

# New York City Watershed Forestry Research

## Annotated Bibliography

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## **Purpose**

For more than 20 years, the New York City Watershed (“Watershed”) has been a model for cities around the world about ways to manage their water supplies for clean water and viable rural economies. As a model, the Watershed has both funded and attracted significant research attention, particularly for the way it manages its forests.

The purpose of this bibliography is to provide in one location a list of all forestry-related Watershed research. The list includes research funded by the Watershed Agricultural Council (WAC) Forestry Program as well as projects that used the Watershed region as their research focus.

An annotated bibliography does more than list papers. Each citation includes a brief description of the study, its findings, and how it impacted Watershed forest management.

This bibliography is a living document. Both the list and annotations can and should grow and change over time. New research projects will come out, and old studies may spur new management approaches.

By its nature, forest research is long-term. Projects take months or years to complete. Even when a study is finished, its full impacts may not be felt at the implementation level until years later. Field work to evaluate Watershed timber harvests occurred as far back as 2002. Yet it was only in 2013 that WAC staff were able to translate those results into the business plans that overhauled the Watershed Forest Management Plan Program to focus on 480-a and MyWoodlot.

This annotated bibliography is much more than a list. It is a quick reference to remind staff, funders, and Watershed stakeholders not only of the impacts Watershed research has already had, but the potential impacts it could have in the future.

## Definitions

***Peer-Reviewed Articles*** – These papers were published in scientific journals and went through the peer-review process. In this process, other professional researchers with expertise in a paper’s topic evaluate the paper for scientific rigor and relevance to the journal’s audience. Authors can make changes to their articles based on the reviewers’ feedback. Only if the reviewers deem the article acceptable can it be published in the journal. Reviewers are not compensated for providing reviews, and reviews are anonymous for both authors and reviewers.

***Literature Reviews*** – As part of the WAC Forestry Program’s contract with SUNY-ESF, Forestry Program staff can request that the Model Forest Coordinator complete literature reviews on specific topics. In contrast to other areas of this bibliography, literature reviews typically do not involve original research. Rather, they summarize existing research on a topic. The Forestry Program uses these reviews when it needs to quickly come up to speed on an emerging topic or potential new program offering.

***Reports*** – Reports include internal research papers, commissioned studies, and other organizational publications that do not go through a third-party publisher. Because a great deal of the research that occurs in the Watershed is targeted to this region, the outcomes from that work are frequently too narrow in scope for traditional scientific journals to publish. This is particularly true for staff-driven research, which typically applies existing peer-reviewed methods to the Watershed. Such research is of immense value to the Watershed, but offers little new to the broader scientific community that would make the research worthy of publication in a journal. Critically, although reports do not go through formal peer review or publication, WAC staff aspires to perform the research that fuels reports such that it could pass peer review if submitted for publication.

***Theses & Dissertations*** – Theses and dissertations are the papers written by Master’s and PhD candidates (respectively) as requirements for their degrees. They do not go through peer review, but they are reviewed by the student’s committee of professors. They often become condensed into peer-reviewed papers in the future.

***Other*** – Other provides a catch-all for research papers related to NYC Watershed forestry that do not fit cleanly into any of the above four categories. Examples include papers that did not go through formal peer review, such as an article in the proceedings of a conference or an opinion piece in a scientific journal.

***Additional Resources*** – These are peer-reviewed articles that have only ancillary connections to NYC Watershed forestry. The research occurred in the Watershed, and the studies focus on water quality, land use, and regional socioeconomic issues. However, they do not address Watershed forestry specifically. They are included at the end of the bibliography for reference, but annotations are not provided for them.

## Explanation of Symbols



The research field work took place on a Watershed Model Forest.



The research was conducted by the State University of New York – College of Environmental Science and Forestry (SUNY-ESF) in partnership with the WAC Forestry Program.



WAC funded the research, which was carried out by a third-party contractor *other than* SUNY-ESF.



