataset of areas flown with feature classes for each year of data
    - Feature class of damage data aggregated across all years
    - Feature class of flown/not flown data aggregated across all years

[2] Online at http://www.uvm.edu/vmc/project/nydec-aerial-survey/dataset/historical-new-york-forest-tent-caterpillar

Task 2: Catalogue of Undigitized Data

In the process of digitizing the forest tent caterpillar maps, additional paper maps were examined and inventoried. A summary of the available maps is shown in Table 2.

Table 2. Summary of available historical disturbance data on paper maps. Maps in highlighted rows have been scanned, but not digitized.

Damage Agent	Extent of Maps	Years Covered	Number of Maps
Forest tent caterpillar egg mass surveys	Central New York	1953, 1955-56, 1959	21 Maps
Spruce budworm	Most of the Adirondack Park	1945-48, 1950-57 (some)	48 quadrangle maps
Eastern spruce bark beetle		1949, 1951	24 quadrangle maps
Oak wilt	Randolph/Salamanca	1951,1952	4 quadrangle maps (on FTC maps)
Saddled prominent		1968	6 maps
Gypsy moth	Whitehall/Fort Ann	1952	2 maps (on FTC maps)
White pine weevil	St Lawrence, Chenango, Maddison, Cayuga counties	1947-49, 1955-57, 1959, 1964	36 maps
White pine blister rust	Hamilton, St Lawrence, Fulton Counties	Roughly 1932-1970 (intermittent)	Hand drawn plot maps (blueprints)

Of these datasets, the forest tent caterpillar egg mass survey maps, the spruce budworm maps and the eastern spruce bark beetle maps were scanned as TIFF files, but not georectified or digitized. The data for oak wilt and gypsy moth are recorded on FTC maps, and thus have been scanned and georectified, but not digitized. The data for the FTC egg mass surveys is tabular and still undigitized, these records should be attached to the survey plot maps to which they belong. These maps have tags with the name of the image file they correspond to. The spruce budworm dataset is the most comprehensive dataset, showing multiple years of data on each quadrangle map. The white pine weevil dataset is largely treatment test plot maps with a variety of map quality and date ranges. The white pine blister rust dataset has paper data tables in alphabetical order for each of St. Lawrence, Fulton, and Hamilton counties. In the box there are drawn blueprints of each of the sites examined in each county corresponding to the data tables. This dataset has the largest span of years from roughly 1935-1970 (not contiguous).

Task 3: Current Aerial Detection Survey Data

The digital aerial survey data from 2002 to 2015 that is already held digitally at the New York DEC were added to the VMC database[3]. The yearly aerial survey data from this dataset were aggregated into a single feature class (see Figure 3) containing the damage data for all years. Note that for the 2002 to 2006 data the geometry had to be repaired on several features. The same aggregation was done for the area flown data for 2007 to 2015.

