LAND CONSERVATION AND WATER QUALITY IN THE SARATOGA LAKE WATERSHED

By

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ABSTRACT

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This study examined land conservation and its potential impacts on water quality within the Saratoga Lake watershed. Conserved lands were mapped in GIS from Saratoga County tax parcel, New York State Gap Analysis Project, and World Database on Protected Areas data. These lands were compared with a vegetation map derived from United States Geological Survey land cover data, to analyze the land cover of the watershed as a whole and the conserved lands in particular. Overall, the watershed is approximately 70% forest, with 81 conserved parcels, and conserved forest lands covering 2.17% of the watershed's 210 square mile total area. Since 30% or more wooded land is typically recommended for the maintenance of good water quality, our water is unlikely to be in danger of degradation currently, but will require more extensive forest conservation to ensure its quality for the future in the face of rapid development.

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Introduction

A watershed is a geographic region that drains into a common outlet, such as a stream, river, or lake. The common outlet intimately connects the land, water, and activities taking place in the region. Because of this, water quality (the characteristics of water that make it useful for human applications and ecological functioning) may be strongly influenced by human land use within the watershed.

All land-disturbing activities such as agriculture and construction may cause the addition of sediment to water bodies (Lenat and Crawford 1994). Runoff from agricultural lands often adds nutrients, sediments, and toxic chemicals such as pesticides to water, reducing its quality (Frankenberger 2000). However, water quality degradation due to agricultural land use typically does not occur until these lands represent at least 20% land cover, with significant degradation not occurring until approximately 50% land cover (Wang et al. 1997).

Urban development, however, impacts water quality at lower levels of land use. Urban runoff may add nutrients and toxic chemicals (i.e., gasoline) to water bodies (Lenat and Crawford 1994). Most importantly, increasing urbanization comes with increasing impervious surface cover. Impervious surfaces are land cover types that allow little or no infiltration of water into the ground (such as pavement and buildings; Barbec et al. 2002). As these surfaces increase, the amount and velocity of runoff increases, causing more sediments, nutrients, and pollutants to be added into water bodies while also increasing erosion and stream channel changes (Fongers and Fulcher 2002; Barbec et al. 2002; Aldrich and Wyerman 2006). Studies have found water quality degradation to occur with as little as 7-15% impervious surface cover, corresponding to 20-30% urban land use (Barbec et al. 2002; Wang et al. 1997).

Efforts to mitigate these effects have included detention and infiltration ponds and riparian buffers, with mixed success (Barbec et al. 2002). Detention ponds and infiltration setups may reduce water surges by absorbing additional runoff, and may even increase ground water infiltration, but cannot filter and sequester nutrients and toxins as vegetation can (Barbec et al. 2002). Often cited as the panacea of watershed protection, riparian buffers are vegetated areas adjacent to waterbodies. By interrupting the otherwise direct flow of runoff into surface water, these areas help to slow the rate of runoff and decrease erosion while filtering and trapping nutrients, pollutants, and sediments (Guidebook of BMPs 1998; Lowrance et al. 1984; Aldrich and Wyerman 2006). Generally they are between 10-150m wide, but they have been seen to function poorly at less than 30m (Guidebook of BMPs 1998; Lowrance et al. 1984). Moreover, when imperviousness reached 45% in Seattle Washington, riparian buffers ceased to protect the water condition (Barbec et al. 2002). Additionally, water degradation has been found to occur in areas with 100% riparian buffers with as little as 10% imperviousness even where storm water is considered well managed (Barbec et al. 2002; Aldrich and Wyerman 2006). Thus, riparian buffers and mitigation efforts may be less important for water quality preservation than overall land use.

For this reason, open space is often cited as a key to countering the detrimental effects of development. Typically defined as “land not intensively developed for residential, commercial, industrial or institutional use,” this includes everything from agricultural fields, and lawns, to mature forests (DEC OPRHP 2006). The National Land Trust cites that, “it may be best to keep certain areas in a watershed as open space to… protect water quality” (Aldrich and Wyerman

2006). The importance of open space rests on the assumption that it has greater permeability than developed lands, thus being able to counteract the effects of increased urbanization by increasing groundwater infiltration and decreasing erosion while filtering and trapping nutrients, pollutants, and sediments (Guidebook of BMPs 1998; Lowrance et al. 1984; Aldrich and Wyerman 2006). However, not all open space lands are equal with respect to this capacity. Gravel surfaces, bare soil, grassed lawns, and unnatural fields do not have the permeability or capacity to function in these respects as well as mature biotic communities such as forests and wetlands (Barbec et al. 2002). It has been estimated that grass covered lawns and meadows are only about 85% as permeable as mature forests, and that agricultural fields are only about 50% as permeable as mature forests (Frankenberger 2000). In fact, agricultural fields may runoff half as much water as fully impervious surfaces (Frankenberger 2000). Thus, not all open space is valuable for preserving water quality and the maintenance of mature forest and vegetative communities may be the single most effective method of controlling the damages to water quality caused by urbanization. As a general rule, studies have found that areas with good water quality tend to have a minimum of 30% wooded land cover (Kauffman and Brant 2000).