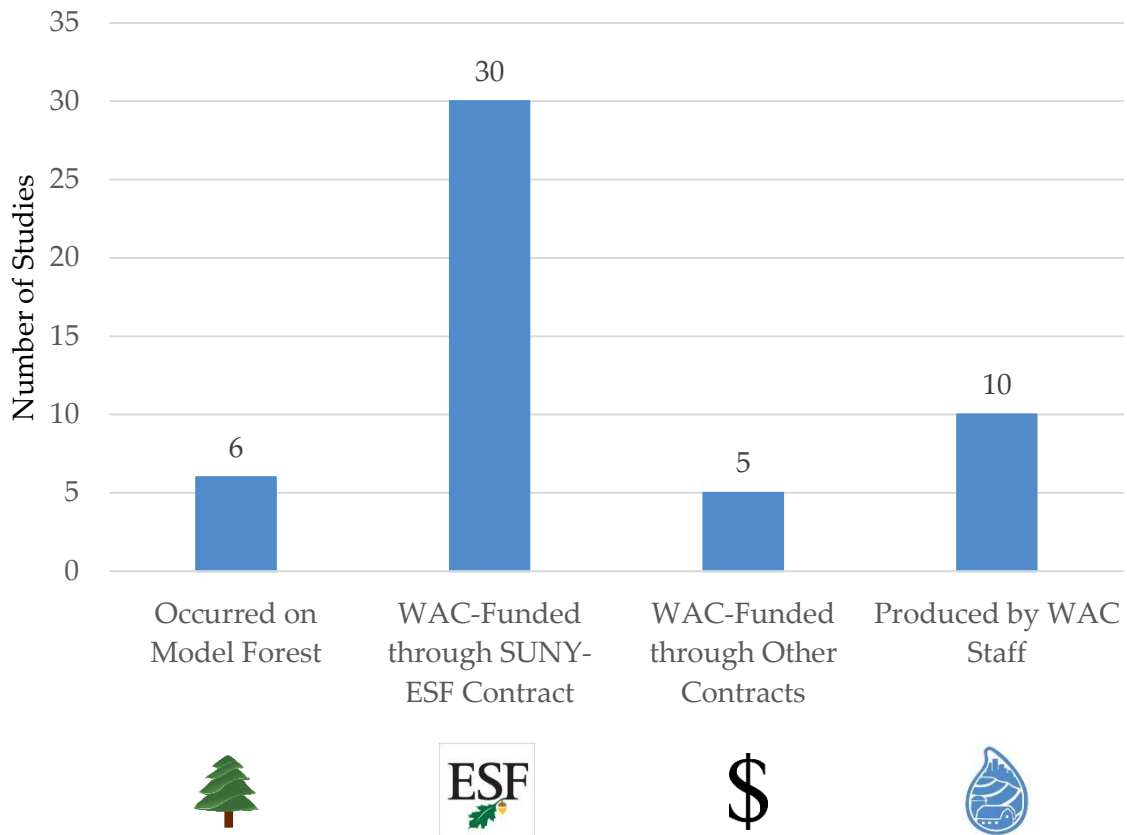
WAC staff conducted the research and wrote the referenced article.

## Summary of Article Types

### *Summary of Watershed Forestry Research*

Article Type	Number of Pieces
Peer-Reviewed Articles	25
Literature Reviews	8
Reports	13
Theses & Dissertations	7
Other	4
Additional Resources	22
<b>Total</b>	<b>79</b>

### *Summary of WAC-Connected Research*





## Quick-Reference Bibliography

(Digital Users: Ctrl+Click on an Entry to Go to Its Description)

- Anderson, N.M., R.H. Germain, and M. Hall. 2012. An Assessment of Forest Cover and Impervious Surface Area on Family Forests in the New York City Watershed. *Northern Journal of Applied Forestry* 29(2): 67-73.
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## Peer-Reviewed Articles

1. Anderson, N.M., R.H. Germain, and M. Hall. 2012. An Assessment of Forest Cover and Impervious Surface Area on Family Forests in the New York City Watershed. *Northern Journal of Applied Forestry* 29(2): 67-73.

**Description:** This project combined field measurements with aerial photos to quantify forest cover and impervious surface area on new parcels created through subdivision. It then compared the amount of impervious surface on subdivided vs. intact parcels. It included what has become a critical figure for the NYC Watershed: that each subdivided parcel adds on average an extra 300 square meters (3,200 square feet) of impervious surface within 20 years of division.

**Impact:** This article made the critical connection between parcelization and development. As a result, it has become a core argument for why the Forestry Program focuses on 480-a as a tool that can slow subdivision and therefore impervious surface growth in the Watershed.

2. Burns, D.A. and P.S. Murdoch. 2005. Effects of a Clearcut on the Net Rates of Nitrification and N Mineralization in a Northern Hardwood Forest, Catskill Mountains, New York, USA. *Biogeochemistry* 72(1): 123-146.



**Description:** This USGS study used weirs at Frost Valley Model Forest to assess how clearcut harvesting affected nitrogen delivery to streams. The study found that nitrogen in streams went up after the harvest, likely caused by the loss of plants to uptake nitrogen. Nitrate concentrations increased from 20 micromoles/liter before the harvest to 100 micromoles/liter afterward, an unprecedented amount for that site. The nitrate declined to 90 micromoles/liter within 3 years of the harvest, but it remained above nitrate concentrations in uncut areas.

**Impact:** This article reinforced that clearcutting can have negative water quality impacts when done close to streams (this cut did not leave a riparian buffer). However, this article, in combination with two other Frost Valley studies (Wang et al. 2006, Passhaus et al. 2004), together found that partial harvesting can occur with minimal water quality impact. This is good news for the working landscape in the NYC Watershed, as partial harvests are far more common in the region than clearcuts.

3. Caron, J.A., R.H. Germain, and N.M. Anderson. 2012. Parcelization and Land Use: A Case Study in the New York City Watershed. *Northern Journal of Applied Forestry* 29(2): 74-80.

**Description:** This corollary project to Anderson et al. (2012) looked at how subdivision and development impact timber harvesting and water quality. The researchers surveyed owners of subdivided and intact family forest parcels. They also used field data on forest stocking collected in the Watershed. The study found that landowners with large parcels (>50 acres) had significantly higher water quality awareness than owners of small parcels. They also found that full-time residents were more likely to engage in practices that negatively impact water quality such as adding structures and driveways and using lawn additives.

**Impact:** This project found no difference in forest stocking between landowners with and without management plans. Of all its findings, this finding had the greatest impact in the Forestry Program, as it was one more piece of evidence that forest management plans were not resulting in better on-the-ground stewardship.

4. Germain, R.H., C. Pinkoski, and E. Bevilacqua. 2016. Parcelization and Land Use Change in the Rural Residential Landscape of the Catskill Region in New York State. *Journal of Conservation Planning* 12(2016): 29-40.