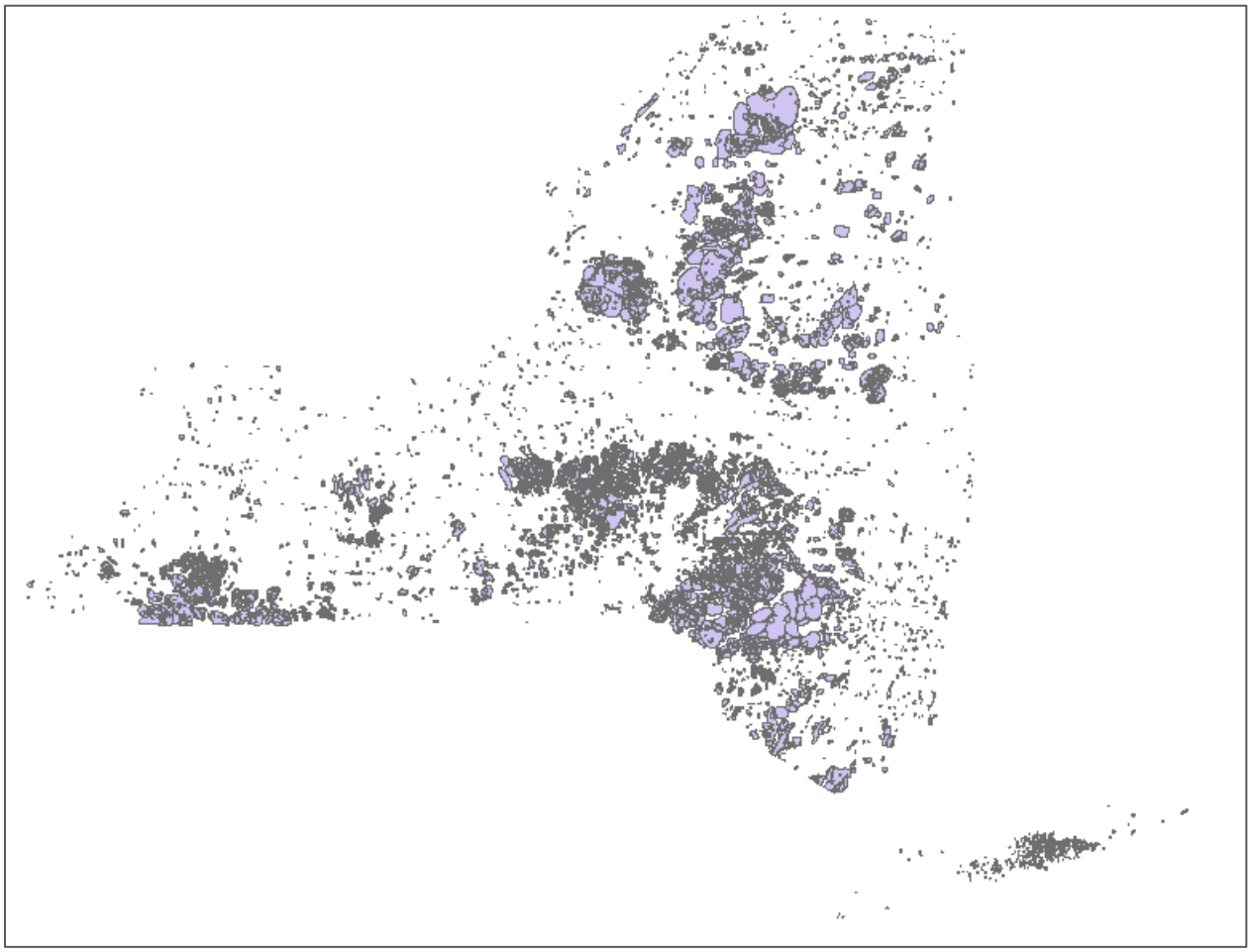

Figure 3. Aggregated aerial survey data from 2002 to 2015.

From these feature classes summary statistics were calculated for both the area flown data and damage area data (Table 3). An ArcGIS toolbox was assembled to extract repeat damage data by damage agent and damage type for New York.

[3] Online at http://www.uvm.edu/vmc/project/nydec-aerial-survey/dataset/ny-dec-aerial-detection-survey

Table 3. Summary statistics of all aerial detection survey data collected between 2006 and 2015.

Year	Total Acres Damaged (Acres)	Total Area Flown (Acres)	Percent of Area Flown with Damage	Average Polygon Size (Acres)	Number of Damage Polygons Mapped
2002	27,974	N/A	N/A	185	151
2003	82,261	N/A	N/A	297	277
2004	374,555	N/A	N/A	276	1358
2005	697,942	N/A	N/A	1161	601
2006	1,253,555	N/A	N/A	1947	644
2007	1,637,105	25,865,484	6%	2574	636
2008	663,972	21,158,065	3%	1216	546
2009	744,948	25,693,331	3%	1444	516
2010	1,544,280	23,388,524	7%	2808	550
2011	103,176	24,494,138	0.4%	163	632
2012	708,695	19,171,330	4%	794	893
2013	405,929	15,204,063	3%	966	420
2014	36,141	11,910,976	0.3%	118	307
2015	154,602	8,616,092	2%	232	666

Sample heat maps were made to show repeat damage of several damage agents and types. These include: forest tent caterpillar defoliation damage, forest tent caterpillar mortality damage and forest tent caterpillar total damage both current and historical, gypsy moth total damage, southern pine beetle total damage, hemlock woolly adelgid total damage, defoliation damage and mortality. Figure 5 shows areas of long term repeated forest tent caterpillar damage as an example. To create the repeat damage statistics, the US Forest Service damage agent[4] codes were used, in some cases old codes in the dataset were revised to match current damage agent codes.

