Surveying Upstate NY Well Water for Pesticide Contamination

Year 2 Final Report **DRAFT**

to the

New York State Department of Environmental Conservation

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EXECUTIVE SUMMARY

NYS DEC contracted with Cornell University to undertake a survey of selected representative areas in upstate New York to determine the occurrence of pesticide contamination of groundwater by sampling well systems in rural (domestic and farm) and suburban areas. Of particular interest are areas judged most vulnerable, where significant pesticide use (agricultural and otherwise) coincides with shallow aquifers, presenting elevated contamination risks in contrast to areas with low pesticide use and/or less vulnerable groundwater resources. The second year of work documented here was a program in Schenectady County, following the first year's study of Cortland County.

Schenectady County sampling results Well selection was based on a combination of groundwater modeling, reviewing the PSUR pesticide application database, visually surveying the areas and sending outreach letters to prospective landowners in Schenectady County. The Schenectady County Soil and Water Conservation District (SCSWCD) and Water Quality Coordinating committee (WQCC) were consulted to determine areas of interest, based on physical and hydrological patterns and the general knowledge of pesticide use. The rate of affirmative response was low, and additional potential sites were scouted by Cornell personnel during sample collection, which took place between August 2005 and March 2006.

Not evident from statewide assessment used in Year 1 for selecting the county was the extent of in-county overlap of pesticide use (largely suburban) and large-scale public water supply systems (which are not targets of program efforts, given their ongoing monitoring programs). This made site selection a challenge; low rates of landowner response exacerbated this. Well samples included a number of areas near application sites but also a range of less vulnerable land uses.

Wells sampled were characterized for surrounding land uses. Given the patchy nature of land use in Schenectady County, woods and scrub regrowth was the most common land use, occupying primary positions around wells around just over half of the wells sampled (21), and secondary or tertiary contributions to 6 more wells. Dairy farm croplands that included significant corn (evident from detailed aerial photos taken in early spring) were the primary surrounding land use for 4 wells. Fields used for hay or small grains were more numerous, being the primary land use around 12 wells and the secondary land use for 14 more. Managed turfgrass – either as lawns in dense suburban areas, large areas in localized clusters of non-suburban housing, or golf courses – was primary for 3 wells and tertiary for 2 wells. Appearing near sampled sites with unexpected frequency were utility rights-of-way (typically subject to annual sprayings of herbicide for vegetation control), representing the secondary land use near 1 well and as the tertiary use near 3 additional wells. Most wells sampled (34) served single houses with 3 serving barns and 3 serving turf/field irrigation. Of the 34 wells for which the depths were known by landowners, 6 wells were shallow (<30 ft.), 8 were between 30 and 100 ft. deep, and 20 wells exceeded 100 ft.

Detection limits for the 93-compound scan run by DEC laboratory were markedly improved, all at or below 1 μg/L except for three analytes at 2 μg/L. Well sample analysis found no detectable pesticides or herbicides in any of the 40 samples examined. These nondetects thus established that the 40 well samples from Schenectady did not exceed any MCLs or guidance values for those 15 analytes with such standards.

ELISA scans at Cornell similarly showed no quantifiable imidacloprid, with all samples below 0.2

μg/L . Only a single sample had detection of a potential (but non-quantifiable) trace of imidacloprid, falling between the 0.2 μg/L quantitation limit and the 0.07 μg/L trace detection limit. Nitrate values were low, with mean levels of below 0.6 mg/L and a maximum single well value of 3.6 mg/L.

State-wide assessment The statewide assessment integrated publicly-available datasets to identify those areas where population dependence on groundwater from hydrologically-vulnerable systems coincides with significant pesticide use as a basis for locating future research. The protocol was improved to eliminate county-level final aggregation as well as flagging single industrial high-use applications. Using this approach, we identified a band of relatively vulnerable areas spanning the intensive agricultural areas of central and western NY counties south of Lake Ontario, as well as clusters of intensive use areas in southeast NY. Based on these observations, we initiated work in both regions for the Year 3 and 4 efforts, resulting in ongoing work in Orange County in the Southeast and both Cayuga County in the lake plain. Work in Genesee County is now starting for Year 5 activities. Further improvements to the assessment protocol are also underway.

1. INTRODUCTION

As summarized in the review of Flury (1996), pesticide transport from agricultural and other sources to groundwater is a well-documented problem, with transport occurring not only through coarse sandy soils but also through preferential flow paths in fine, structured soils. Leaching losses can represent up to 4 to 5% of applied pesticides. A nationwide survey in the late 1980's by USEPA found pesticide-related contamination in over 10% of community water systems and over 4% of rural household wells. Similar contamination problems on the deep sandy soils of Long Island are well documented.

The NYS DEC, the NY State Soil & Water Conservation Committee, and other stakeholders have expressed an interest in a survey of representative areas in upstate New York to determine the occurrence and extent of pesticide contamination of groundwater by sampling rural water systems (domestic and farm), small municipalities and suburban areas. Of particular interest at present are areas where significant pesticide use (agricultural and otherwise) coincides with shallow aquifers, presenting elevated contamination risks in contrast to areas with low pesticide use and/or less vulnerable water resources. The results of this survey would contribute to an assessment (by DEC and others) of the human exposure risk from pesticides in groundwater, and to identify needed changes in pesticide management through avenues such as product registration, applicator training, consumer advice, and technical assistance.

The first year of work was a pilot-scale program, focused on a single shallow aquifer system in the Cortland Valley. This second year report concerns testing done in Schenectady County, which is more suburban and less agricultural than Cortland County, which was selected as part of year 1 county-level screening activities.

Cornell University used a landowner confidentiality approach where public reporting of data involves general but not specifically georeferenced results. Landowners receive confidential reports for their wells, but are not identified in any public reporting. This measure was taken in part as an incentive to attract landowner cooperation which would enhance the weight of project findings by maximizing sampling of sites deemed most vulnerable.

2. PROJECT COMPONENTS

Four project components are reported here. The first is the *site selection process* (Section 2.1) used to identify well sites, including refinement and application of a simple groundwater risk screening model developed in the first year effort, and the application of Pesticide Sale and Use Reporting (PSUR) database information. Second is the *site characterization* (2.2) of the selected sampling sites. Third is the presentation of *sampling results* (2.3) of the well sampling carried out in Schenectady County. The final component is the refinement of the GIS-based *statewide assessment of relative groundwater risk* (2.4) used for selection of counties/regions for future research.

2.1. Site Selection Process

The Schenectady County Soil & Water Conservation District (CCSWCD; David Mosher, Programs Coordinator) actively cooperated in this undertaking, with input from the Schenectady County Water Quality Coordinating Committee (WQCC) as well as individual members thereof.

Funding constraints dictated that a maximum of 40 well water samples be analyzed in the DEC pesticide laboratory. Because DEC's interest is in targeted sampling of the most vulnerable sites, identification of the best potential sites was important. The site selection process involved three primary approaches: 1) assessing local knowledge about areas of likely vulnerability, 2) using a potential transport screening model to determine relative vulnerability based on soil type and depth to groundwater, and 3) examining the NYS DEC PSUR database for application trends. These three approaches were used iteratively.

2.1.1. Site selection: local knowledge

This approach involves assessing local knowledge about areas of likely vulnerability, a process that isboth iterative and interactive. Input was gathered in an initial meeting with the WQCC and through ongoing contacts with the Soil & Water Conservation District and via referrals with the county's GIS program. As contacts and sampling progressed, we conducted additional scouting of potential sites via visual observations (of topography and land use) as well as networking. Existing mapsets were accessed to exclude areas served by public water supply systems.

2.1.2. Groundwater Exposure Assessment Modeling

The development of the screening model of relative risk based on soil characteristics and groundwater depth was reported in detail last year and is only briefly summarized here. The model (Sinkevich 2004, Sinkevich et al. 2005) was used as a screening tool to identify where soils types and shallow groundwater could make groundwater more vulnerable.

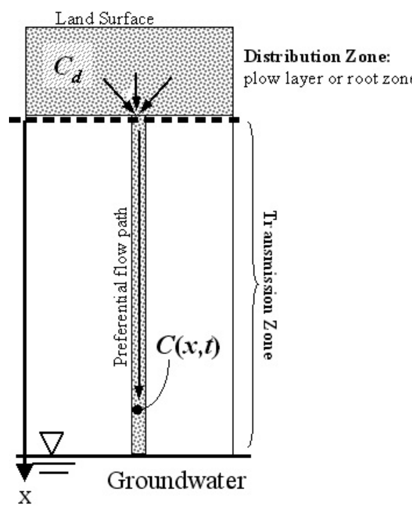


Figure 2.1.1. Schematic diagram of the preferential solute transport process in the vadose zone.

Pesticide contamination of groundwater is dependant on many factors, many of which cannot be fully known without intensive data collection. However, simplified screening models have been developed to help predict the potential for contaminant transport. One of these models is the Generalized Preferential Flow Model (GPFM), which needs only limited inputs – soil properties and aquifer recharge data – to predict potential preferential transport in soils. It is important to note that this is a *relative risk* assessment tool designed to detect areas with greater groundwater vulnerability, *not* an attempt to predict actual groundwater pesticide concentrations. Results are thus used only to aid in sampling area selection.

The Generalized Preferential Flow Transport Model

The GPFM describes solute transport between the land surface and the groundwater. Figure 2.1.1 shows the conceptualization of the soil profile used to develop the GPFM, which is divided into two zones: a near surface distribution zone and a deeper transmission zone (Jarvis et al., 1991; Steenhuis et al., 1994; Ritsema and Dekker, 1995; Shalit and Steenhuis, 1996; Kim et al., 2005; Steenhuis et al., 1991, 2001). In the distribution zone, water and solutes are funneled into preferential flow paths, which transports the solutes through the transmission zone, often accelerating contaminant transport (Camobreco et al. 1996, Beven and Germann 1982, Darnault et al. 2004, Geohring et al. 1999). The thickness of this distribution zone depends on land use or geomorphology, e.g., plow depth in cultivated land. The GPFM has been successfully tested with both lab and field experiments.

To develop a groundwater contamination risk assessment tool, we implemented the GPFM in a GIS using spatially-distributed estimates of average percolation velocity, *v*, and depth to the groundwater, *x*. Groundwater depth typically varies throughout the year but for the purposes of risk assessment, the soil survey or SURRGO/STATSGO minimum groundwater depths sufficiently capture the distributed water table depths for the purposes of pollutant risk assessment.

Model Application

This study used atrazine as a model of a mobile, slowly-degraded model compund, and assumed label-based pesticide application rates. For this study we simulated one complete pesticide pulse. Table 2.1.1 summarizes the atrazine parameters used in this study.

Table 2.1.1. Pesticide parameters for atrazine as the screening assessment model compound.

Parameter	Value	Source
K_{oc}* Pesticide Organic Adsorption Coefficient	160 cm^3/g	DelVecchio and Haith, 1993
$t_{1/2}$ Half-life	60 days	DelVecchio and Haith, 1993
H EPA Drinking Water Standard	3 µg/L	http://www.epa.gov/safewater/mcl.html#mcls
M Application Rate	1.45 x 10^{-4} g/cm^2	http://www.usda.gov/nass/

* K_{oc} is used in Eq. 2.2.11 to solve for *k* with *Om* from STATSGO (see "Soils" section below).

In order to determine a group of possible sampling locations, a relative risk classification was calculated for each soil type in Schenectady County. The risk classification was found from the predicted relative concentration of a model pesticide at the estimated groundwater depth for each soil type. The data required to do this consisted of: annual amount of recharge to groundwater table (calculated from precipitation, temperature, and evaporation data), soil type and properties, depth to groundwater, and specific chemical data (degradation rate and chemical adsorption rate). Once the predicted concentration was determined a risk classification was assigned. The risk classification was calculated based on the relative risk (i.e. each predicted concentration divided by the highest predicted concentration).The data was imported into a Geographic Information System (GIS) software package and combined with data from land use and municipal water supply. The areas with overlapping agricultural use and that were not supplied by a municipal water system were selected as principal areas of interest. Soil types coded by predicted relative risk are mapped in Figure 2.1.1; this paticular map was also largely restricted to agricultural (denoted in green) land uses and surrounding areas. It should be remembered that the figure indicates areas with greater relative groundwater vulnerability using mobility characteristics of a model pesticide, and are not predictions of actual contamination. This map served to help identify areas for the initial site search.

Other specific points of interest incorporated into the site selection were golf courses and suburban areas, two classes of sites that use fertilizers and pesticides for turf maintenance. The Schenectady Internet Mapping website (simsgis.org) was then used to obtain addresses for identified areas using a visual comparison method between the compiled map and the tax classification parcels on the website. These addresses were then geocoded using the Manifold GIS software.