**Description:** This project updated the work from LaPierre and Germain (2005) by documenting parcelization from 2004 to 2010. Parcelization continued in the Watershed through the Great Recession. Average parcel size declined from 13.9 to 13.1 acres. This is a slower per year rate than LaPierre and Germain (2005) found (0.13 acres/year vs. 0.19 acres/year), but parcelization remains an issue in the Watershed. The paper concluded that because parcelization continued despite the Watershed's outreach, extension, and easement efforts, stronger tools like land-use zoning might be needed to ensure water quality protection and the region's rural character into the future.

**Impact:** The Forestry Program has not made specific changes based on this article, but the study reinforces the need for continued efforts to challenge parcelization.

5. Germain, R.H., N. Anderson, and E. Bevilacqua. 2007. The Effects of Forestland Parcelization and Ownership Transfers on Nonindustrial Private Forestland Forest Stocking in New York. *Journal of Forestry* 105(8): 403-408.

**Description:** This study completed forest inventories on 137 family forest woodlots in Delaware County. The study sought to understand how parcelization affected forest stocking, given anecdotal evidence that land transfers are often associated with

liquidation harvests. The study found that organized subdivisions were associated with lower forest stocking and poorer-quality residual stems. By contrast, there was no relationship between land tenure and forest stocking or quality. The authors concluded that their study “does not provide a ‘smoking gun’ in support of the general perception that liquidation cuts before parcelization and property transfers result in lower-quality residual stands when compared with management practices under more static ownership regimes.”

**Impact:** The Forestry Program has not made specific changes based on this article. However, it does reinforce the Forestry Program’s decision not to focus on silviculture per se as an extension objective. Rather, the Program focuses on access system BMPs as well as limiting subdivision to reduce development. These areas are more problematic for water quality than the particular trees removed in a logging operation.

6. Germain, R.H., J.F. Munsell, and K. Brazill. 2007. The New York City Watershed Model Forests Revisited Five Years Later: An Assessment of Successes, Failures, and Challenges for the Future. *Journal of Extension* 45(3). Available online at: <https://www.joe.org/joe/2007june/a6.php>.



**Description:** This project evaluated the successes and failures of the Model Forest Program after seven years of operation. The paper discussed work that occurred at Lennox and Frost Valley Model Forests as well as the challenges faced by proposed model forests at Nimham Mountain and Mink Hollow. A survey of model forest event attendees conducted for the study found attendees overwhelmingly valued the education and the applied, “outdoor classroom” concept the model forests provide.

**Impact:** This article provided an early evaluation of one of WAC’s programs and found that overall the model forests that had been established at that time were successful educational venues.

7. Germain, R.H. and J.F. Munsell. 2005. How Much Land Is Needed for the Harvest Access System on Nonindustrial Private Forestlands Dominated by Northern Hardwoods? *Northern Journal of Applied Forestry* 22(4): 243-247.



**Description:** This project involved assessing the area used for landings, skid trails, and forest roads on Watershed timber harvests. The study found that the average area disturbed was 6% with a range of 3 to 13%. By contrast, BMP guidelines suggest the area disturbed should range from 10 to 15%.

**Impact:** This article helped the Forestry Program better understand skid trail layout for timber harvests. It revealed a surprising finding, which was that minimizing disturbance does not necessarily minimize water quality impacts. A longer, flatter road or trail can have less erosion than a shorter but steeper one.

8. Germain, R.H., J.J. Schwartz, and J. Parrish. 2001. Developing the New York City Watershed Model Forests: Working Laboratories to Study and Demonstrate Sustainable Forestry. *Journal of Extension* 39(2). Available online at: <https://www.joe.org/joe/2001april/iw2.php>.



**Description:** This article explained the background of the Model Forest Program as well as the concept behind the “outdoor classroom” approach to teaching landowners, foresters, and loggers about forest stewardship. The article laid out the basic components of what a model forest includes: forest monitoring, research, demonstration, and outreach.

**Impact:** This article made the case for the NYC Watershed Model Forests, which were just beginning their development at that time. Today we have four Model Forests across the region that annually educate thousands of students and landowners about forests, forestry, and their connection to clean water.

9. Homyak, P.M., R.D. Yanai, D.A. Burns; R.D. Briggs, and R.H. Germain. 2008. Nitrogen Immobilization by Wood Chip Application: Protecting Water Quality in a Northern Hardwood Forest. *Forest Ecology and Management* 255: 2589-2601.



**Description:** This study was conducted at the Frost Valley Model Forest. It involved an area that was patch clearcut. The researchers spread woodchips in varying amounts over several areas of the harvest, then monitored soil movement of nitrogen compounds and potassium chloride. The study found that areas with woodchips mobilized nitrate at a rate 25% of areas without them. Potassium chloride movement in woodchip areas was only 13% of non-woodchip ones. They concluded that woodchip application at a rate equivalent to the amount of slash smaller than eight inches in diameter could immobilize between 19 and 38 kilograms of nitrogen per hectare in the first year after



harvesting. The authors suggested that the application of woodchips following harvesting operations warranted additional research as a potential new BMP in regions with elevated atmospheric nitrogen deposition.

**Impact:** None at this time. Follow-up conversations with the authors of this paper revealed that although woodchips were effective at reducing nitrate mobilization after timber harvests, the practice itself was so impractical and expensive that they could not see it becoming a recommended BMP.