[4] http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5361666.pdf

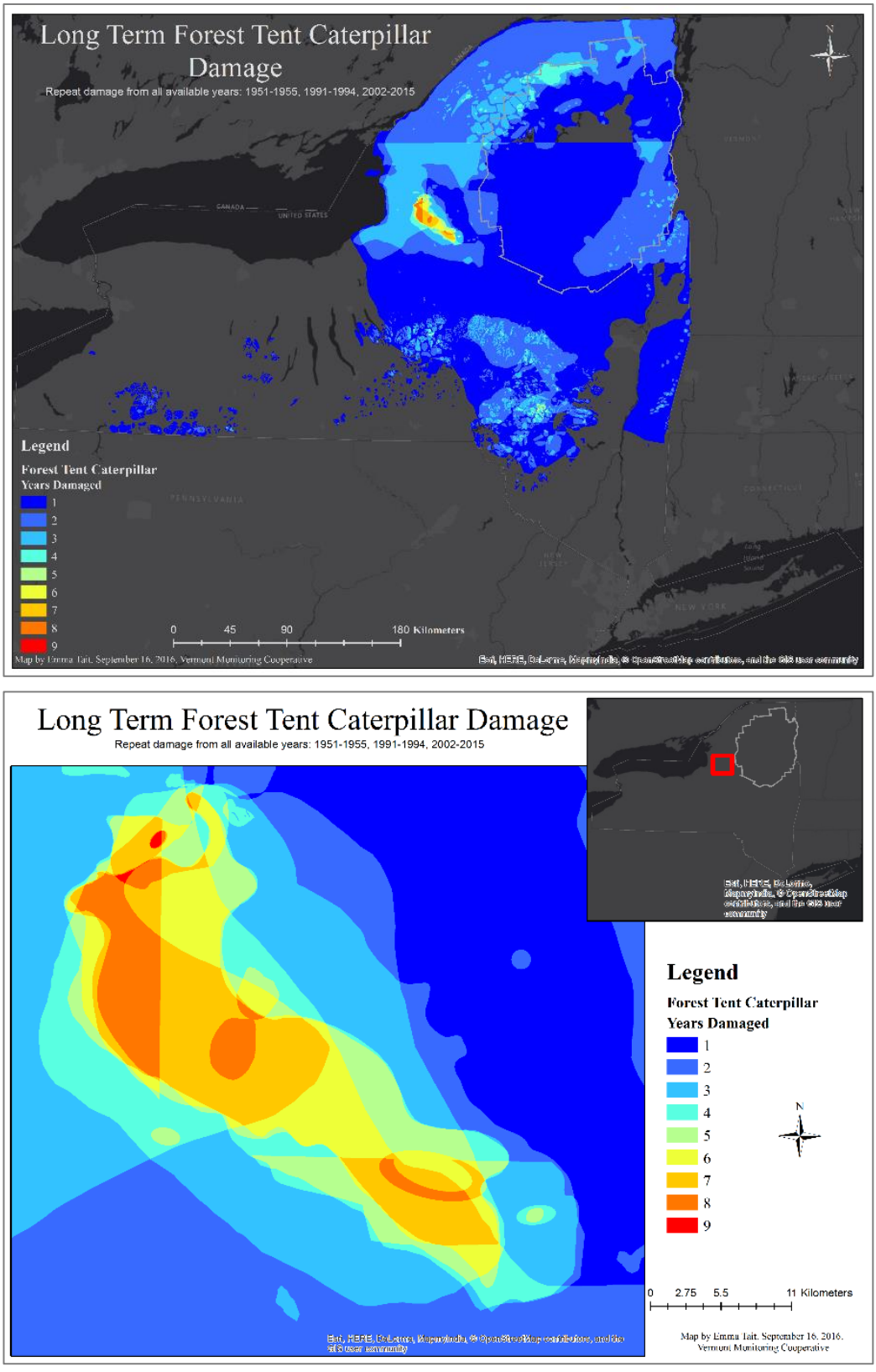

Figure 4. Sample "heat maps" of repeat forest tent caterpillar damage

Potential Next Steps

With the completion of this initial pilot work, there are a couple of potential avenues for further activities to strengthen the historical record of mapped disturbance data.

- Incorporate the existing digital data into the regional Forest Health Atlas covering Maine, Massachusetts, New Hampshire, New York and Vermont (separate funding);
- Digitize additional years of mapped data, working backward from the current digital holdings already available at New York DEC;
- Digitize older data from other damage agents that were scanned but not digitized in this pilot project;
- Assemble other datasets such as climate or pollution input data that could contribute to a greater understanding of the drivers and consequences of the repeated damage events mapped in this project.