The need for mature biotic communities is changed into the need to conserve such communities by strong developmental pressures. Ecologically important lands in New York State have been degraded and developed in the past due to lack of knowledge or the lack of expectation they would ever be threatened (DEC OPRHP 2006). In order to preserve these biotic communities that are so important for our water quality in the face of increasing developmental pressures, they must be explicitly protected for their natural value and services. With this in mind, this study defines conserved lands as those with permanent protection from conversion to human use and development, and management practices intended to preserve natural system functioning.

These issues are highlighted by the strong developmental pressures in the region of study. Saratoga Lake is a 5.8 square mile body of water in the middle of Saratoga County, New York, U.S.A. The lake is fed by a 210 square mile watershed covering parts of 12 different municipalities mostly to the north and west of the lake. Since it is fed primarily by surface waters, the lake may be particularly prone to the negative effects of development (SLIPID 2002; Aldrich and Wyerman 2006). Over the last 20 years, Saratoga County has been the fastest growing county in the state, with extensive residential and commercial development (Executive Summary 2001). With so much development, the threats to local waters are serious. Increased development in the region seems to be contributing increased phosphorous, sediments, nutrients, and pollutants to the lake at a rate such that the water quality has made only slight improvements in the last 25 years, despite the diversion of municipal sanitary wastes out of the watershed starting in the 1980's (SLIPID 2002). Moreover, the city of Saratoga Springs, Northwest of the lake, is currently deliberating on the possibility of drawing water from Saratoga Lake to supplement its current reservoir (Loughberry Lake), which is believed to be unable to meet future demand (SLIPID 2002). However, if Saratoga Lake is damaged too thoroughly by the effects of human development, expensive water treatment or alternative supplies will have to be considered (Aldrich and Wyerman 2006)

As discussed, previous literature reports that areas with good water quality tend to have less than 50% agricultural lands, less than 15% impervious surfaces, and more than 30% wooded lands (Kauffman and Brant 2000; Wang et al. 1997; Barrios 2000). In addition, water quality issues are of great importance in this region. With this in mind, this study sought to use GIS mapping and legal resources to analyze the conserved lands and vegetation of the region and their implications for current and future water quality.

Methods

First, all lands within the watershed possibly fitting the description of conserved, were selected in GIS (ESRI ArcMap) from Saratoga County tax parcel data (2005). This was done by choosing all parcels with a property class code of 900 of greater (falling into the category "Wild, forested, conservation lands, and public parks") as well as those with the property class description "Park" or "Recreation center."

In addition, interviews were conducted with the New York State Department of Environmental Conservation, Saratoga County Planner's Office, Saratoga Preserving Land and Nature (Saratoga PLAN), the Farmland Trust, and the Wilton Wildlife Preserve and Park to determine if any lands had been missed in the initial GIS search. Further, maps of conserved areas from the 2000 New York Gap Analysis Project (NYGAP) and the 2000 World Database on Protected Areas (WDPA) were also used to verify and expand upon the initial tax parcel search.

Once all of these lands were mapped, the conservation status and restrictions on use were then determined for each of the property classes represented using New York State laws and metadata from NYGAP stewardship file (2000).

A map of vegetation cover was created for the watershed from United States Geological Survey 2001 land use data. The land cover categories were simplified from 15 initial classes to 5 more general classes (water, developed, agricultural, forested, shrubby/herbaceous growth; See Appendix B). This map was then overlaid on the watershed and on each conserved land parcel to analyze the different patterns of land cover.

Results

The first search through GIS yielded 191 possibly conserved parcels (of 29,272 total parcels) within the watershed (Appendix A, Figure 1). These fell under the following categories: private park (0.42 square miles), government park (0.63 square miles) , cultural and recreational (3.16 square miles), private forest (6.49 square miles), and government forest (2.82 square miles; Table 1 and Figure 1).