10. Kelly, M.C., R.H. Germain, and S. Bick. 2017. Impacts of Forestry Best Management Practices on Logging Costs and Productivity in the Northeastern USA. *Journal of Forestry*. In Press.



**Description:** This study was conducted at WAC's request because of concerns about whether the Forestry Program's BMP cost-share rates were appropriate. The study involved two phases. In one phase, the researchers assessed logging costs on the ground for eight harvests. In the second phase, the researchers used a survey to assess costs on a hypothetical harvest both with and without BMPs. The study found that BMP costs and productivity losses vary tremendously by operator skill and crew size, with the highest costs for loggers who work by themselves. BMP costs varied from \$0/acre to \$62/acre, and productivity decreases varied from 0% to 20%.

**Impact:** This project gave the Forestry Program, for the first time ever, region-specific cost figures for installing BMPs. More important, the study confirmed that the Forestry Program's BMP rates were appropriate, matching nearly dollar for dollar with the costs determined in the study. Moreover, loggers with the TLC Incentive can earn a small profit installing BMPs for WAC.

11. Kelly, M.C. and R.H. Germain. 2016. Is It Efficient to Single-Handedly Run a Multi-Machine Harvesting Operation? A Case Study from the Northeast United States. *International Journal of Forest Engineering* 27(3): 140-150.



**Description:** This case study examined three single-logger operations to assess their harvest costs and productivity. The loggers chosen all had Trained Logger Certification

and more than 20 years of experience. The study found that although adding workers increased labor costs, overall costs per unit of production went down. System productivity increased between 77% and 145% when additional loggers were added, while costs per cubic meter of wood decreased by as much as 28%. The study concluded that from a business perspective, it makes sense for single-logger operations to consider adding another logger or two to their crew.

**Impact:** Many NYC Watershed loggers operate alone, and this study revealed the challenges they face in making a profit. This study, along with related papers, helped inform the cost-share rates for WAC's BMPs as well as WAC's logger viability efforts such as logger training and the promotion of the Planning and Analysis in Timber Harvesting software.

12. Kelly, M.C., R.H. Germain, and S.A. Mack. 2016. Forest Conservation Programs and the Landowners Who Prefer Them: Profiling Family Forest Owners in the New York City Watershed. *Land Use Policy* 50: 17-28.



**Description:** This study expanded on Kelly et al. (2015) (see below). It went beyond that study's survey and conducted focus groups with landowners to better understand their preferences for conservation easement programs and identify potential barriers to participation. The study found that landowners overall had a lack of knowledge about conservation easement programs, reluctance to burden their children with land restrictions, concerns for resale values and tax assessments, and a "simmering animosity towards New York City's watershed management efforts." At the same time, landowners do support preserving the region's natural landscape and character, and some view easements as a way to meet that goal. Only 25% of respondents listed the amount of the program payment as the most important factor in their participation decision. The study offered potential strategies to increase enrollment in conservation programs, including: 1) marketing amenity benefits such as wildlife habitat; 2) offering multiple programs with more flexible contract terms; 3) offering a one-time "opt out" clause only exercisable by heirs at the time of inheritance; 4) simplifying programs to make them easier for landowners to understand; 5) providing a strong outreach and education effort; 6) emphasizing legacy and estate planning in education; and 7) providing individual consultation on legacy planning.

**Impact:** None at this time.

13. Kelly, M.C., R.H. Germain, and S.V. Stehman. 2015. Family Forest Owner Preferences for Forest Conservation Programs: A New York Case Study. *Forest Science* 61(3): 597-603.



**Description:** This study was conducted at WAC's request because of WAC proposals to pilot either a Forest Easement or Forest Bank Program in the Watershed. The researchers surveyed landowners about their willingness to enroll in four simulated programs. The programs varied based on the rights conveyed, the amount of payment, and the length of the contract commitment. The study found that expected enrollment rates in the Forest Bank Program were extremely low because landowners did not want to give up control of how timber was harvested on their properties. By contrast, traditional easements had much higher projected enrollments, as high as 15%.

**Impact:** This project confirmed that the Forest Easement, and not the Forest Bank, was the correct program for WAC to pursue. WAC's Forest Easement Program is now closing on its first easements and appears poised to move beyond a pilot into a long-term program.

14. LaPierre, S. and R.H. Germain. 2005. Forestland Parcelization in the New York City Watershed. *Journal of Forestry* 103(3): 139-145.

**Description:** This project assessed the change in parcel sizes in the Watershed from 1984 to 2000. The project found that average Watershed parcel size declined from 17.6 acres in 1984 to 14.5 acres in 2000. The 14.5 acre figure was 10 acres below the national average parcel size at that time. The project also found that the pace of parcelization in the Watershed exceeded the national average.

**Impact:** This seminal article was an early force driving attention to the problem of parcelization in the New York City Watershed. It identified the problem of "single homes with big backyards" that are neither economically viable for timber management nor advantageous for water quality protection.

15. Munsell, J.F., R.H. Germain, V.A. Luzadis, and E. Bevilacqua. 2009. Owner Intentions, Previous Harvests, and Future Timber Yield on Fifty Working Nonindustrial Private Forestlands in New York State. *Northern Journal of Applied Forestry* 26(2): 45-51.