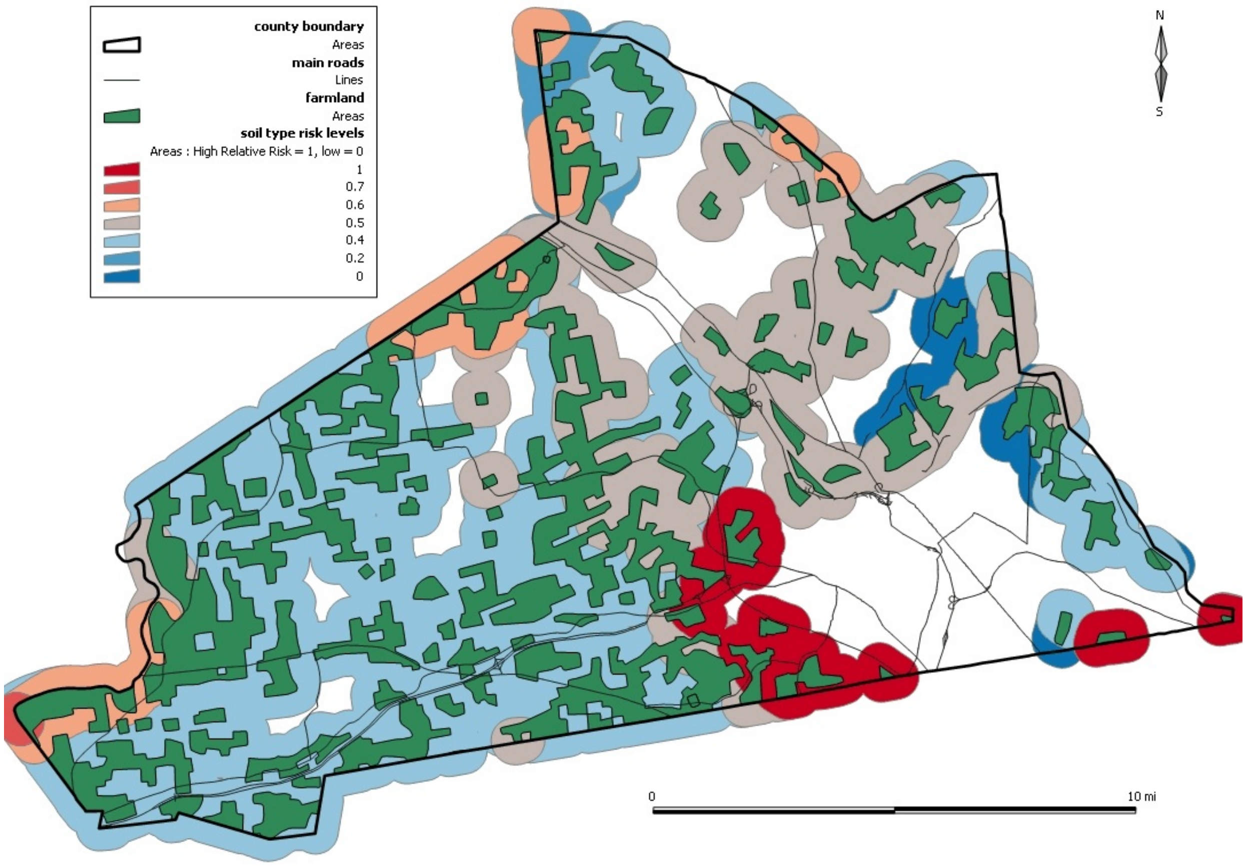


Figure 2.1.2. Relative groundwater vulnerability as a function of soil characteristics using mobility characteristics of a model pesticide (atrazine in agricultural use).

2.1.3. Utilization of the PSUR Database

Prior to sampling we requested and were granted access to the confidential application records of the PSUR database, which helped inassessing quantities of pesticides sold to end users or applied by commercial applicators. The request-to-data access time lag was 8-9 months, notably shorter than the 11 month process experienced in the first year. In contrast to our prior experience, few of the documented applications were agricultural chemicals, and most applications were done in the suburban areas of Schenectady County served by public water supplies.

Geocoding procedures and data blurring
GIS maps of the PSUR application data were generated by geocoding – a process that converts address locations to latitude and longitude coordinates – and were superimposed on physical and hydrological maps of Cortland County. The GIS system used for this study was Manifold GIS, which was selected for its integrated geocoding system. The geocoding tool uses a database based on the US government's official address database published in the TIGER/Line data set to find estimated positions for street addresses in the United States. It works best in urban and suburban areas where street addresses follow reasonably regular patterns . The pesticide data were imported into Manifold for geocoding purposes. Manifold then created two additional columns for latitude and longitude coordinates. The table was then copied and pasted as a drawing and the locations plotted on a map that also included imported geographical and hydrological data of the region.

Incomplete or unidentified locations were marked for subsequent review and editing before geocoding was again attempted.

Individual maps of hydrologic features, freshwater areas, county boundaries, and agricultural land-use areas for the county were downloaded and imported for use as a base map. CUGIR coordinates its activities with the National Spatial Data Clearinghouse and the New York State GIS Clearinghouse to provide geospatial data and metadata for New York State with special emphasis on those natural features relevant to agriculture, ecology, natural resources, and human-environment interactions.

Any data reported visually was blurred to prevent identification (either directly or by inference) of individual application sites, in compliance with the New York State Pesticide Reporting Law. The data was blurred in any GIS maps prepared for disclosure by overlying a coarse uniform grid created on the maps so that each grid cell had an associated area. The information for any points within an individual cell was added to the lumped data for the cell. This procedure provided a means of summing and showing the general patterns of application data without disclosing application locations.

PSUR database results

As found in Year 1, the majority of PSUR data records were georeferenceable, albeit with a number of spurious sitings (Figure 2.1.3) due to provided address or georeferencing program limitations. The concentration of commercial applications and sales reports in the eastern urban/suburban areas is evident. These areas of the county are primarily on municipal water supplies so these areas were not included in the considerations for sampling. Chlorpyrifos and imidacloprid were among the most heavily reported substances, again concentrated in the eastern part of the county, as shown in Figure 2.1.4. In the remaining areas of the county (i.e. the western side) there were approximately 2,000 applications reported among the 25,000 total for the year 2002. In contrast to our Year 1 work in Cortland County, atrazine was seldom used, which corresponds to the low field corn acreage in the county (personal communication, T. DellaRocco, USDA-FSA). In fact, there were only 20 reported applications of atrazineamong over 25,000 records of applied restricted chemicals in 2002.

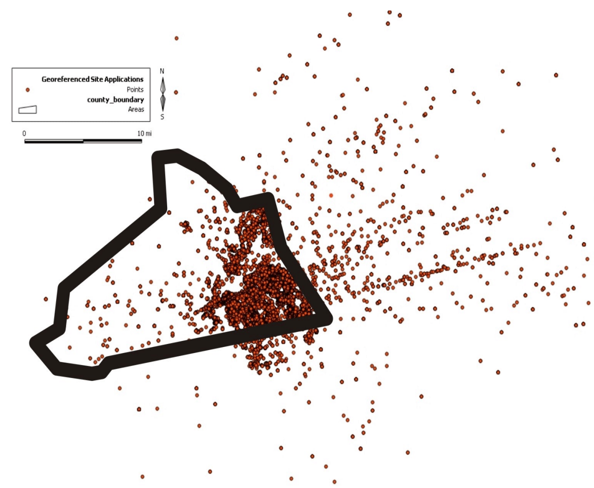


Figure 2.1.3. Georeferencing of PSUR records based on provided address information (county boundaries blurred and altered to prevent discrete record site identification).

As will be discussed later, the county selection protocol used in the initial statewide assessment aggregated data at the county-level in the final assessment in a manner that did not discriminate pesticide applications in areas of counties served by large municipal water systems that already have monitoring protocols in place and are thus not the focus of this program.

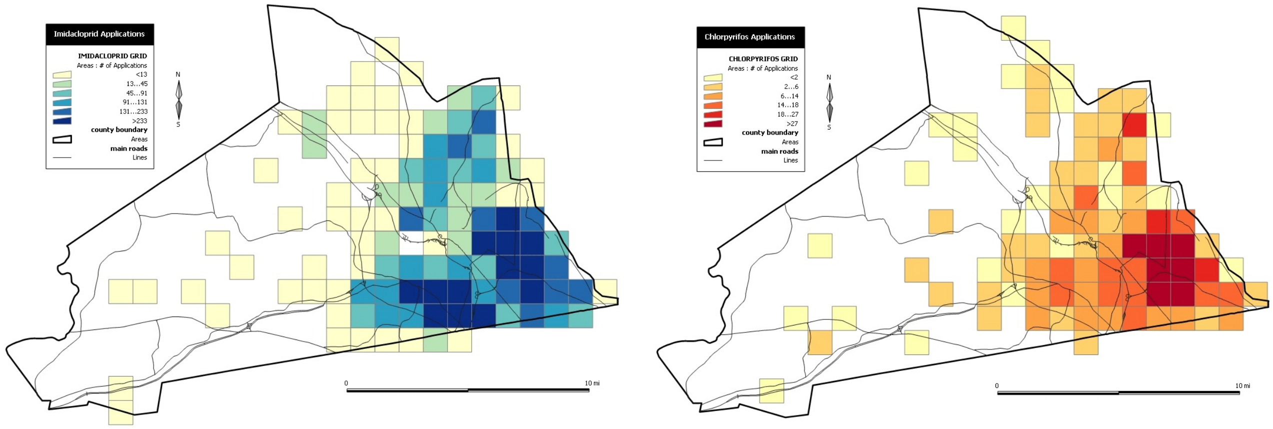


Figure 2.1.4. Schenectady County blurred distribution of imidacloprid (L) and chlorpyrifos (R) applications and sales: darker color indicates greater quantities. Blocking and aggregation of applications within blocks used to perform the required blurring of PSUR data records.

2.1.4. Landowner recruitment and confidentiality guidelines

Recruitment of landowners in selected study areas was be carried out in conjunction with SCSWCD. Information detailing samples collection and confidentiality/disclosure protocols (discussed below) were distributed. Landowner cooperation was essential, especially for gaining access to sites deemed to have elevated risk of contamination. (If such access is not obtained, it may be argued that the whole intent of the sampling program – to test the most vulnerable sites as a way of assessing the upper limits of exposure risk – would be frustrated.)

Candidate landowners were presented with the protocol (via the landowner handout that appears in the Appendix) that introduced the program and specified the confidentiality/disclosure protocol, with the following provisions:

- □ In all *public* reporting (published reports to DEC as well as any academic or extension publications), only blurred georeferences – such as rounded map coordinates – would be reported.
- □ Reports indicating pesticide concentrations determined by Cornell and NYS DEC would be compiled and sent to individual landowners.
- □ In the event that pesticide concentrations exceeding drinking water standards were found, the landowner would be contacted and the well would be resampled twice to confirm the initial findings. If confirmed by resampling, the SCSWCD would be advised. The SCSWCD would notify relevant county agencies (most likely the County Department of Health) to safeguard the health of those consuming water from the well(s) by taking appropriate remedial and/or preventative measures.
- □ In cases where levels were somewhat elevated but not in excess of drinking water standards, landowners would be encouraged to contact relevant agencies (such as local DOH or Agricultural Environmental Management) for appropriate remedial and/or preventative measures.

□ Cornell would retain a list of all landowner contact information and exact well locations that will be disclosed only to NYS DEC upon reasonable request from NYS DEC.

The process of securing permission from landowners took far longer than anticipated, even in view of the extended process experienced in Year 1 Initially, nearly 40 possible locations for sampling were identified in the county. Candidate sites were given to the County Soil and Water Conservation District for making initial landowner contacts. The rate of affirmative response was low, primarily attributable to difficulty in getting *any* sort of response from landowners, in addition to approximately 30% of those who actually responded declining participation, resulting in repeated series of inquiries. Samples acquired included 5 each in both August and September 2005, 8 in October 2005, and 6 in November 2005, with the remaining 16 collected in March 2006.

2.2 Site Characterization and Sampling

2.2.1. Sampled Well Sites

Table 2.2.1 presents the sampled well information, including well use, depth, surrounding land use(s) and sampling date. Land uses were characterized during the site sampling visits and by subsequently reviewing topographic maps and aerial photographs, including detailed interactive viewing via Google Earth, which provides detailed mapsets for Schenectady County.

Well depths and facilities served are summarized in Table 2.2.2. Most wells sampled (34) served single houses with 3 serving barns and 3 serving turf/field irrigation. Of the 34 wells for which the depths were known by landowners, 6 wells were shallow (<30 ft.), 8 were between 30 and 100 ft. deep, and 20 wells exceeded 100 ft.

Table 2.2.3 summarizes the prioritized land uses in surrounding and upslope areas, which were judged to be more likely (though by no means certain, depending on the complexity of the underlying strata) to serve as potential contributing areas to each well. Land uses were then ranked as primary (i.e. most extensive and occupying upslope areas), and, if present to a significant degree, secondary and tertiary. In some cases a primary land use was paired with a tertiary land use which occupied an areal extent to small too be termed secondary.