Table 1: Area of Potentially Conserved Parcels by Property Class

Property Class	Square Miles	Percentage of Watershed
Private Parks	0.42	0.20
Government Park	0.63	0.30
Cultural and Recreational	3.16	1.50
Private Forest	6.49	3.09
Government Forest	2.82	1.34
Total	13.52	6.43

The laws underlying each of these land uses were used to determine if they would be classified as conserved. Private parks are not subject to any legal land use restrictions. In fact, all of the private parks in the watershed are simply lawn or partially forested areas maintained for housing developments.

Government parks are managed under the same guiding principles as cultural and recreational lands: "to conserve, protect and enhance the natural, ecological, historic, cultural and recreational resources contained therein and to provide for the public enjoyment of and access to these resources in a manner which will protect them for future generations" (PAR 3.02). Thus, there is a split in priorities between conservation and human recreation on these lands, which allows the creation of museums, art galleries, nature trails, bike paths, and other developments handicapping the natural services of the lands, and disqualifying them from the conserved category (Assessor's manual 2006).

The private forest classification reflects all privately owned, forested lands that do not fit any of the other classifications (Assessor's manual 2006). These may include tree plantations and timber tracts, so inclusion in this category is not enough to prove or disprove a conserved status. (Assessor's manual 2006).

Government forests are broken into two categories. State owned land within the Adirondack Forest Preserve is limited in its use: such land may not be harvested for timber, used for agriculture, built upon, or bought from the state (ENV 9-0303). Thus, these lands will be considered conserved. There are 4 such parcels in the most northwestern extension of the watershed, where the Adirondack Park boundary just crosses through the watershed. Most other state forest, however, may be subject to a variety of uses. Many are open to timber harvest (RPT s480; ENV 9-0501), others for recreation (ENV 9-0501), others for reforestation, watershed protection, or conservation, and these uses are subject to change over time (ENV 9-0501). Like private forests, these lands could not be immediately categorized as conserved or not.

To determine which of these lands specifically were conserved, I compared my possible parcels to NYGAP and WDPA stewardship information. The parcels designated conserved in these data were used to pare down my preliminary conserved lands from the tax parcel searches. This resulted in a total of 54 parcels with significant conservation status accounting for 3.64 square miles (1.7%) of the watershed.

The NYGAP system of classifying conserved lands was used for the government owned lands**,** so these results may be standardized and more easily comparable across studies. This system uses rankings from 1-4 to describe conservation status. Class 1 lands, the most conserved, have permanent protection from development and management plans in operation and prohibit activities that would cause anthropogenic disturbance of the land (or anthropogenic interruption of natural disturbance) (NYGAP 2000). There are no lands of this class in the watershed. Class 2 lands have permanent protection from development and management plans in operation for at least 90% of the land, but may receive uses or management practices that degrade the quality of natural communities (NYGAP 2000). There are four parcels of this class in the watershed (totaling 0.31 square miles), all of which are in the northwest most section where the Adirondack Park boundary crosses though the watershed. Class 3 lands have permanent protection for the majority of the area but are subject to extractive uses of a broad, low-intensity type (i.e., logging) or local, high-intensity type (i.e., mining) (NYGAP 2000). There are 8 such parcels in the watershed (totaling 3.33 square miles), concentrated in two main groups in the southwest corner of Greenfield.

To these parcels, I added conservation easements from the organization Saratoga PLAN, due to their known conservation status but lack of appearance in any of the previous methods. There are 27 such parcels in the watershed, covering 1.4 square miles. These are lands covered by legal agreements between the owners and Saratoga PLAN, to maintain the land for the conservation of its natural value (SPNHF 1997). Most development and disrupting activities are restricted on the lands, and the restrictions are binding for future owners (SPNHF 1997). Thus, these lands will be considered conserved. The rest of the land in the Saratoga Lake watershed falls under class 4: lands with no known public or private restrictions to prevent anthropogenic development or disturbance (NYGAP 2000).

Overall, this process yielded a total of 81 conserved parcels accounting for 4.82 square miles (2.29%) of the 210.48 square mile watershed (Appendix A, Figure 2). Of the entire watershed, 69.57 percent is forested, 13.87 percent is developed, 12.34 percent is agricultural, 3.34 percent is open water, and 0.88 percent is shrubby/herbaceous low growth (Table 2;

Appendix A, Figure 3). Of the conserved lands, 0.4% is open water, 2.31% is developed, 94.60% is forested, 0.58% is low growth, and 2.10% is agricultural (Table 3). Perhaps the most relevant statistic, 2.17% of the watershed (4.56 square miles) is both conserved and forested (Table 3).