**Description:** This study came about as a byproduct of John Munsell’s evaluation of sustained yield management in Watershed timber harvests. The study combined the field data collected for the sustained yield management work with landowner interviews about the harvest choices they’d made and why. The study found that although “nearly all owners plan to manage for a sustained yield of sawtimber,” exploitative harvesting (e.g., high-grading and diameter-limit cutting) were overwhelmingly the types of harvests that actually occurred. Moreover, the article concluded that in order for most of these landowners to achieve a goal of sustained yields, they would need to regenerate their woods or convert to uneven-aged management, practices that were entirely absent from the study.

**Impact:** This study indicated that Watershed landowners overall want to do right by their land, but still harvest exploitatively. The article reinforced the problem a lack of low-grade wood markets creates: landowners can’t manage sustainably even if they want to because sustainable forestry is not economically viable in the Watershed. This study also called out the absence of Watershed regeneration harvests. Although this issue has since been well discussed in other papers and meetings, as of this writing the Watershed has made no formal programmatic effort to encourage more regeneration cutting.

16. Munsell, J.F., R.H. Germain, and I.A. Munn. 2008. A Tale of Two Forests: Case Study Comparisons of Sustained Yield Management on Mississippi and New York Nonindustrial Private Forestland. *Journal of Forestry* 106(8): 431-439.



**Description:** This study compared the sustained yield management logging practices (or rather, the lack thereof) in the Watershed with those in Mississippi. The study combined field measurements of recent timber harvests with interviews of the landowners. The study made use of 5 criteria to determine sustained yield management, a system later expanded by Josh VanBrakle’s thesis work to 7 criteria. Overall the study found that sustained yield management was not occurring in the Watershed, and regeneration harvests were completely absent from the Watershed sample compared with the Mississippi sample. The study concluded that long-term timber supply in the Watershed is hampered because of premature cutting, overthinning, and diameter-limit cutting.

**Impact:** Apart from its conclusion that Watershed forests are not managed sustainably, the article made a key point about why poor management abounds. Both Mississippi and Watershed landowners had similar groupings of landowners based on the National Woodland Owner Survey’s four types of owners, with the Watershed having slightly

more amenity-focused owners. The study made the key implication that landowner knowledge and traits are less important for influencing sustained yield management than the broader context those landowners operate in, such as the lack of low-grade markets in the Catskills. Like other studies to come out of John Munsell's PhD work, "Tale of Two Forests" led the Forestry Program to pursue regional woody biomass opportunities.

17. Munsell, J.F. and R.H. Germain. 2007b. Woody Biomass Energy: An Opportunity for Silviculture on Nonindustrial Private Forestlands in New York. *Journal of Forestry* 105(8): 398-402.



**Description:** This study came about as a byproduct of John Munsell's evaluation of sustained yield management in Watershed timber harvests. The study combined the field data collected for the sustained yield management work with silvicultural simulations to assess how a biomass market could improve Watershed forestry. The study found that when looking at Catskills timber harvests, an average of 6.75 oven-dried tons per acre of woody biomass could have been removed alongside a sustainable volume of sawtimber. The result would have been larger, higher-quality stock remaining in the forest and an economically viable harvest compared with the exploitative cuts that did happen.

**Impact:** This study suggested that woody biomass could provide a low-grade market that would help landowners manage their woods more sustainably. This argument encouraged WAC to pursue biomass prefeasibility studies for regional facilities including businesses, schools, and offices. Those studies in turn led to new biomass systems at two facilities: Catskill Craftsmen and Frost Valley YMCA.

18. Munsell, J.F., R.H. Germain, E. Bevilacqua, and R.M. Schuster. 2006. Voluntary Best Management Practice Implementation by Nonindustrial Private Forestland Owners in New York City's Water Supply System. *Northern Journal of Applied Forestry* 23(2): 133-140.



**Description:** This article was part of John Munsell's Master's research that investigated BMP use in the Watershed. This article focused less on the actual measuring of implementation (for that, see Munsell and Germain 2007 under "Other"). Instead, this

article discussed the diffusion of innovations model as it relates to BMPs. Specifically, it looked at whether landowners' awareness of BMPs translated into greater BMP use. The article concluded that although the Watershed relies on volunteerism over regulation for BMP use, "managers have made great strides and the system stands today as an example of successful urban-rural collaboration." At the same time, however, the study concluded that landowner attitudes and knowledge of BMPs appeared to be decoupled from BMP implementation. The article noted that BMP use often did not depend on the landowner's decision but rather the skill and willingness of the logger.

**Impact:** This article revealed what has since become standard practice for WAC's BMP Program: focus on loggers over landowners. Loggers are the ones making decisions on the ground, and by working directly with loggers, WAC gets better BMP results. Even if WAC educates landowners about BMPs, the decision to install them and the quality of that installation hinge on the loggers' skill and willingness to use BMPs.

19. Munsell, J. and R. Germain. 2004. Forestry Extension Participation and Written Forest Management Plan Use in New York City's Water Supply System. *Journal of Extension* 42(2). Available online at: <https://www.joe.org/joe/2004april/rb7.php>.



**Description:** This project surveyed landowners to see if there was a relationship between participation rates in forestry extension programs (workshops in this case) and the rate of management plan adoption. The study found that those who attended a forestry workshop were more likely to have a management plan. The study also found that 21% of Catskill/Delaware family forest owners had a written management plan, a much higher rate than New York State or the country overall. However, 84% of respondents did not participate in any extension programs during the year prior to the survey, suggesting room to expand programming to reach more people.