Table 2.2.1. Well use and sampling site characteristics. NA indicates well depth not available.				
ID	Well use	Depth (ft)	Well position relative to land use and topography	Sample date
01	turf	6	near water body in upscale suburban cluster with turfgrass; scrub to N and E; hayfield to NW.	8/11/2005
02	house	400	downslope from large dairy farm	8/11/2005
03	house	65-75	upslope scrub and woods; hayfields downslope; large farm and hayfields at distant top of slope. Artesian well	8/11/2005
04	house	250	downslope from patchy turfgrass and hayfields, otherwise wooded	8/11/2005
05	house	375	downslope from hayfields, scrub regrowth and scattered woodlots	8/11/2005
06	barn	63	downslope from extensive farm fields and pasture	9/9/2005
07	turf	60-100	golf course on 2 sides of well; relatively flat, some hayfields to SW	9/9/2005
08	house	NA	pasture/turf/hayfield above well up to nearby ridge	9/9/2005
09	house	100	well near water body in upscale cluster of suburban turfgrass; hayfield to NW, scrub to N and E	9/9/2005
10	house	250	scrub/turf/woodlot near well; hayfields and woodlot dominate upslope	9/9/2005
11	house	350	scrub regrowth upslope with a few hayfields	10/13/2005
12	house	NA	relatively flat; large hayfields/small grains on N	10/13/2005
13	house	10	spring-fed well downslope from extensive dairy farm fields, some smallgrains and scattered woodlots	10/13/2005
14	house	147	steep upslope dominated by scrub regrowth, some open fields; many ponds surrounding and upslope	10/31/2005
15	house	180	scrub regrowth nearby with turf; large hayfields downslope to N and W	10/31/2005
16	house	29	downslope from suburban area	10/31/2005
17	house	NA	on small ridge downslope from hayfields; hayfields and scattered woodlots in all directions	10/31/2005
18	barn	NA	upslope from apple farm, downslope from small livestock farm, mixed hayfields and scrub regrowth	10/31/2005
19	house	260	downslope from upscale turfgrass plots scattered among scrub regrowth and trees	11/17/2005
20	house	120	scrub regrowth nearby with turf; large hayfields downslope to N and W	11/17/2005
21	house	325	on small field surrounded by extensive scrub and trees	11/17/2005
22	house	NA	upslope hayfields and scrub, with woods above; hayfields to West	11/17/2005
23	house	160	upslope hayfields and scrub; dairy farm to S at top of hill	11/17/2005
24	house	98	downslope from scrub to SE; hayfields/farmland in all other directions. Adjacent to utility right-of-way that runs downslope.	11/17/2005
25	house	150	hay fields cross-slope to SW and NE. Downslope from area of scattered houses/lawns. Above that, extensive hay/small grain fields to hilltop.	11/17/2005
26	house	400	well surrounded on all sides by large dairy farm	3/01/2006
27	house	110	hayfields and houses near well; scrub and wood upslope to NE and E; hayfields upslope to N and NW	3/1/2006
28	house	400	trees upslope for 0.5 mi; above that large farm with hay/small grain fields	3/1/2006
29	house	200-300	trees upslope for 0.6 mi; above that large farm with hay/small grain fields	3/1/2006
30	house	188	fallow fields and trees surrounding well, no apparent active agriculture	3/18/2006

Table 2.2.1. Well use and sampling site characteristics, continued				
31	house	427	Scrub/woods upslope to N, some hayfields upslope to NW. Large utility right-of-way cuts across slope 0.4 mi upslope from well.	3/18/2006
32	house	NA	Upslope are scattered hayfields among scrub and woods. Large utility right-of-way cuts across slope 0.2 mi from well on slight downslope.	3/18/2006
33	barn	85	Woods/scrub surrounding corn/hayfields around well; farm fields downslope to W and SW. Large utility right-of-way 0.2 mi downslope to S. Historical DDT use in area.	3/18/2006
34	house	202	Steeply sloping area, mostly woods. Utility right-of-way 0.2 downslope to NE	3/18/2006
35	house	70	On farm: hay/small grain fields to upslope to E, NE and W; scrub to NW. Large utility right-of-way runs downslope toward well for >0.8 mi.	3/18/2006
36	house	~30	Dominated by forested steep upslope to S; some hayfields to E. Spring-fed pond near well.	3/25/2006
37	house	15	Cross-slope farm fields run SW to NE by well . Scrub and trees on ridge above fields to N. Historical atrazine use.	3/25/2006
38	house	20	Farm fields (mostly hay/small grain) cross-slope and for 0.8 mi upslope, with some woodlot/scrub patches. Above that, scrub dominates.	3/25/2006
39	field well near 38	20	Farm fields (mostly hay/small grain) cross-slope and for 0.8 mi upslope, with some woodlot/scrub patches. Above that, scrub dominates.	3/25/2006
40	house	110	Scrub to N, E and SE. Patchy corn and fields slight downslope to W, some hay/pasture to N/NE.	3/25/2006

Table 2.2.2. Summary of sampled well uses (left) and reported depths (right).

Facility served by wells	Wells	Well depth class	Wells
house	34	less than 30 ft.	6
barn	3	30 to 100 ft.	8
turf / irrigation	3	greater than 100 ft.	20
Total	40	depth unknown	6

Land uses were classified and coded in Table 2.2.3 as follows:

- T Turf/lawns, including suburban development and managed turfgrass (golf courses)
- D Dairy farm fields which include corn, typically found in rotation with forages
- H Other farms fields (including apparently forage-only dairy farms) dominated by hayfields and small grains.
- W Woods, trees, including scrub (brush and small trees) regrowth of abandoned farmland
- U Utility rights-of-way for powerlines or pipelines, typically subject to annual sprayings of herbicide for vegetation control.

Table 2.2.3. Prioritized land uses in surrounding and upslope areas				
		Land use(s) by ranked by extent		
Well	**Well use**	**Primary**	**Secondary**	**Tertiary**
1	turf	T	W	H
2	house	D		
3	house	W		
4	house	W		T
5	house	W	H	
6	barn	H		
7	turf	T	H	
8	house	H		
9	house	W	H	
10	house	W	H	
11	house	W	H	
12	house	H		
13	house	D	H	
14	house	W	H	
15	house	W		
16	house	T		
17	house	H		
18	barn	H	W	
19	house	W		
20	house	W		
21	house	W		
22	house	W	H	
23	house	H	W	
24	house	W	H	U
25	house	H		T
26	house	D		
27	house	H		W
28	house	W	H	
29	house	W	H	
30	house	W		
31	house	W	H	U
32	house	W	H	U
33	barn	D	W	
34	house	W		
35	house	H	U	
36	house	W		
37	house	H		W
38	house	H		
39	field	H		
40	house	W	H	
Legend and category totals by priority class				
Turf/lawns (T)		3	0	2
Dairy corn/hayfield (D)		4	0	0
Woods/scrub (W)		21	4	2
Hayfield/small grains (H)		12	14	1
Utility right-of-way (U)		0	1	3

Given the patchy nature of land use in Schenectady County, woods and scrub regrowth was the most common land use, occupying primary positions around wells around just over half of the wells sampled (21), and secondary or tertiary contributions to 6 more wells. Dairy farm croplands that included significant corn (evident from detailed aerial photos taken in early spring) were the primary surrounding land use for 4 wells. Fields used for hay or small grains were more numerous, being the primary landuse around 12 wells and the secondary land use for 14 more. Managed turfgrass – either as lawns in suburban areas, large areas in localized clusters of non-suburban housing, or golf courses – was primary for 3 wells and tertiary for 2 wells. Appearing near sampled sites with unexpected frequency were utility rights-of-way, representing the secondary land use near 1 well and as the tertiary use near 3 additional wells. As noted, these rights-of-way for powerlines or pipelines are typically subject to annual sprayings of herbicide for vegetation control, hence their delineation as a distinct land use.

2.2.2. Sampling protocols

The protocol followed during field sampling is summarized here; the *Sampling Protocol* and *Sample Information Log* forms developed and used are shown in the Appendix. Landowners were asked to identify accessible spigots or faucets that were closest to the well and preceding, if possible, any existing water treatment equipment such as softeners or carbon filters. The faucet/spigot was allowed to run for several minutes to purge the plumbing lines.

Certified precleaned (Environmental Sampling Supply, PC class) narrow-mouth amber glass bottles were used for sample collection. Two 1 L bottles were collected for samples for submission to DEC, and two 125 mL bottles were collected for Cornell analysis and archiving. Sample bottle labels specified only a tracking code. Nitrile gloves were used to prevent operator contamination of the water sample (with several landowners needing reassurance that we were not trying to protect ourselves from their well water). Contact with the interior of the cap and bottle was avoided. Bottles were rinsed three times with the sampled water prior to filling. Bottles were filled approximately 40% full to allow subsequent freezing and were placed in an ice chest. Bottles were frozen within 8 hours of collection by laying them horizontally in a freezer to prevent breakage.

To prevent breakage issues encountered in the first year, frozen sample bottles were hand-delivered to the NYS DEC laboratory in two installments in March and April 2006.

2.3 Analysis and Results

Pesticide analysis conducted by DEC consisted of 93 pesticides, phenoxy acid herbicides and carbamates, as detailed below. Analyses conducted at Cornell University included nitrate-N concentrations as well as ELISA screening for imidacloprid.

2.3.1. Analytical Protocols

DEC pesticide scans

This section consists of text forwarded by Peter Furdyna of the NYS DEC Pesticides Laboratory:

The water samples which were submitted to the NYSDEC Pesticides Laboratory under the group numbers Y201-Y240 (as well as Y104, a repeat of a Year 1 sample) were screened for pesticides, phenoxy acid herbicides and carbamates. All sample results were non-detect at the laboratory's method detection limit (MDL). The reporting levels were 1 ppb (µg/L) for all compounds except quizalofop ethyl, flufenoxuron, and pendimethalin, which had detection limits of 2 ppb (Table 2.2.3). For this project, the MDLs are at the lowest calibration concentration on the calibration curve.

All samples submitted to the laboratory were successfully analyzed.

All of the pesticide and herbicide compounds except trifluralin, benfluralin, diazinon, dithiopyr, malathion, chlorpyrifos, pendimethalin, and azinphos methyl were analyzed by direct injection followed by HPLC/MSMS. The remaining eight chemicals were extracted using the solid phase extraction (SPE) technique and analyzed by gas chromatography/mass spectrometry (GC/MS).

Quality control consisted of analyzing reagent blanks, method blanks (DI water), matrix spikes, and matrix spike duplicates. All target chemicals were spiked for QC analyses. Spike levels were between 4 and 10 ppb.

The chlorophenoxy acid herbicides were spiked at 10 ppb, in 4 sets of MS, MSD's. Spike recoveries ranged from 48% to 118%, with relative percent differences ranging from 0.0% to 12.2%.

With the exception of diaminozid, spike recovery and precision information are as follows:

For HPLC/MSMS direct injection pesticide samples, recoveries ranged from 8% to 158%, with RPD's ranging from 0.0% to 70.0%. Chemicals were spiked between 5 and 10 ppb, in 12 sets of duplicates, noting that not all duplicate sets were spiked with all chemicals, but all of the chemicals were spiked in at least 4 sets of duplicates.

For GC/MS extraction and analysis samples, chemicals were spiked at 4 ppb in 4 sets of duplicate samples. Recoveries ranged from 27.5% to 105.0%, with RPD's ranging from 0.0% to 26.7%.

For the chemical daminozid, analysis was performed by direct injection LC/MSMS. Daminozid was spiked at 5 ppb in 4 sets of duplicate samples. In 3 of the 4 duplicate sets of samples, recoveries were considered normal, and ranged from a low of 78% to a high of 128%, with RPD's ranging from 9.4 to 13.3%. One of the samples had oddly enhanced recoveries for daminozid. Sample Y221, which did not have daminozid detected, gave recoveries of 1648%, and 1772% when spiked at 5 ppb. When the experiment was repeated on a fresh sample from a different sample container, utilizing fresh standards and reagents, the sample again was non-detect for daminozid, and presented recoveries of 1882%, and 1938% when spiked at 5 ppb. Literature review turned up little in the way of information on this observed enhancement. Because it was reproducible for this sample, while other samples gave "normal" responses, the effect can be considered a matrix effect specific to this sample for daminozid.