Appendix A: List of Products

Product name	Description	Filename(s)
Forest Tent Caterpillar Database	Geodatabase of historical FTC data as feature classes.	FTC.gdb The files are named for the year surveyed and the extent of the map.
Forest Tent Caterpillar Maps	Scanned and georeferenced maps of all historical forest tent caterpillar aerial survey data	FTC_Scans_referenced (folder) The files are named for the year surveyed and the extent of the map.
Spruce Budworm Maps	Scanned maps of historical spruce budworm aerial survey data. These maps are not georeferenced	budworm_scans (folder) The files are named for the extent of the map.
Eastern Spruce Bark Beetle	Scanned maps of historical eastern spruce bark beetle aerial survey data. These maps are not georeferenced	spruce_bark_beetle _scans (folder) The files are named for the year surveyed and the extent of the map.
Current Aerial Survey Data (2002-2015)	Geodatabase of current aerial survey data. Individual years as well as aggregated feature class containing data for all years	Albany_ADS.gdb Aerial Survey Data layers start with NY_ADS_ followed by the year. Flown/Not-Flown data layers start with NY_FNF_ followed by the year. Aggregated data for both types have the range of years listed
Historical damage statistics	Statistics on acres damaged for historical data	Statistics.xlsx (sheet 2)
Current damage statistics	Basic statistics on damage area, including damaged acres as percent of area flown for 2002-2015	Statistics.xlsx (sheet 1)
Forest tent caterpillar statistics	Statistics of acres damaged by forest tent caterpillar 1951-1955, 1991-1994, 2002-2015	Statistics.xlsx (sheet 3)
Sample repeat damage maps	Series of maps illustrating areas of repeat damage by damage type and/or damage agent	Sample Repeat Damage Maps.pdf
Inventory of Datasets	List of all datasets found in the historical maps with years and extent.	Dataset_Inventory.xlsx There are separate sheets for each dataset

Appendix B: A List of Scanned Forest Tent Caterpillar Maps

Extent	Year(s)	Status	Scanned Image File Name
Bolton Quadrangle	1952	Digitized	bolton_quad_1952
Central and Eastern NY	1954	Digitized	northern_ny_1954
Cranberry lake/Saranac Lake/Oswegatchie/Northern NY	1955	Digitized	northern_ny_1955
Eastern NY	1955	Digitized	eastern_ny_1955
Fort Ann Quadrangle 1952	1952	Digitized	fort_ann_quad_1952
Glens Falls Quadrangle	1952	Digitized	glens_falls_quad_1952
Kasoag Quadrangle	1954	Digitized	kasoag_quad_1954
Lake Bonaparte Quadrangle	1954	Digitized	lake_bonepart_quad_1954
Lake Placid Quadrangle	1954	Digitized	lake_placid_quad_1954
Lowville Quadrangle	1954	Digitized	lowville_quad_1954
Luzerne Quadrangle	1952	Digitized	luzerne_quad_1952
Nicholville Quadrangle	1953	Digitized	nicholeville_quad_1953
Nicholville Quadrangle	1954	Digitized	nicholeville_quad_1954
Santa Clara, Potsdam and Nicholville Quadrangles	1951	Digitized	Sclara-pots-nichol_1951
North Creek Quadrangle	1952	Digitized	north_creek_quad_1952
Northern and Central NY	1953	Digitized	ftc_north_central_ny_1953
Northern NY	1952	Digitized	north_ny_1952
Orwell Quadrangle	1954	Digitized	orwell_quad_1954
Osceola	1991	Digitized	osceola_1991
Osceola	1992	Digitized	osceola_1992
Osceola	1993	Digitized	osceola_1993
Osceola (Croghan)	1994	Digitized	osceola_croghan_1994
Osceola (Fine)	1994	Digitized	osceola_fine_1994
Osceola (Lewis)	1994	Digitized	osceola_lewis_1994
Osceola (Lorraine)	1994	Digitized	osceola_lorraine_1994
Santa Clara Quadrangle	1954	Digitized	santa_clara_quad_1954
Saratoga County	1952	Digitized	saratoga_cnty_1952-3
Southern NY	1955	Digitized	southern_ny_1955
St Lawrence/Franklin County	1951	Digitized	st_lawrence-franklin_1951
Taberg Quadrangle	1954	Digitized	taberg_quad_1954
Washington County	1952	Digitized	washington_cnty_1952-3
Whitehall Quadrangle	1952	Digitized	whitehall_quad_1952
Whole State	1955	Digitized	ny_state_1955
Churubusco Quadrangle	1954	Not Digitized	churubusco_quad_1954
Dannemora Quadrangle	1954	Not Digitized	dannemora_quad_1954
Mooers Quadrangle	1954	Not Digitized	mooers_quad_1954
Rensselear/Columbia Counties	1952	Not Digitized	rensselear_columbia_1952
Rouses Point Quadrangle	1954	Not Digitized	rouses_point_quad_1954

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