**Impact:** This article reinforced the value of outreach (workshops, in this case) as a tool to drive program participation.

20. Schuler, J.L. and R.D. Briggs. 2000. Assessing Application and Effectiveness of Forestry Best Management Practices in New York. *Northern Journal of Applied Forestry* 17(4): 125-134.



**Description:** This project evaluated 42 BMPs on 61 timber harvests in the Catskills and 53 harvests in the Adirondacks between 1997 and 1998. It was the first study to evaluate BMPs in the NYC Watershed. The study found that BMP implementation was 78% for haul roads, 87% for landings, 59% for skid trails, 88% for equipment maintenance/operation, and 73% for buffer strips. The study found that the most common BMPs not found were water diversion devices like waterbars. The study advised more emphasis on these practices in particular. The study also found that where BMPs were used, they were effective. In the Catskills, 27 of the 33 BMPs tested showed a statistically significant relationship between BMP application and prevention of sediment movement. Moreover, imperfect application of BMPs reduced their effectiveness. The study found, for instance, that road drainage structures generally failed to adequately control erosion when spacing between them was excessive.

**Impact:** This study came out around the time the Forestry Program's BMP Program was being developed. Although this study did not inspire the BMP Program, it helped inform that program's development.

21. Siemion, J., D.A. Burns, P.S. Murdoch, and R.H. Germain. 2011. The Relation of Harvesting Intensity to Changes in Soil, Soil Water, and Stream Chemistry in a Northern Hardwood Forest, Catskill Mountains, USA. *Forest Ecology and Management* 261: 1510–1519.



**Description:** This project expanded on other studies at Frost Valley Model Forest that examined how different harvest intensities affected water quality. The study examined harvests that removed 22%, 28%, and 68% of the basal area. They then looked at how those harvests affected aluminum, calcium, and nitrate concentrations in soil extracts, soil water, and surface water. They also compared those values against previous studies that looked at a clearcut and a 40% removal harvest. The study found that in the lower-intensity harvests, all three solutes returned to pre-harvest concentrations in soil water and stream water in 2-3 years. It took 3 years for the 68% harvest to return to normal solute concentrations. Overall, the study concluded that when harvests were below 40% basal area removal, the effects on aquatic ecosystems were minimal and short-term. However, as removal increases to 68% and beyond, those impacts become greater and last longer.

**Impact:** This study reinforced the findings of other Frost Valley studies like Wang et al. (2006) that found that lower-intensity harvests of the kind most commonly used in the NYC Watershed have minimal water quality impacts (provided BMPs are used on the access system). It and other Frost Valley studies helped inform a conclusion in WAC's



GIS analysis of timber harvesting (VanBrakle and Pavlesich 2017) that the cutting of trees specifically is not a water quality threat in the NYC Watershed.

22. Stone, R.S. and M.L. Tyrrell. 2012. Motivations for Family Forestland Parcelization in the Catskill/Delaware Watersheds of New York. *Journal of Forestry* 110(5): 267-274.

**Description:** This project surveyed landowners who had subdivided and sold land as well as landowners of intact parcels. The goal was to determine why landowners subdivide. The study found that financial pressure was the dominant reason landowners subdivided. Those who subdivided had lower incomes, less formal education, and were more likely to be retired or have “blue collar” jobs like farming and construction. Nearly 50% had annual household incomes below \$50,000, compared with 20% for landowners who hadn’t subdivided. By contrast, development pressure wasn’t important. Less than 10% of subdividing landowners cited “a great offer” as a top-three reason why they sold land. Half of subdividing owners reported that lower property taxes would have been important in preventing their decision to sell. Unfortunately, 54% of subdividing landowners had no idea cost-saving programs like 480-a exist. The authors wrote that their findings were “indicative of an apparent communication problem” with programs like 480-a.

**Impact:** This article has become a cornerstone piece for the Forestry Program. The article revealed for the first time that the primary driver of Watershed subdivision (and therefore development, per Anderson et al. 2012) was financial pressure, specifically from property taxes. The article also revealed a lack of awareness of 480-a. The article made several policy recommendations, among them a switch from traditional assistance programs like management plans and toward “addressing [landowner] financial needs...through tax abatements for protecting and conserving forests.” The Forestry Program has adopted this recommendation by switching from funding management plans to helping landowners get into New York’s Forest Tax Law Program. The study also reinforced the importance an economically viable working landscape has for water quality. “Although land-based income will not compete with soaring real estate prices,” the authors wrote, “it is an added incentive for people who want to keep their land.”

23. VanBrakle, J.D. 2015b. Family Forest Management Plans: An Obsolete Paradigm? *Journal of Forestry* 113(1): 75-76.



**Description:** This commentary article questioned whether the traditional forest management plan—a cornerstone of private landowner stewardship efforts—is effective

in promoting family forest conservation. The article cited studies that found that plans failed to reach unengaged landowners and did not affect land-use decisions or BMP use. The article then advocated for transitioning to approaches that could reach more landowners at lower cost, in particular peer-to-peer learning and websites. *Journal of Forestry* does not typically subject commentary articles to peer review, but due to this article's subject, this article was held to that standard.

**Impact:** This article became the “elevator speech” that made the case for MyWoodlot.

24. VanBrakle, J.D., R.H. Germain, J.F. Munsell, and S.V. Stehman. 2013. Do Forest Management Plans Increase Best Management Practices Implementation on Family Forests? A Formative Evaluation in the New York City Watershed. *Journal of Forestry* 111(2): 108-114.