Table 2.2.4. Method detection limits (MDL) of pesticide/herbicide analyses run by the NYS DEC laboratory. All MDL concentrations are reported as µg/L (ppb). * indicates revised MDL determinations for several analytes.			
Analyte	**MDL**	**Analyte**	**MDL**
2,4-D	1	Imidacloprid	1
3 Hydroxy Carbofuran	1	Isoproturon	1
3,4,5 Trimethacarb	1	Isoxaflutole	1
6-chloro-4-hydroxy-3-phenyl-pyridazin	1	Linuron	1
Acephate	1	Malathion	1
Aldicarb	0.175*	MCPA	0.44*
Aldicarb Sulfone	1	MCPP	1
Aldicarb Sulfoxide	1	Metalaxyl	1
Amidosulfuron	1	Metamitron	1
Atrazine	1	Methamidophos	1
Azinphos Methyl	1	Methiocarb	1
Azoxystrobin	1	Methomyl	0.175*
Bendiocarb	1	Metolachlor	1
Benfluralin	1	Metsulfuron-Methyl	1
Butocarboxim	1	Monocrotophos	1
Butoxycarboxim	1	Nicosulfuron(Accent)	1
Carbaryl	1	Omethoate	1
Carbendazim	1	Oxamyl	1
Carbofuran	1	Oxydemeton-Methyl	1
Chlorosulfuron	1	Pendimethalin	2
Chlorpyrifos	1	Primicarb	1
Cinosulfuron	1	Promecarb	1
Clethodim	1	Propamocarb	1
Clopyralid	1	Propoxur	1
Cyprodinil	1	Prosulfuron	1
Daminozid	1	Pymetrozine	1
DCPP	1	Pyridate	1
Demeton-S-Methyl Sulfone	1	Pyrimethanil	1
Diazinon	0.7*	Quinmorac	1
Dicamba	0.44*	Quizalofop Ethyl	2
Dimethoate	1	Rimsulfuron	1
Dithiopyr	1	Spiroxamine	1
Diuron	1	Tebuconazole(Folicur)	1
Ethiofencarb	1	Tebufenozide	1
Ethiofencarb-sulfone	1	Thiacloprid	1
Ethiofencarb-sulfoxide	1	Thifensulfuron-Methyl	1
Fenhexamid	1	Thiodicarb	1
Fenoxycarb	1	Thiofanox-sulfone	1
Fenpropimorph	1	Thiofanox-sulfoxide	1
Flazasulfuron	1	Triadimefon	1
Fluazifop-p-butyl	1	Triasulfuron	1
Flufenoxuron	2	Trichlorfon	1
Furathiocarb	1	Triclopyr	1
Halofenozide	1	Trifluralin	1
Haloxyfop Ethoxyethyl	1	Triflusulfuron-Methyl	1
Haloxyfop Methyl	1	Vamidothion	1
Imazalil	1		

ELISA and nitrate assays

Water samples were screened at Cornell University for imidicloprid (as the most likely to be detected pesticide, given significant reported use and relative mobility). Screening was carried out with an Envirologix (Portland, Maine; www.envirologix.com) Imidacloprid QuantiPlate kit (EP-006). The method employs Enzyme-Linked ImmunoSorbent Assays (ELISA) to detect the analyte and related compounds with a quantitation range of 0.2 - 6 ppb (μg/L) and a trace limit of detection of 0.07 ppb. The contribution of closely-related compounds (cross-reactivity) present cannot be distinguished by the screening test, and results are reported on an "as imidicloprid" basis. The test exhibits a typical reduced sensitivity to cross-reactive species, with a greater concentration of a given cross-reactant needed to yield a signal equivalent to 1 ppb imidacloprid. The name and required concentrations of related compounds yielding a signal equivalent to 1 ppb imidacloprid include: imidacloprid olefin (3.3 ppb), desnitro imidacloprid (1.75 ppb), imidacloprid urea (3.1 ppb), Thiacloprid (4.4 ppb), and Acetamiprid (4.4 ppb). Humic acid is reported as non-reactive up to 100,000 ppb, and 26 other common pesticides were reported as non-reactive up to 1000 ppb.

Samples were analyzed using a Biotek μQuant 96-well plate spectrophotometer. In contrast to standard colorimetric tests where increasing absorbance linearly correlates to increasing analyte concentration, atrazine and related compounds compete with reagents that favor color development in the ELISA assay.

Calculations thus transform absorbance data as a fraction of the absorbance (B/B_0) produced by the "negative control" (zero standard) at 450 nm..

The calibration data is then linearized using logarithms:

$$\log(B/B_0) = C^* \text{ slope} + \text{intercept} \qquad \text{Eq. 2.1.1}$$

where B = sample absorbance
B_0 = absorbance of zero standard (negative control)
C = standard or sample concentration, μg/L (ppb)

Test kit calibration points include 6.0, 1.0 and 0.2 ppb (μg/L). Initial runs were made in 2006 but were later judged unreliable due to poor calibration reproducibility. The analysis was rerun on frozen samples in March 2008.

Nitrate, sulfate and chloride were analyzed at Cornell by ion chromatography (Dionex ICS-2000 with anion columns). Nitrate was expressed as ppm (mg/L) of nitrate-N.

2.3.2 Analysis Results

DEC analysis

Pesticide analysis at the NYS DEC laboratory was completed and final reports transmitted in June 2007. As noted in the prior section, the NYS DEC pesticide screening found that *all analytes were below the detection limits* specified in Table 2.2.4. DEC analytical results are summarized in Table 2.2.5.

Table 2.2.5. Results of analyses run by the NYS DEC laboratory. All concentrations are reported as µg/L (ppb). ND indicates non-detects, indicating concentration less than the associated method detection limit. * - indicates revised MDL determinations for several analytes.

Analyte	Conc. (µg/L)	Analyte	Conc. (µg/L)
2,4-D	ND < 1	Imidacloprid	ND < 1
3 Hydroxy Carbofuran	ND < 1	Isoproturon	ND < 1
3,4,5 Trimethacarb	ND < 1	Isoxaflutole	ND < 1
6-chloro-4-hydroxy-3-phenyl-pyridazin	ND < 1	Linuron	ND < 1
Acephate	ND < 1	Malathion	ND < 1
Aldicarb	ND < 0.175*	MCPA	ND < 0.44*
Aldicarb Sulfone	ND < 1	MCPP	ND < 1
Aldicarb Sulfoxide	ND < 1	Metalaxyl	ND < 1
Amidosulfuron	ND < 1	Metamitron	ND < 1
Atrazine	ND < 1	Methamidophos	ND < 1
Azinphos Methyl	ND < 1	Methiocarb	ND < 1
Azoxystrobin	ND < 1	Methomyl	ND < 0.175*
Bendiocarb	ND < 1	Metolachlor	ND < 1
Benfluralin	ND < 1	Metsulfuron-Methyl	ND < 1
Butocarboxim	ND < 1	Monocrotophos	ND < 1
Butoxycarboxim	ND < 1	Nicosulfuron (Accent)	ND < 1
Carbaryl	ND < 1	Omethoate	ND < 1
Carbendazim	ND < 1	Oxamyl	ND < 1
Carbofuran	ND < 1	Oxydemeton-Methyl	ND < 1
Chlorosulfuron	ND < 1	Pendimethalin	ND < 2
Chlorpyrifos	ND < 1	Primicarb	ND < 1
Cinosulfuron	ND < 1	Promecarb	ND < 1
Clethodim	ND < 1	Propamocarb	ND < 1
Clopyralid	ND < 1	Propoxur	ND < 1
Cyprodinil	ND < 1	Prosulfuron	ND < 1
Daminozid	ND < 1	Pymetrozine	ND < 1
DCPP	ND < 1	Pyridate	ND < 1
Demeton-S-Methyl Sulfone	ND < 1	Pyrimethanil	ND < 1
Diazinon	ND < 0.7*	Quinmorac	ND < 1
Dicamba	ND < 0.44*	Quizalofop Ethyl	ND < 2
Dimethoate	ND < 1	Rimsulfuron	ND < 1
Dithiopyr	ND < 1	Spiroxamine	ND < 1
Diuron	ND < 1	Tebuconazole (Folicur)	ND < 1
Ethiofencarb	ND < 1	Tebufenozide	ND < 1
Ethiofencarb-sulfone	ND < 1	Thiacloprid	ND < 1
Ethiofencarb-sulfoxide	ND < 1	Thifensulfuron-Methyl	ND < 1
Fenhexamid	ND < 1	Thiodicarb	ND < 1
Fenoxycarb	ND < 1	Thiofanox-sulfone	ND < 1
Fenpropimorph	ND < 1	Thiofanox-sulfoxide	ND < 1
Flazasulfuron	ND < 1	Triadimefon	ND < 1
Fluazifop-p-butyl	ND < 1	Triasulfuron	ND < 1
Flufenoxuron	ND < 2	Trichlorfon	ND < 1
Furathiocarb	ND < 1	Triclopyr	ND < 1
Halofenozide	ND < 1	Trifluralin	ND < 1
Haloxyfop Ethoxyethyl	ND < 1	Triflusulfuron-Methyl	ND < 1
Haloxyfop Methyl	ND < 1	Vamidothion	ND < 1
Imazalil	ND < 1		

Table 2.2.6. Comparison of NYS ambient groundwater (GA) MCL standards with DEC pesticide scan method detection limits:			
Analyte	**NYS MCL (µg/L)**	**DEC Scan Detection Limit (µg/L)**	**Does DEC nondetection rule out MCL exceedence?**
2,4-D	50	1	Yes
Aldicarb+Methomyl (sum of both)	0.35	0.35**	Yes**
Aldicarb Sulfone	2*	1	Yes
Aldicarb Sulfoxide	4*	1	Yes
Atrazine	7.5 (3*)	1	Yes
Azinphos Methyl	4.4	1	Yes
Carbaryl	29	1	Yes
Carbofuran	15	1	Yes
Diazinon	0.7	0.7**	Yes**
Dicamba	0.44	0.44**	Yes**
Malathion	7	1	Yes
MCPA	0.44	0.44*	Yes**
Metolachlor	10	1	Yes
Oxamyl	50	1	Yes
Trifluralin	35	1	Yes

*guidance levels rather than actual standards
**re-examination of detection limits for these compunds led to reductions of the MDLs to values shown.

In Table 2.2.6 we compare the maximum allowable MCL (NYS DEC 1998; with the addition of a more recent metolachlor standard) with the DEC pesticide scan detection limits. The table shows only those analytes shown in Tables 2.2.4/2.2.5 that have an associated groundwater (class GA) MCL standard (or, as in the case of aldicarb sulfone and sulfoxides, guidance levels in the absence of a promulgated standard. The lower atrazine guidace level is also shown). Of the 15 analytes listed, eleven had DEC scan detection limits that were lower than the MCL, which means that the tests that yieded nondetects ruled out MCL exceedence. Conversely, four entries (aldicarb/methomyl, diazinon, dicamba and MCPA) had MCL levels slightly lower than the initial testing results. Reexamination of the detection limit determinations by Peter Furdyna of the DEC laboratory led him to conclude that nondetects could be confirmed for those analytes as well, with resulting detection limits of 0.175 µg/L each for aldicarb and methomyl (therefore with a total less than 0.35 µg/L), 0.7 µg/L for diazinon, and 0.44 µg/L for both dicamba and MCPA.

Cornell analysis

ELISA scans using 96-well imidacloprid test kits conducted at Cornell University indicated no quantifiable imidicloprid, with a lower quantitation limit of 0.2 µg/L. All samples tested had B/Bo levels in excess of 85% and thus imidacloprid levels were well below the minimum quantitation limits (Figure 2.2.1). Only a single sample (number 4) had detection of a potential trace but non-quantifiable level of imidacloprid, falling between the 0.2 µg/L quantitation limit and the 0.07 µg/L trace detection limit (trace detection limit of B/Bo of 88%). All other samples had readings well below the trace detection limit.

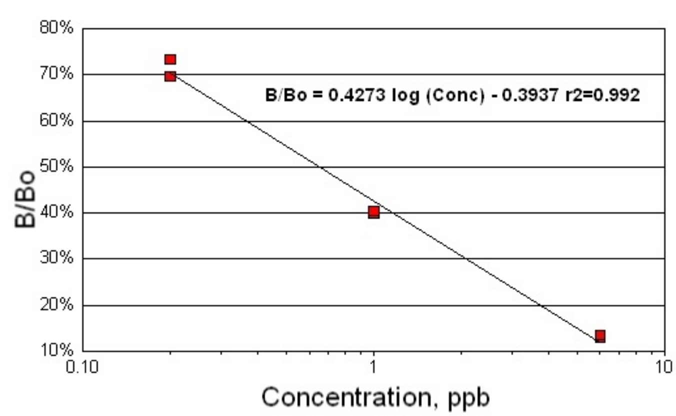


Figure 2.2.1. Imidacloprid ELISA assay standard curve (0.2, 1 and 6 µg/L standards). All Schenectady County samples had B/Bo levels in excess of 85% and were thus well below the minimum quantitation limits of 0.2 µg/L.