Table 2: Area of Land Cover Types In Watershed

Land Cover	Area (mi^2)	Percent of Watershed
Shrubby/Herbaceous	1.85	0.88
Open Water	7.03	3.34
Agriculture	25.98	12.34
Developed	29.19	13.87
Forest	146.42	69.57

Table 3: Area of Land Cover Types In Conserved Lands

Land Cover	Area (mi^2)	Percent of Conserved Lands
Open Water	0.02	0.40
Shrubby/Herbaceous	0.03	0.58
Agriculture	0.10	2.10
Developed	0.11	2.31
Forest	4.56	94.60

Discussion:

These results indicate that the current threat to our water quality is low because we have low urban land cover and high forest cover. 13.87% of the watershed is developed land (Table 2). As mentioned, significant water quality degradation due to urban development typically does not begin until approximately 20-30% urbanization (7-15% imperviousness; Barbec et al. 2002; Wang et al. 1997). Moreover, 69.57% of the watershed is currently forested land (Table 2). Since water quality degradation typically occurs in areas with <30% forested lands, it is likely our high area of forest is more than enough to counter the ill effects of increasing development

(Kauffman and Brant 2000). Overall, these results indicate that the low level of urbanization and high level of forestation probably mean our water is not significantly compromised on a watershed scale.

However, our water quality may not be sustained in the future given the high rate of growth in the county and lack of conserved lands within the watershed. With the fastest growth rate in the county, it is important that current forest lands are protected from future development. For example, a large portion of the 69.57% of the watershed that is forested is zoned for other purposes (such as residential) and has a high possibility of being developed (Quentin and Siegwarth 2007). Meanwhile, 4.82 square miles (2.29%) of the watershed is conserved from future development (Table 3). Of the 4.82 square miles, 94.60% is forest, meaning that the appropriate type of land is being conserved for the maintenance of water quality. However, this indicates that only 4.56 square miles (2.17%) of the watershed is conserved forest. This is immensely important because this number is far too low to provide significant protection of water resources if human development continues.

To ensure water quality protection for the future, mitigation efforts should be continued, and forests should be maintained. To mitigate the effects of water quality degradation, efforts such as storm water management, riparian vegetation, detention ponds, and infiltration ponds should be used. Even though these have been mentioned to have mixed results, used in conjunction they are likely to produce measurable improvement. Most importantly, forest lands should be conserved from human development and disturbance. This may be done in a number of ways. The government may purchase lands and preserve them as parks and forests. Individuals and land trusts may increase the number of conservation easements. Finally, restrictions may be needed on the use of private property. While this final proposition would certainly come against strong opposition, it may be one of the only options to protect water quality in the future if lands are not conserved beforehand.

Further research should be conducted on a number of related issues. First, wetlands are critical areas for permeability and water quality protection. These areas were excluded from my analysis due to discrepancies in the 2001 USGS land cover data, bringing into question their mapping of wetlands. However, the distribution and importance of these lands within the region should be studied in the future. Moreover, the distribution, composition, and importance of riparian buffers within the watershed should be evaluated, since these may also be important in water quality preservation. Impervious surface cover and importance should also be studied. Finally, the specific conservation plans for each parcel should be researched so our knowledge of the conserved lands is more thorough.

Finally, it is important to consider that the results of this study should only be interpreted on a watershed scale. For instance, this study indicates the watershed is not likely experiencing significant water quality degradation since urbanization is less than 15%. However, the city of Saratoga Springs likely has urbanization well in excess of 15%, and its local waters may be experiencing degradation due to its development. Thus, this report is not intended for analyses below the watershed level.

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Appendix A: Figures

Figure 1: Possibly Conserved Parcels

Figure 2: Conserved Parcels

Figure 3: Watershed Land Cover

Appendix B: Data

Table 1: Condensing USGS Land Cover Classifications for the Entire Watershed

USGS Classification	My Classification	Sq Miles	Subtotals by Common Class
Open Water	Open Water	7.03	7.03
Low Intensity Residential	Developed	17.25	29.19
High Intensity Residential	Developed	8.58	
Commercial/Industrial/Transport	Developed	2.36	
Otherwise Developed	Developed	1.01	
Bare rock/sand/clay	Forest	0.15	146.42
Deciduous	Forest	36.04	
Evergreen	Forest	29.47	
Mixed forest	Forest	16.58	
Shrub	Other Veg	0.82	1.85
Grassland/Herbaceous	Other Veg	0.20	
Pasture/hay	Ag	12.11	25.98
Row crops	Ag	13.87	
Woody Wet	Forest	64.19	
Shrubby Wet	Other Veg	0.82	