**Description:** This project used the New York City Watershed to evaluate the impact of management plans on BMP use. It combined new field data collected in 2009 and 2011 with data collected in 2002 for another Watershed-funded project. The study found that properties with management plans had significantly higher BMPs in just 2 of 6 categories. The article called for further evaluation into the effectiveness of management plans.

**Impact:** Along with research into management plans and sustained yield management (see Reports), this article catalyzed the Forestry Program's transition away from traditional management planning. The study was also among the first peer-reviewed articles to question the effectiveness of family forest management plans. Subsequent research from across the U.S. has corroborated this study with similar findings that management plans have minimal impact on landowners' stewardship behavior, particularly when compared against cheaper outreach methods.

25. Wang, X., D.A. Burns, R.D. Yanai, R.D. Briggs, and R.H. Germain. 2006. Changes in Stream Chemistry and Nutrient Export Following a Partial Harvest in the Catskill Mountains, New York, USA. *Forest Ecology and Management* 223: 103-112.



**Description:** This study examined changes in stream chemistry resulting from partial cutting (a shelterwood cut in this case). The study looked at changes in nitrate, ammonia, calcium, potassium, and aluminum following harvests at the Frost Valley Model Forest. The study also assessed changes in streamflow. The project found that

streamflow did not change significantly because of the cuts. The cuts did temporarily raise levels of all the tested nutrients, but stream chemistry returned to normal within a year with the exception of nitrate, which remained elevated 18 months after the cut.

**Impact:** This article demonstrated that partial harvests—by far the dominant logging method used in the Watershed—can occur with minimal water quality impact, particularly over the long term. This was true even for a shelterwood cut, which is more intensive than the thinnings more commonly seen in the Catskills. As long as BMPs are used on the access system, the tree removal itself is not a water quality threat. The study also reinforced the need for riparian buffers, especially during heavy harvests like clearcuts.

## Literature Reviews

1. Germain, R.H. and M.C. Kelly. 2011. The Effects of Timber Harvesting on Water Quality: A Literature Review. 10 p.



**Description:** This literature review covered existing research on the relationship between various logging intensities and water quality with a focus on the Catskills. The literature review reinforced the trio of Frost Valley studies' results (Wang et al. 2006, Burns and Murdoch 2005, Paashaus et al. 2004). Highly intensive harvests like clearcuts and whole-tree harvesting do lead to long-lasting increases in nutrient concentrations. Less intensive cuts, such as thinnings, result primarily in small increases that are only short-lived. The review also looked at the effectiveness of riparian buffer strips. It reported that studies had found that nitrate concentrations in streams only increased when riparian buffers were not used. By contrast, riparian buffers of as little as 3 meters were effective at mitigating nitrate delivery to streams.

**Impact:** This literature review reinforced studies happening at Frost Valley that timber harvesting—particularly partial cuts with riparian buffers applied—does not result in additional nutrient delivery to streams.

2. Jayasuriya, M.T. and R.H. Germain. 2017. Literature Review: Riparian Management Zones. 16 p.



**Description:** WAC requested this literature review in response to conflicting information about the effectiveness of fixed-width versus functional riparian area definitions. The NYS BMP field guide has traditionally used a functional definition, but research in the Catskills suggested that at least for first-order streams, a 100-foot buffer could largely match the functional riparian area and be simpler to implement. The literature review discussed the effectiveness of riparian zones of various widths and setups. It also gave an overview of riparian zone guidelines by US state and Canadian province.

**Impact:** This literature review noted that the functional approach to riparian zone designation is more complex, but it does a better job of identifying the riparian zone without over- or under-protecting land and water resources. Ultimately, however, the Forestry Program adopted the 100-foot riparian zone advised in a peer-reviewed article

from the Stroud Water Research Center. This 100-foot figure replaced the more complicated functional definition in the 2017 NYS BMP field guide.

3. Kelly, M.C. and R.H. Germain. 2014. Use of Herbicides in Forestry: An Overview. 15 p.



**Description:** This literature review discussed the ways herbicides are used in forestry, such as to control invasive plants and perform TSI. It discussed application methods, environmental impacts, efficacy, and costs.

**Impact:** The Forestry Program combined this literature review with its own research on herbicide effectiveness on TSI projects to make changes to MAP guidelines. The changes streamlined the use of herbicide for TSI projects. The results included quicker payment processing for foresters and easier inspections for staff.

4. Kelly, M.C. and R.H. Germain. 2013. Timber Stand Improvement: A Review. 18 p.



**Description:** This literature review emerged out of concern that MAP's TSI cost-share might not be effective. For example, there was concern that some foresters did not thin at a sufficient intensity to affect growth. The literature review described what TSI is, how to evaluate stand conditions to see if TSI is warranted, TSI effects on stand development, silvicultural guidelines for carrying out TSI, and whether the cost of TSI is recouped in higher future revenues. In regard to this last item, the literature suggests that where low-grade markets exist, landowners are better off waiting until a commercially viable pulpwood harvest is possible. In areas without pulpwood markets (like the Catskills), TSI investment can make economic sense on high-quality sites.