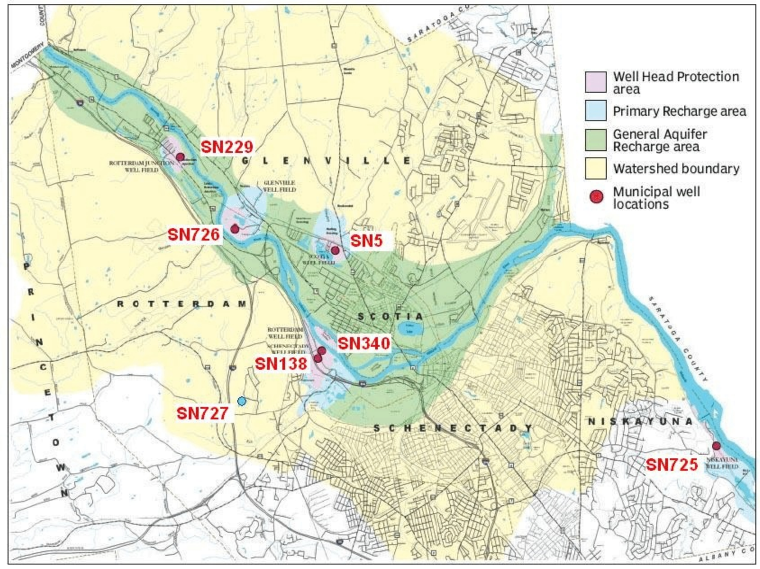
Cornell analysis of well nitrate, chloride and sulfate are shown in Table 2.2.7. Nitrate concentrations were all below the 10 mg N/L drinking water standard, with the observed maximum concentration of 3.6 mg/L and a mean of 0.58 ± 0.88 mg N/L (using values of zero for non-detects, a negligible error). Chloride mean values were 36.8 ± 50.6 mg/L, while sulfate levels averaged 18.5 ± 26.7 mg/L. These values are consistent with recent municipal drinking water reports that indicate ranges of 0.5-0.8 mg/L for nitrate-N, 23-28 mg/L for sulfate, and 32-42 mg/L for chloride (Annual Drinking Water Reports 2006 (Schenectady, Glenville) and 2007 (Ballston)).

Table 2.2.7. Well analysis: nitrate, chloride, and sulfate results (mg/L).

ID	Nitrate-N	Chloride	Sulfate
1	<0.01	99.2	6.2
2	1.87	8.5	7.8
3	<0.01	93.9	10.7
4	<0.01	14.9	46.1
5	0.50	36.9	9.7
6	<0.01	129.7	72.6
7	<0.01	3.5	<0.01
8	<0.01	185.5	112.6
9	0.38	196.8	9.1
10	0.48	10.0	9.4
11	3.62	8.1	21.5
12	<0.01	40.9	32.7
13	1.20	51.9	3.5
14	<0.01	10.6	2.7
15	3.11	1.2	<0.01
16	0.80	123.3	8.1
17	<0.01	7.1	8.7
18	0.97	9.0	<0.01
19	1.16	9.6	<0.01
20	<0.01	43.0	<0.01
21	0.79	1.5	5.7
22	<0.01	60.5	0.1
23	0.42	1.8	3.7
24	<0.01	1.6	86.1
25	<0.01	2.6	<0.01
26	0.72	14.9	11.5
27	0.64	13.2	7.8
28	0.37	36.9	26.7
29	<0.01	108.2	29.0
30	<0.01	1.3	<0.01
31	0.54	1.7	16.3
32	0.41	13.5	6.5
33	<0.01	1.6	24.8
34	<0.01	1.3	49.1
35	<0.01	6.7	84.8
36	0.33	1.4	1.5
37	<0.01	0.6	12.1
38	1.39	54.8	4.2
39	2.93	62.9	2.5
40	0.48	2.3	7.5
Mean	0.58	36.8	18.5
Std Dev	0.88	50.6	26.7

Comparative Data

The USGS river basin sampling (as reported in Butch et al 2003) provides additional evidence of low contamination potential in Schenectady County, albeit for a more select set of samples. The sampling included 7 sites near Schenectady (Figure 2.2.2 and Tables 2.2.8). Six sites were municipal wells near the Mohawk river, while the seventh (SM 727) was apparently a control site in a wooded area significantly upgradient from the river. This series of municipal wells draws from the Great Flats (or Schenectady) Aquifer and serves Schenectady, the village of Scotia and the towns of Glenville, Niskayuna, Rotterdam and Ballston (Schenectady County, 2008).



SOURCE: SCHENECTADY COUNTY DEPARTMENT OF ECONOMIC DEVELOPMENT AND PLANNING

Figure 2.2.2. USGS river-basin sampling of Schenectady area municipal wells (red) and upland control well (blue). (Original map source: Schenectady County Dept. of Economic Development & Planning.)

The USGS results – which represent a single sampling but with extremely sensitive protocols and thus very low detection limits – are here summarized in two tables: chloride, sulfate and nitrate-N as well as any pesticide detections are shown in Table 2.2.9, while Table 2.2.10 summarizes the majority of analytes (and respective detection limits) for which all samples were nondetects. As can be seen, detections were in general rare and at low values. The municipal wells are influenced by subsurface recharge from the Mohawk River (D. Eckhardt, personal communication), as indicated by the presence in several wells of trace atrazine and other pesticides despite having no significant agricultural activities in their delineated overlying recharge areas.

Table 2.2.8. USGS River Basin Sampling in Schenectady County: well identification and characteristics.

Well ID	USGS Station ID	Date	Well Depth ft	NAD27 coordinates		Strata
				Lat.	Lon.	
Municipal wells						
SN 5	425052073585102	08/26	85	42 50' 50"	73 58' 55"	sand/gravel
SN 135	424909073591601	08/21	69	42 49' 09.8"	73 59' 16.1"	sand/gravel
SN 229	425211074021605	08/21	63	42 52' 13.4"	74 02' 17.1"	sand/gravel
SN 340	424918073591001	08/21	81	42 49' 19.2"	73 59' 10.7"	sand/gravel
SN 725	424748073503401	08/26	55	42 47' 48"	73 50' 34"	sand/gravel
SN 726	425111074010501	08/26	60	42 51' 11"	74 01' 05"	sand/gravel
Upland well						
SN 727	424836074005501	09/04	166	42 48' 35.5"	74 00' 54.6"	ordovician, upper

Table 2.2.9. USGS 2002 River Basin Sampling in Schenectady County results: Chloride, sulfate, nitrate-N and pesticide detections (indicated as water-dissolved unless otherwise noted). *Italicized values indicate nondetects;* ***E*** prefix indicates estimated concentrations; ***M*** entry indicates analyte presence verified but not quantified.. SN 727 is the upland well site; all others are municipal wells.

Well ID	**Chloride**	**Sulfate**	**Nitrate as N**	**Atrazine**	**Deethyl atrazine**	**Metol-achlor ESA***	**Metol-achlor**	**Pro-meton**	**Simazine**
		(mg/L)				(µg/L)			
SN 5	66.7	21.8	0.77	E 0.004	E 0.005	*<0.05*	*<0.013*	*<0.01*	*<0.005*
SN 135	26.9	21.4	0.21	0.017	E 0.007	0.1	E 0.004	M	E 0.003
SN 229	101	33.1	5.21	*<0.007*	E 0.001	0.06	*<0.013*	*<0.01*	*<0.005*
SN 340	26.7	23.4	0.29	0.015	E 0.008	0.09	E 0.004	M	E 0.003
SN 725	80.2	35.5	1.05	*<0.007*	*<0.006*	*<0.05*	*<0.013*	*<0.01*	*<0.005*
SN 726	35.9	28.5	0.38	0.007	E 0.004	0.06	E 0.004	*<0.01*	*<0.005*
SN 727	41.2	135	<0.05	*<0.007*	*<0.006*	*<0.05*	*<0.013*	*<0.01*	*<0.005*

* denoted as filtered sample (0.7 µm)

Table 2.2.10. USGS 2002 River Basin Sampling in Schenectady County results: analytes for which all samples were nondetects (method detection limits reported as µg/L), sorted by USGS-described sample preparation: in "water" (0.7 µm filtration) or "dissolved" in some cases with unspecified filtration.

Water, 0.7 µm filtered				***Dissolved or unspecified filtration***	
2,6-Diethylaniline	<0.006	Metolachlor OA	<.05	Alachlor	<0.004
Acetochlor ESA	<0.05	Molinate	<.002	Butylate	<0.002
Acetochlor OA	<0.05	Napropamide	<.007	Chlorpyrifos	<0.005
Acetochlor water filt	<0.006	Pebulate	<.004	Cyanazine	<0.018
Alachlor OA	<0.05	Pendimethalin	<.022	Diazinon	<0.005
Alachlor ESA	<0.05	Permethrin CIS	<.006	Dieldrin	<0.005
Benfluralin	<0.010	Phorate	<.011	Dimethenamid OA	<0.05
Carbaryl	<0.041	Pronamide	<.004	Dimethenamid ESA	<0.05
Carbofuran	<0.020	Propanil	<.011	Flufenacet ESA	<0.05
DCPA	<0.003	Propargite	<.02	Flufenacet OA	<0.05
Disulfoton	<0.02	Tebuthiuron	<.02	Fonofos	<0.003
EPTC	<0.002	Terbacil	<.034	Lindane	<0.004
Ethalfluralin	<0.009	Terbufos	<.02	Malathion	<0.027
Ethoprop	<0.005	Thiobencarb	<.005	Metribuzin sencor	<0.006
Linuron	<0.035	Triallate	<.002	P, P' DDE	<0.003
Methylazinphos	<0.050	Trifluralin	<.009	Parathion	<0.010
Methylparathion	<0.006			Propachlor	<0.010

2.4. Statewide Assessment of Relative Groundwater Exposure

One task begun in the first year effort was the development of a protocol to guide the identification and prioritization for screening of other vulnerable upstate aquifers. This framework followed a GIS-based protocol which overlays vulnerable aquifers, population dependence on groundwater and several indices of pesticide use. These components were overlaid using or GIS system to determine the NYS counties with the most population potentially exposed to pesticide residues via groundwater used as drinking water. Cortland and Schenectady counties emerged from the first year screening process as the primary counties to sample based on the screening criteria used.

However, as indicated previously, the first-year county selection protocol aggregated data at the county level in the final step in a manner that did not adequately discriminate pesticide applications in areas of counties served by large municipal water systems which, by virtue of having existing monitoring programs in place, are not the focus of this inquiry. The final aggregation also served to mask elevated vulnerability areas within counties that also had low vulnerability areas that yielded a more moderate average score. The following section thus describes a modified process made during the second year that eliminates the final county-level aggregation, producing vulnerability assessment maps that rpesent data at the zip-code level.

The protocol developed during year 1 was presented in the year 1 report and is summarized here in sections 2.4.1 and 2.4.2, with the intermediate GIS maps shown in Appendix E.

2.4.1. Protocol Considerations

A risk-based selection process overlays vulnerable aquifers, population dependence on groundwater and several indices of pesticide use. This procedure was first carried out by graduate research assistant Benjamin Liu (BEE) with guidance and input from Steven Pacenka (NYS WRI), with assistance from the Cornell University Pesticide Management Education Program (PMEP).

The process for determining potential exposure of groundwater consumers to pesticide residues involved assessment of two major components: 1) population dependence on groundwater, and 2) pesticide application intensity. These two components were overlaid and masked to vulnerable aquifer areas using ArcGIS, to determine the NYS counties with the most population potentially exposed to pesticide residues via groundwater used as drinking water.

Key Aquifers and Dependence Upon them for Drinking Water
New York State has identified principal aquifers based on existing or potential major use for water supply. Many rivers and larger streams have unconsolidated alluvial and glacial outwash deposits yielding sufficient water to supply municipalities and industries. Sandstone and carbonate rock aquifers typically yield less water but sometimes support smaller public systems when unconsolidated aquifers are absent.

New York pays special attention to unconsolidated aquifers due to the large dependence on them and their greater vulnerability than deeper confined aquifers (NYS DOH, 1999). They may not be the most vulnerable type. A USGS review of sampling in the Middle Atlantic region found carbonate aquifers to have the highest rate of pesticide residue detections of any aquifer type, attributing this to both land use above them and the effect of solution cavities on transit time between land surface and aquifer (Ator and Ferrari, 1997). Some New York communities have used carbonate sources. Deeper non-carbonate aquifers such as sandstone should receive a lower selection priority than carbonate and unconsolidated types.

The NYS Health Department tracks population served and source types for public supply systems. Beyond public systems, it is a conservative assumption that persons not served by a public supply system use private wells. (An exception is that households along larger lakes tap those lakes.) Notable areas of high spatial density of ground water use include Rockland, Orange, Dutchess, Putnam, and Westchester Counties in southeastern NY, and Broome, Cortland, Chemung, Cortland, Monroe, Saratoga and Onondaga counties farther upstate. Monroe and Onondaga Counties stand out even more when considering that large numbers of their residents use Lake Ontario and Finger Lakes sources.

Pesticide Use

Other factors equal, a greater amount of a given active ingredient applied per unit area of total land above an aquifer will lead to higher residue concentrations in the aquifer. Thus it would be helpful to estimate pesticide use rates over the aquifers to help set priorities. (Usage near wells becomes important when selecting individual wells to sample within an area.) As in the Cortland County geographic assessment, there are two sources of data to utilize, the State Pesticide Sales and Usage Reporting (PSUR) database and land use data.

One part of the PSUR database covers pesticides applied by commercial applicators; farm owners who apply pesticides themselves are required to keep records but not to report routinely. Thus the "use" PSUR data provide a lower bound of usage in agricultural areas. A second type of records in PSUR are "sales" records. These do include sales to farm owners who do not report use but the only tracking available is the probable zip code of use. While imperfect, the combination of sales and use records in the PSUR database is the best available indicator of pesticides used in an area.

A consideration is that the PSUR database began in 1997. Ground water reflects pesticide use and transport over a years-to-decades time scale. (In eastern Suffolk County the aquifers contain significant residues of pesticides last used before 1980.)

Annual PSUR reports have mapped solid and liquid pesticide application and sales by county, separately for solid and liquid types. Because different forms of the same pesticide have different active ingredient (AI) concentrations, for use in exposure assessment the PSUR data were re-expressed as AI applied per unit area. PMEP's Product Ingredient Management System (PIMS) provides weight percentages of each AI in each registered or discontinued product.

For liquid pesticides, it is necessary to convert the liquid volume to a weight before applying the AI weight concentrations. PMEP provided preliminary data about specific gravities (or densities) for the majority of the liquid formulations of interest.

To get a closer spatial match between pesticide application and ground water use, year 2001 5-digit zip-code level data were used instead of county data. Besides this variant from the maps published by PMEP and DEC, the following additional refinements were done:

- conversion of product liquid volumes to weights
- conversion of product weights to active ingredient weights
- coverage of only "restricted use" pesticides.

All of the caveats about data quality and completeness mentioned in the 2001 annual report (NYS DEC, 2003) apply to these interpretations, as well as additional caveats from working with finer spatial detail and non-authoritative liquid densities.

Not relying upon actual usage data, a Pennsylvania assessment (Petersen and others, 1996) and the NYS DOH Source Water Assessment Program (NYS DOH, 1999) employ land use data as a surrogate for pesticide use. They reasoned that because pesticide use is highly correlated with land use types (little on forests and wetlands, more on suburban and agricultural land), area-wide assessments could rely on land use proximity to wells as a surrogate for actual pesticide use.

In New York, statewide uniform land use data are rare. The most consistent source reasonably representative of the last couple of decades is probably the USGS land cover data set, which is from the early 1990's.

For this process, the pesticide application estimates were divided by the areas of land assumed to be associated with pesticides. This improves two aspects compared to using the PSUR zip code data (a weight of total AI of restricted use pesticides) directly. Residue concentrations in ground water are sensitive to the AI weight applied per unit of land to which it is actually applied. (An alternative would have been to divide by the total land area of a zone. This would underestimate exposure in zones having a large proportion of forest or parkland and small developed or agricultural areas.)

2.4.2. GIS Procedures

Presented here are the stepwise GIS procedures used and resulting GIS maps. Note that the objective is to rapidly identify large potentially higher exposure areas, such as single counties or small clusters of counties, for sampling. Some of the input data are weak in values or spatial locations, but averaging and grouping to the county level compensate for most of the limitations.

Population dependence on groundwater

Public systems

USEPA's Safe Drinking Water Information System (SDWIS) provides water supply source (ground water, surface water, purchased ground water, etc), population served, and mailing zip code, for each regulated water supply system. Besides the obvious community systems, restaurants, institutions, fairgrounds, and other group water users are covered. Populations served by ground water (excluding ground water under the influence of surface water) were summed for each zip code. This table was then joined to the *ZCTA (Zip Code Tabulation Area) Boundary* map. Population dependent on groundwater was normalized by the area of each ZCTA to yield the *Population Dependent on Public Groundwater* per km^2, as shown in Figure E.1 (top).

Individual Households

The 1990 U.S. Census tabulated households by water source per municipality, including individual wells as a source. (The 2000 Census would have been used had it included this variable.) Household counts were multiplied by 4 persons/household to have the same units as the public supply data, and this estimated population served by individual wells was summed by municipality. This table was then joined to a *Municipality* map. Analogously to pesticide application data, population dependent on groundwater was divided by the area of each municipality to yield the *Population Dependent on Private Groundwater* per km^2, as shown in Figure E.1 (bottom).

Combining public and household systems

The populations dependent on groundwater were summed when the *ZCTA Boundary* and *Municipality* maps were combined. ArcMap was used to overlay the two maps which are based on different polygons. Essentially, to get a zip code value for household well users, ArcMap determined which municipal polygons fall into the zip code polygon and formed an area-weighted mean of the household values. Then the derived zip code map was added to the public system zip code map to yield the *Combined Population Dependent on Groundwater* map (Figure E.2).

Pesticides Applied

<u>Sales and Commercial Use</u>

For commercial applications of restricted use pesticides, kilograms of active ingredient(s) were summed by zip code. This table was joined to the *ZCTA Boundary* map. Pesticide use sums were normalized by the total area of each ZCTA to yield commercial pesticide use per km^2, as shown in Figure E.3 (top) *Commercial Pesticide Use*.

For pesticides not applied by commercial applicators, direct usage statistics were not available, so sales data of restricted use pesticides were used. It was assumed that the pesticides sold would be applied in the same year and within the same zip code area as the sale. Again, kilograms of active ingredient(s) were summed by zip code then joined to the *ZCTA Boundary* map. Pesticide use was normalized by the area of each ZCTA to get *Pesticide Sales* per km^2, displayed as Figure E.3 (bottom).

When working at a zip code level, there will be urban locations where a single business reports a large use of a single pesticide within a zip code area that does not occupy much land. There is one zip code in the Cortland area where reported use of one pesticide, probably all indoors at a single business, inflates the zip code's aggregate kilograms/square kilometer value far beyond a value that is reasonable when considering ground water. Future refinements of these maps will adjust for such outliers.

<u>Land Use</u>

A separate method of estimating pesticide usage was to use land cover information. From the National Land Cover Database map, the percentage of agricultural and residential land in each ZCTA was calculated and joined to the *ZCTA Boundary* map. This statistic was represented as *Likelihood of Pesticide Use* for each zip code, Figure E.4.

<u>Combining commercial use, private sales, and land use</u>

The commercial pesticide use per km^2 and pesticide sales per km^2 were summed for each zip code. This number was then divided by the area of land likely to involve pesticide use based on land use (Figure E.4) to yield the combined pesticide use per km^2 in the combined *Restricted Use Pesticide Applied* map (Figure E.5).

Finding Relative Potential Exposure Areas

<u>Combining Combined Population Served and Combined Pesticide Use maps</u>

For each ZCTA, population dependent on groundwater per km^2 was multiplied by combined pesticide use (lbs) per km^2 to find the value called "Relative Potential Exposure" per km^2. This combined result was an intermediate ZCTA map, not shown.

The two maps were multiplied since both persons using ground water and pesticide application are required for there to be an exposure; if either is absent there is no current concern. (There could be a future concern, if population density increases significantly. In this case the pesticide use map could be used without combining with population dependence.)

By itself, the map is misleading since it gives an illusion of spatial precision by using zip code polygons, the smallest polygons in any of the underlying data.

Selecting vulnerable aquifers
Carbonate-rock and unconsolidated surficial aquifers were singled out as especially vulnerable in this study. Carbonate-rock aquifers were taken from the USGS 2002 Aquifers of Alluvial and Glacial Origin map and combined with a Surficial Aquifers map to obtain the targeted aquifers in New York. The selected aquifers were buffered by 1 km to account for runoff (with pesticide loads) being able to travel laterally – this resulted in the vulnerable *Carbonate and Surficial Aquifers* map, Figure E.6.

Eliminating land not over vulnerable aquifers
The *Relative Potential Exposure by ZCTA* map was clipped by the vulnerable *Carbonate and Surficial Aquifers* map and then integrated (Union function) with the County Boundaries map, creating many small polygons. The area was calculated for each of the polygons, then a Relative Potential Exposure value derived by multiplying the area by Relative Potential Exposure per km^2.

As noted previously, the refinement developed this year involved evaluating the data at the zip-code level rather than forcing a final summarization at the county level, thus avoiding data blurring when averaging results across an entire county.

2.4.3. Exposure assessment results

Figure 2.4.1 shows the result of overlaying GIS maps of pesticide use (normalized by land use, thus reflecting a pesticide use intensity) and vulnerable aquifers.

Any zip code regions in the figure denoted with "outlier" reflect the case where a single active ingredient accounted for over 70% of the total pesticide weight reported for that zip code and where there are at least nine other active ingredients reported in that zip code. This reflects a situation where a single highly intensive use such as industrial wood preservative use tends to skew results for the entire zip code.

The results in Figure 1 show that the band of reported use spanning across the intensive agricultural areas of central and western NY counties south of Lake Ontario is particularly significant, as are clusters of intensive use areas in the Southeast of the state. Based on these observations, we targeted both regions for the Year 3 and 4 efforts, resulting in ongoing work in Orange County in the Southeast and Cayuga County in the lake plain. Both counties reflect a wide range of pesticide uses. As previously noted, the final stage of the selection process includes assessment of local institutional capability and interest, beginning primarily in the local Soil & Water conservation districts.

2.4.4 Refinements for future years

Refinements are planned for improving the selection protocol, among them:

- incorporation of multiple years of PSUR data (noting that data quality of the PSUR database improved in subsequent years)
- focus on fewer pesticides than the entire list of restricted use products,

- updated land use and water dependence data for avoiding areas served by monitored public supplies
- expressing both liquid and solid products as active ingredient masses.
- incorporating pesticide groundwater ubiquity data (persistence, solubility) for assessing risk.

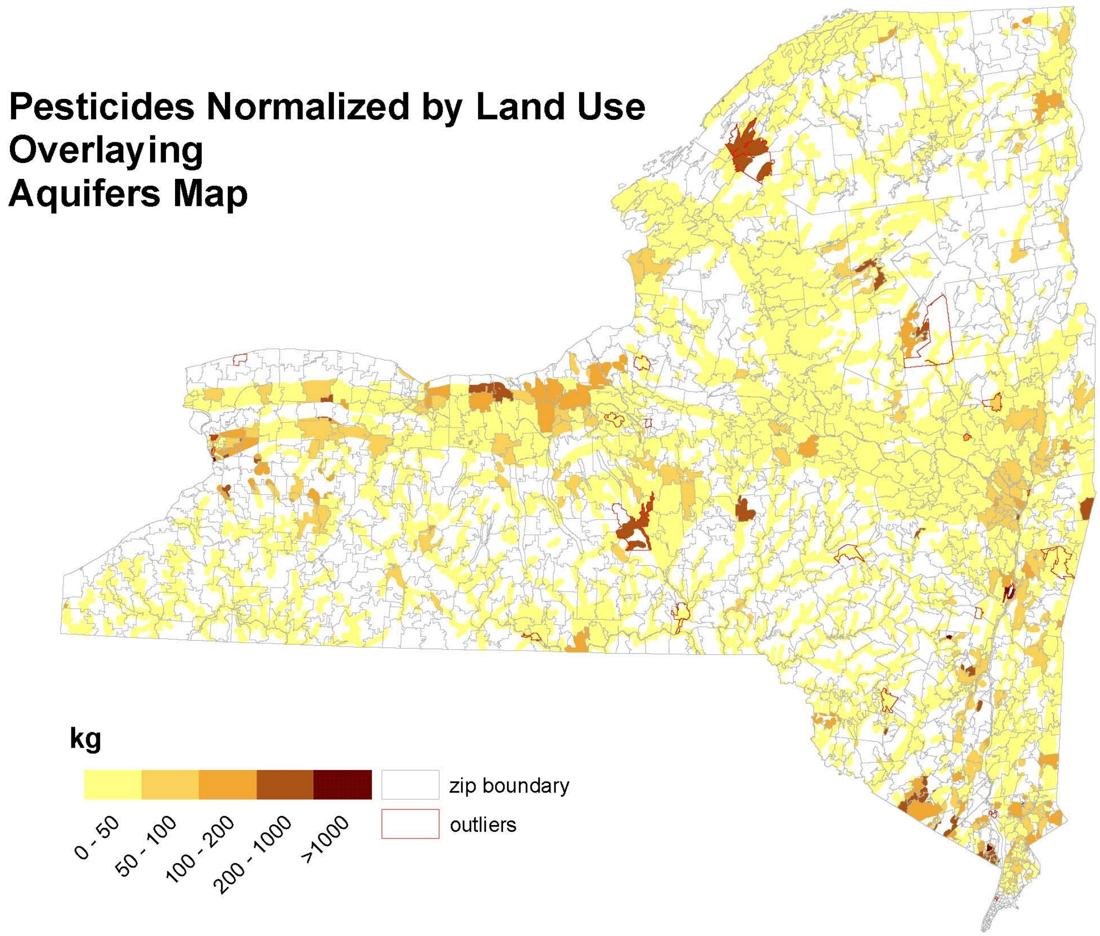


Figure 2.4.1. Result of overlaying GIS pesticide use (normalized by land use, thus reflecting a pesticide use intensity) and vulnerable aquifer maps. Zip codes denoted "outliers" had the most reported active ingredient account for over 70% of the total pesticide weight reported and at least nine other active ingredients.

3. DISCUSSION and ONGOING WORK

Site selection and securing landowner permission remained a primary challenge during this effort, exacerbated by the overlay of public water supplies with primary application areas. Well samples included a number of areas near application sites but also a range of less vulnerable land uses.

The recent instrumentation upgrades in the DEC laboratory allowed for substantially improved detection/reporting limits for 93 analytes. These detection limits (including several subsequently reexamined to establish levels somewhat below the initial 1 μg/L levels) were adequate for determining if samples were in exceedence of the fifteen Class GA ambient groundwater standards (MCLs or, in their absence, guidance values) listed in Table 2.2.6. Well testing results found no detectable pesticides or herbicides in any of the 40 samples examined. These nondetects thus established that the 40 well samples from Schenectady did not exceed any MCLs or guidance values.

ELISA scans at Cornell similarly showed no quantifiable imidacloprid, with all samples below 0.2 μg/L . Only a single sample had detection of a potential (but non-quantifiable) trace of imidacloprid, falling between the 0.2 μg/L quantitation limit and the 0.07 μg/L trace detection limit. Nitrate values were low, with mean levels of below 0.6 mg/L and a maximum single well value of 3.6 mg/L.

Overall our results were consistent with other data, including USGS sampling of a limited number of municipal wells in the Mohawk River basin found few detections even when using protocols with much more sensitive detection limits.

The statewide assessment protocol was adapted during Year 2 activities to improve future targeting by avoiding the county-level aggregation of final data. This has facilitated identifying regions of markedly greater vulnerability that occur within counties (or that run across multiple counties) that would be otherwise masked by aggregation with other lower vulnerability areas.

At the time of writing, DEC analysis and landowner notification has been completed for Orange County (Year 3), with final Cornell ELISA screens nearly complete in preparation for report writing. As noted in the statewide selection protocol section, areas of principal interest include agricultural areas south of Lake Ontario. In response to these findings, two years of effort are being directed to those areas: sampling in Cayuga County (Year 4) is half-completed, and site identification is underway in Genesee County (Year 5). Improvements to the county-level selection process have been made and additional changes are underway. Current in-county site selection procedures are yielding better-characterized sites and greater rates of positive landowner response.

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6. APPENDICES

A) Landowner Information Handout

B) Sampling Protocol

C) Well Sampling Log

D) Landowner Reporting Form

E) Statewide Vulnerability Assessment - Intermediate Figures

A) Landowner information handout
(distributed on Cornell letterhead)

Research Project:
Surveying Schenectady County Drinking Water Wells for Pesticide Residues

What is this about? Cornell University's Department of Biological & Environmental Engineering is carrying out a limited, voluntary sampling of drinking water wells in selected areas of Schenectady County, in cooperation with the Schenectady County Soil & Water Conservation District (SWCD), the Schenectady County Water Quality Coordinating Committee and the NY Water Resources Institute. Sampling and analysis will be confidential and without cost to landowners.

Why? Some areas of NY State – notably Long Island – have had several decades of groundwater monitoring for pesticides. Drinking water wells on Long Island became contaminated as a result of intensive agricultural and suburban use of pesticides on sandy soils and aquifers that allowed the pesticides to leach downward into the groundwater. Conditions in upstate New York are different, and it has long been assumed that there is little probability of groundwater becoming contaminated in the same way. However, little actual sampling of upstate wells has been carried out to confirm this. The NY Department of Environmental Conservation (DEC) wants to confirm the quality of upstate drinking water and has asked Cornell to carry out a limited, voluntary sampling of drinking water wells in selected areas of upstate NY. Schenectady County was chosen because of its location and range of soil and water characteristics. The goal is to get an accurate "snapshot" of well water quality in areas of the county, and is not a "hunt" for potentially contaminated wells.

Where? Potential sampling areas have been selected based on several factors, including likely pesticide use (agricultural and otherwise), relatively shallow groundwater levels, soils that allow leaching, degree of hillslope, etc. as well as people using the groundwater for wells While pesticide contamination of groundwater is unlikely, wells in these situations are more vulnerable as compared to areas where pesticides are rarely used or where the soil resists pesticide leaching. We are trying to locate a range of settings and well types, but due to program constraints can only sample a limited number of wells.

How? Samples will be collected by Cornell University personnel using a pre-established operating procedure, as shown below. Samples will be taken from landowners' existing plumbing systems. Personnel would also like to collect any information about the well (depth, age, type of well, water treatment, if it ever goes dry).

Sampling procedure:

1) Personnel will bring new, certified precleaned amber glass sample containers. These will be coded only with a tracking number.
2) If the sampling point is faucet or a spigot, allow faucet/spigot to run for 5 to 10 minutes to fully purge plumbing lines. If possible, sample at the closest accessible valve to well (i.e. before storage tank) and prior to any existing treatment (such as softeners or filters).
3) Rinse and dump each sample bottle three times with the water being sampled.
4) Fill sample bottles, cap tightly and place bottles in ice chest.
5) Return samples to laboratory for preservation and analysis.

What happens to the samples? Each sample will be analyzed at Cornell for nitrate, which is sometimes found when agricultural pesticides are present in groundwater. We will also analyze for one to three pesticides at Cornell, depending on the likely pesticide use in the area. Samples will be shipped to NY DEC for a complete pesticide scan. Because of program limitations, we can submit only 40 samples to DEC for full analysis. Samples that test free of pesticide residues at Cornell would be less likely to be submitted to DEC.

What will happen with the information about my well? Several things will happen with the data, but first you should understand that information about individual wells is *not* for public disclosure. What will happen?

1) We will prepare and send you a confidential report indicating any pesticide concentrations determined by Cornell and NYS DEC. Note that the DEC analysis may take a long time to be completed. In the event that traces of pesticides are found, we will report for comparison the safe drinking water concentration limits for those pesticides.

2) In the very unlikely event that pesticide concentrations exceeding safe drinking water levels are found, we would contact you in order to resample the well twice to confirm the initial findings. If resampling confirms that levels are too high, we would advise both you and the county SWCD. The SWCD would notify relevant county agencies – most likely the Department of Health – to help safeguard the health of people consuming water from the well(s) by taking appropriate remedial and/or preventative measures.

3) In cases where levels are somewhat elevated but not in excess of drinking water standards, landowners will be encouraged by the SWCD to contact relevant agencies (such as DOH or Agricultural Environmental Management) to take measures that would prevent levels from going any higher.

4) Any published reports about this study will summarize data on a general basis so that the location and concentrations of particular well(s)/land cannot be determined from the report.

5) Cornell is required to retain a confidential list of all landowner contact information and exact well locations that will be disclosed only to NY DEC only upon reasonable request from DEC.

If you have any questions contact Brian Richards of the Department of Biological & Environmental Engineering (607-255-2463; bkr2@cornell.edu) or David Mosher of the Schenectady County SWCD (518-399-6980; psswcd@nycap.rr.com).

B) Sampling Protocol

☐ Fill out SAMPLE INFORMATION LOG SHEET; assign coding number(s) to sample(s).

☐ Label new, certified precleaned (ESS Inc. PC class) narrow mouth amber glass sample containers. Sample bottle labels will specify ***only*** the tracking code; only the SAMPLE INFORMATION LOG SHEET will link the sampling code to the sampling location, date and comments. The coding format will be ## (two digit number beginning with 01) followed by replicate (A/B/C/D). Replicates A and B (large 1000 mL bottles) will be for DEC submission; C and D (small 125 mL bottles) will be for Cornell analysis and archiving.

☐ If the sampling point is faucet or a spigot, allow faucet/spigot to run for 10 minutes to fully purge plumbing lines; sample at the closest accessible valve to well (i.e. before storage tank) or directly from shallow well and prior to any existing treatment (such as softeners or carbon filters).

☐ Use nitrile gloves to minimize potential contamination. Avoid contact with interior of cap or bottle; do not place cap on ground during filling.

☐ Rinse each sample bottle three times with the water being sampled. Discard rinsate into rinse pail.

☐ Fill replicate sample bottles approximately 40% full to allow freezing if needed, and cap tightly.

☐ Place bottles in ice chest.

☐ Return samples to laboratory for immediate preservation: freeze DEC samples and Cornell replicate C immediately; refrigerate Cornell replicate D if analysis will be in the next day; otherwise freeze.

C) Well Sampling Log

Surveying Upstate NY Well Water for Pesticide Contamination

Department of Biological & Environmental Engineering, Cornell University
NY Water Resources Institute
Schenectady County Soil & Water Conservation District

SAMPLE Code: ______
DATE: ______________
INITIALS:___________

SAMPLE INFORMATION LOG SHEET

LOCATION INFORMATION IS CONFIDENTIAL AND IS NOT TO BE DISCLOSED

Contact information

Name ____

Address ____

Phone ______________________ Email __________________________

Well information

Depth: ❑____________ ft. ❑ unknown Type: ❑ drilled ❑ driven ❑ dug ❑ unknown

Age: ❑____________ y. ❑ unknown Wellhead visible? ❑ yes ❑ no

Location (★ on map)_____________________________________

____

____

GPS: N ° W ° Elev ft.

Water system information

Pump type: ❑ submersible ❑ jet/shallow ❑ unknown Tank?:____________________

Treatment: ❑ none ❑ softener ❑ filter ❑ other_____________________________

Point of sampling:____

____

____

Area information (surrounding topography & land use) **Map** ✎ *N*

____

____

____

____

____

D) Example Well Owner Report

Research Project: Surveying Schenectady County Drinking Water Wells for Pesticide Residues

You are receiving this mailing because you participated in the voluntary testing of drinking water wells in selected areas of Schenectady County carried out by Cornell University's Department of Biological & Environmental Engineering, in cooperation with the Schenectady County Soil & Water Conservation District. **These results are confidential and are provided without cost to landowners.** Your sample code number: ______

Analysis results were delayed by factors beyond our control, but are now available. Tests results for the analysis run on the well water samples included pesticides/herbicides and nitrate.

1) Pesticides/herbicides Samples (identified only by a sample code) were analyzed by a NYS DEC laboratory near Albany for 93 different pesticides/herbicides.

Chemical analysis of the sample from your well detected none of the 93 pesticides/herbicides for which analysis was run. Six of the 93 compounds tested have maximum drinking water concentrations established by New York State, and the "not detected" results confirm that none of these six compounds were present at or above the drinking water limits. This was true for all samples tested in the county.

Analysts do not report results as "zero" concentration because all chemical tests have a lower limit below which they simply cannot detect. The lower detection limits for the tests used here were between 1 and 2 micrograms per liter (also commonly referred to as "parts per billion"). Therefore, results for your well were reported to us as "*not detected, less than 1 part per billion*" for 90 of the pesticides/herbicides, and "*not detected, less than 2 parts per billion*" for the other three pesticides/herbicides for which the analyzer had a slightly higher detection limit.

2) Nitrate-nitrogen We also tested for nitrate levels, which are sometimes of concern in New York wells. The drinking water limit for nitrate-nitrogen (NO_3-N) is 10 milligrams per liter (10 parts per million or ppm), based on levels that protect the health of infants who are sensitive to nitrate.

Analysis of the sample from your well indicated a nitrate-N level of ____________ milligrams per liter, **which is far lower than the 10 milligrams per liter drinking water limit.**

Please contact either of us with any questions.

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The figures that follow represent the intermediate steps in the statewide vulnerability assessment. These were originally presented in the Year 1 annual report, and are reproduced here for the reader's convenience.

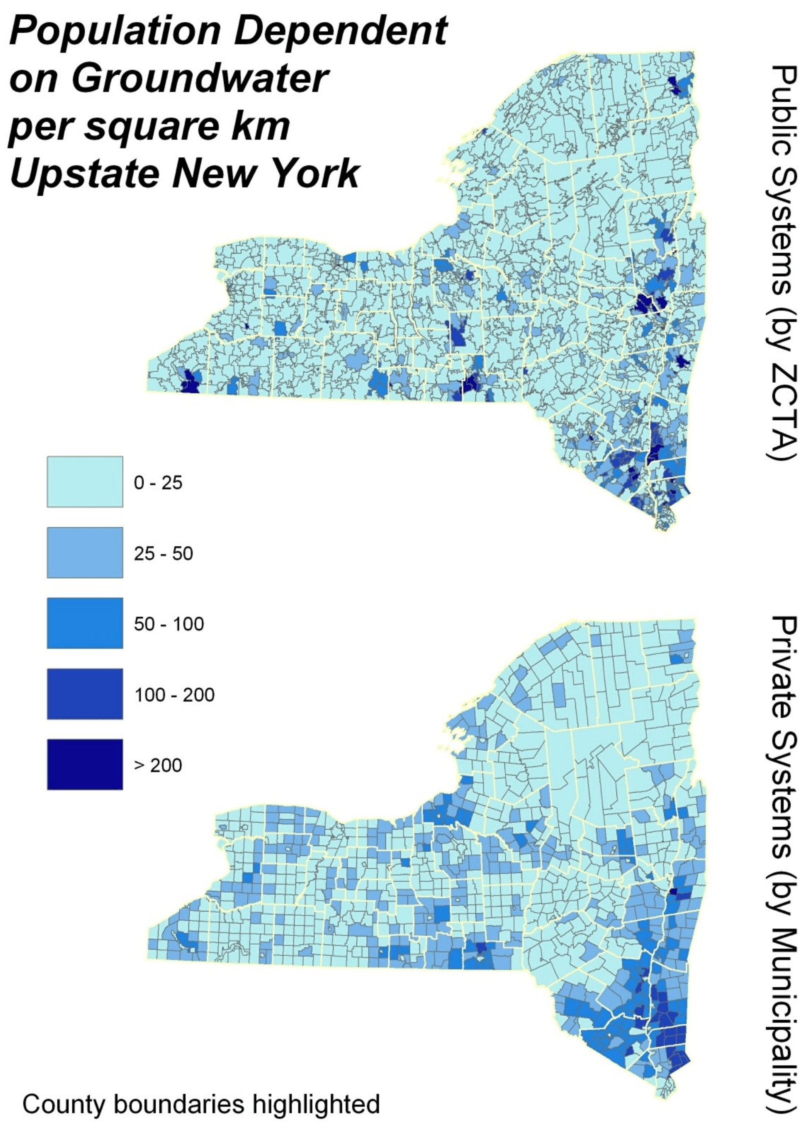

Figure E.1. Population dependence on public (top) and private (bottom) groundwater supplies.

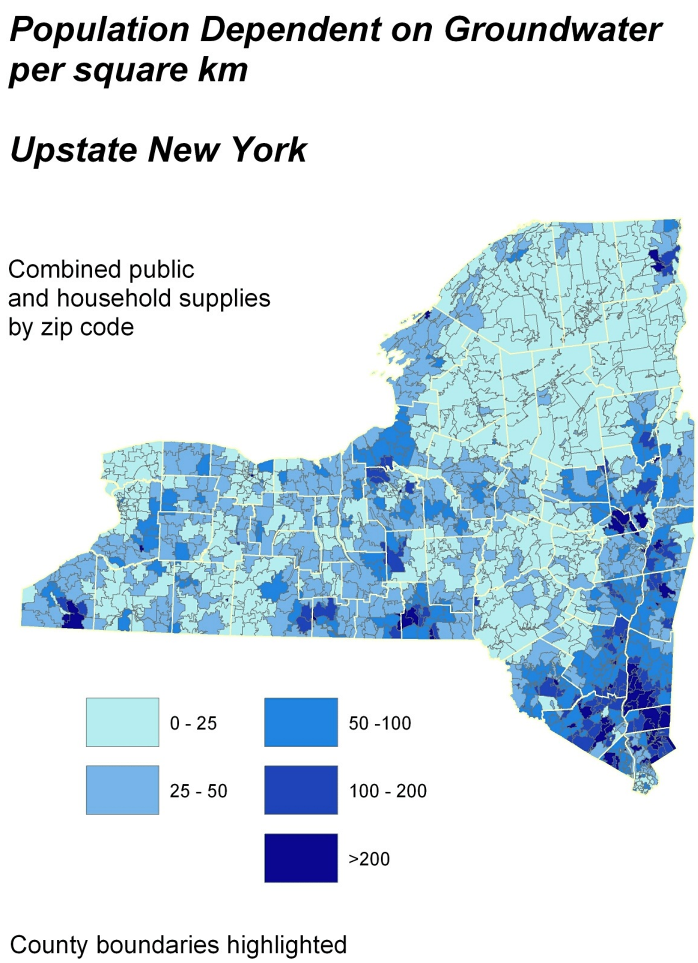

Figure E.2. Combined population dependence on public and private groundwater supplies.

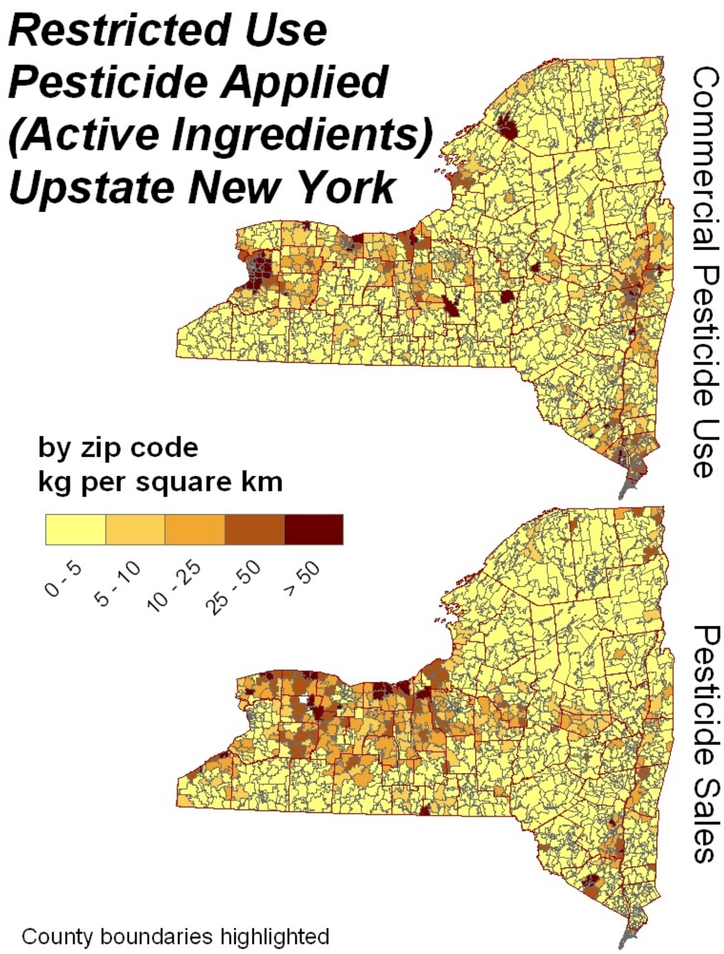

Figure E.3. Commercial pesticide (restricted use active ingredients) applications (top) and pesticide sales (bottom) by zip code.

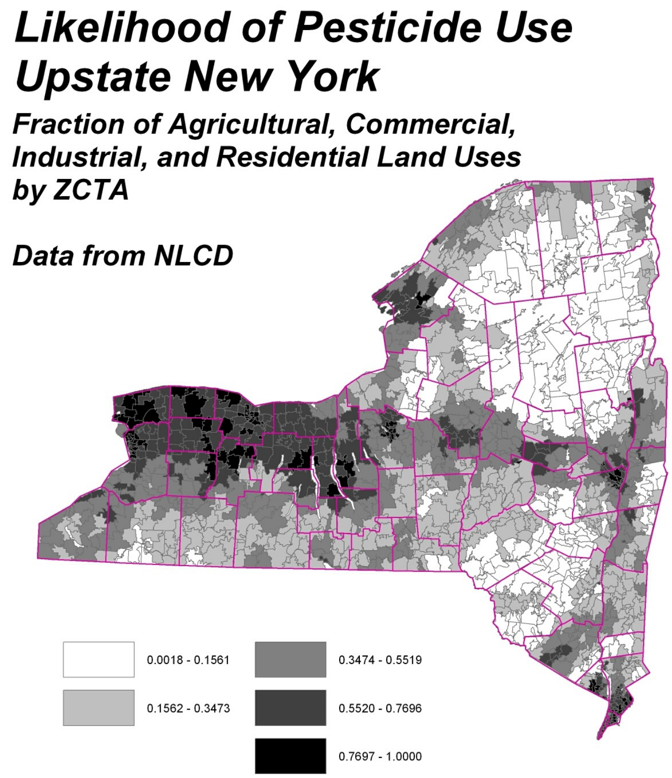

Figure E.4. Likelihood of pesticide use based on land use.

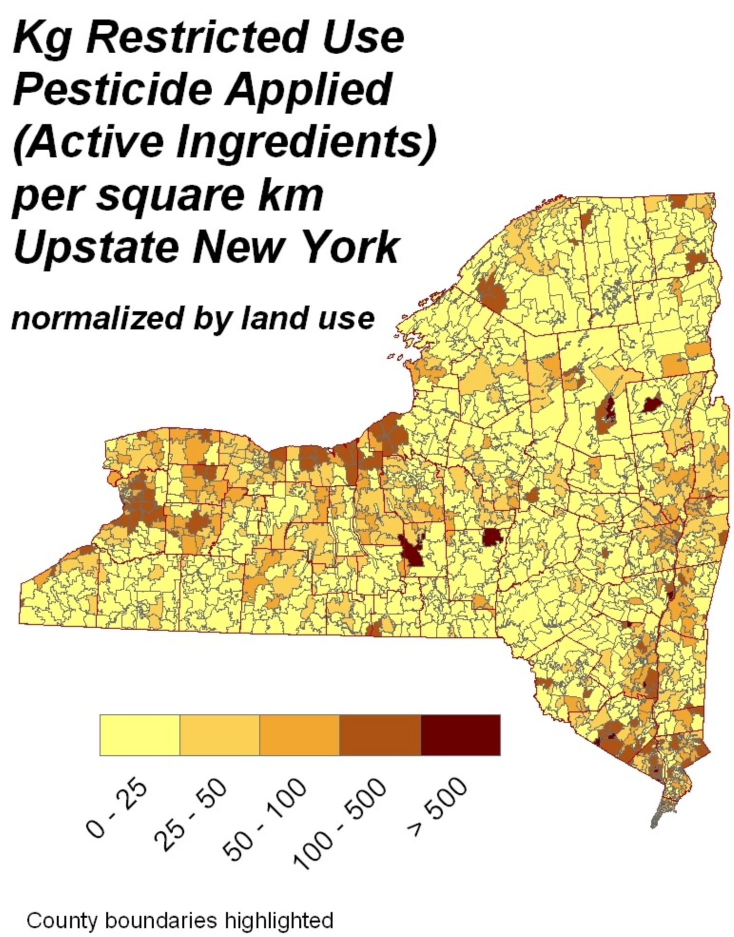

Figure E.5. Pesticide applications (restricted use active ingredients) normalized by land use.

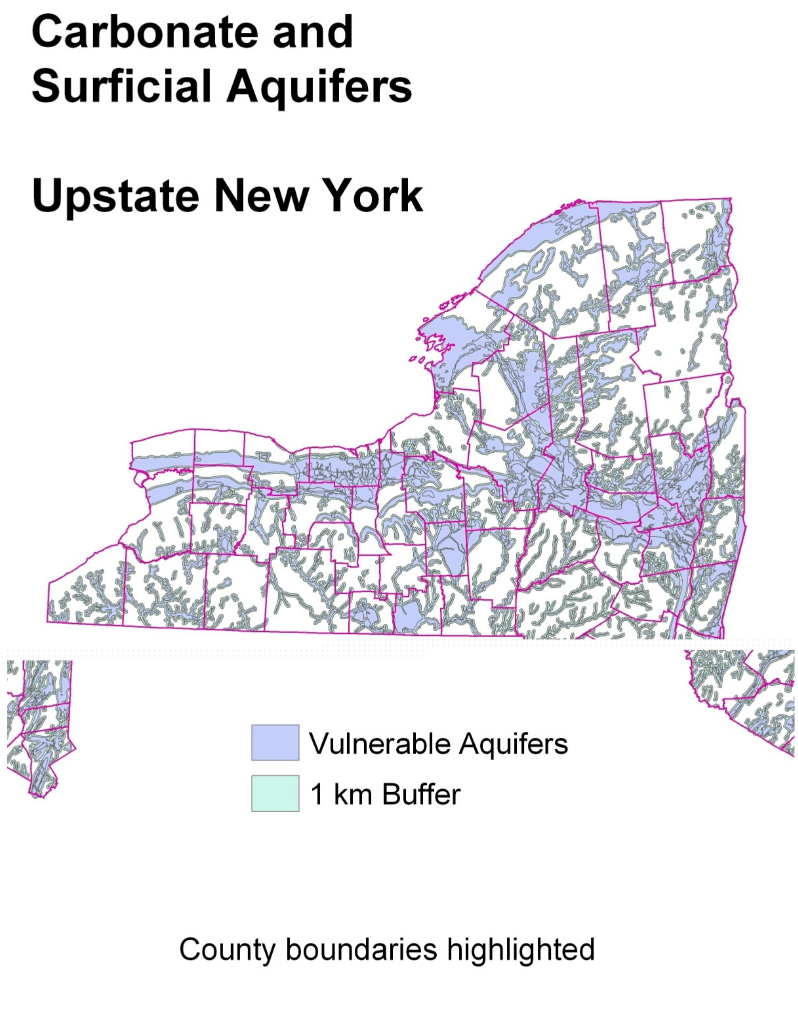

Figure E.6. Carbonate rock and surficial aquifers, including 1 km buffer zone.