**Impact:** This literature review confirmed that TSI can make economic sense in the Catskills if it is practiced on high-quality sites. However, TSI prescriptions are not appropriate in every degraded stand. Critically, the review cautioned that TSI payments based solely on the basal area removed (as MAP does) do not address whether a TSI treatment was appropriate in the first place. The review advised making sure that TSI was warranted before providing funding. To date, the Forestry Program has not acted on this recommendation.

5. Kelly, M.C. and R.H. Germain. 2012b. Measuring Costs of Forestry Best Management Practices: A Literature Review. 23 p.



**Description:** This literature review discussed the existing studies on BMP costs. The review showed that methods and results varied a lot, with BMP costs ranging from \$12.45 per acre (1987 dollars) to \$55.53 per acre (1995 dollars). The study also revealed that accurate cost estimates were lacking for New York, and in particular for the Watershed.

**Impact:** This literature review inspired WAC and Matt Kelly to pursue a BMP cost study for Matt's PhD work. That study in turn has led to a confirmation that the Forestry Program's BMP cost-share rates are appropriate.

6. Kelly, M.C. and R.H. Germain. 2011. Measuring Effectiveness of Forestry Best Management Practices. 17 p.



**Description:** This literature review discussed the existing research on assessing BMP effectiveness. It also discussed methods for evaluating BMP effectiveness, such as the Forest Service's BMP Monitoring Protocol.

**Impact:** Prior to this literature review, research into BMP use in the Watershed focused on implementation. But the question always lingered: were the installed BMPs effective? This literature review helped confirm for the Forestry Program that when BMPs are installed correctly, they are effective.

7. Kelly, M.C. and R.H. Germain. 2010. An Overview of Tree Girdling for Use in Forest Management. 8 p.



**Description:** This literature review discussed proper girdling techniques and tools for the most effective result. It also reviewed girdling applications in forestry as well as the potential liability related to creating hazard trees.

**Impact:** This literature review is a good example of how research may not always be immediately useful, but can have impacts over the long term. The Forestry Program did not make any changes upon receiving this review in 2010. However, when the Forestry Program evaluated herbicide and girdling TSI methods in 2014, this literature review became a critical source of information on proper girdling technique. The review informed MAP guideline changes that included requiring two girdle rings instead of one.

8. Trombley, J.L. and R.H. Germain. 2016. Hemlock Woolly Adelgid: An Overview. 69 p.



**Description:** WAC requested this literature review in response to a potential new MAP practice: treating eastern hemlocks for hemlock woolly adelgid. The literature review discussed the adelgid's life cycle, range, and impacts. It also covered treatment options and methods, both chemical and biological. Finally, it provided cost estimates for treatment. Quotes from two licensed Pesticide Applicators were 1) \$23-\$55 per tree and 2) \$1 per inch of DBH, plus labor costs.

**Impact:** As of this writing, the Forestry Program has not acted on this literature review. The review suggests that woolly adelgid treatment could be added as a MAP practice. Adding it was listed as a potential strategic priority for the FY18 Forestry Program work plan, but it was ultimately not included in that list over higher priority tasks.



## Reports

1. Canham, H. 2003. Forest Taxation in the Catskill/Delaware System of the New York City Watersheds. Report to the Watershed Agricultural Council. 36 p.

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**Description:** This report assessed the level of forest taxation in the New York City Watershed, enrollment in the Forest Tax Law, and the impacts of the Forest Tax Law on Watershed municipalities. The study found that property taxes per acre of forestland in the Watershed range from an average low of \$12.65 to an average high of \$34.92. Property taxes were considered confiscatory on at least half the forestland in the Watershed (confiscatory defined in the report as the point where the tax on an asset takes a higher percent of realizable income than might be possible in an alternative investment). Exemptions due to 480-a were slight, between 1 and 3 percent of real property values. The report recommended actions such as reimbursement to local governments and development of a companion program to 480-a specific to the Watershed.

**Impact:** Forest taxation has gained new relevance in light of statewide efforts to overhaul the Forest Tax Law Program. As a result, this report has resurfaced as a way of demonstrating that the Forest Tax Law has minimal impacts on local property taxes. Moreover, this report helped demonstrate how WAC's efforts since this report have led to greater participation in the Forest Tax Law. That finding in turn helped encourage the shift in WAC's Forest Management Plan Program to focus on Forest Tax Law enrollment.

2. Connelly, N.A., T.L. Brown, and P.J. Smallidge. 2007. *Public Awareness of Invasive Plants and Insects in the Catskills and Lower Hudson Region*. HDRU Series No. 07-7. Human Dimensions Research Unit, Cornell University. 73 p.

### \$

**Description:** WAC commissioned this study to investigate regional landowners' awareness and knowledge of invasive plants and insects. Cornell University's Human Dimensions Research Unit sent out 4,000 surveys and received 1,047 back. They found that invasive species awareness was low. Over half of respondents had never heard of 12 of the 14 invasive plants and insects the researchers asked them about. Landowners did not believe invasives were common, but they did express concern about them on their properties. Few landowners were willing to apply chemicals on their properties.

Landowners indicated they would most likely turn to brochures, fact sheets, web sites, or Cornell Cooperative Extension personnel for information about invasive species in the future. Paired surveys to forestry professionals and municipal officials yielded similar results, with the exception of higher awareness among forestry professionals.

**Impact:** None known at this time.

3. Hall, M., R. Germain, M. Tyrrell, and N. Sampson. 2008. *Predicting Future Water Quality from Land Use Change Projections in the Catskill-Delaware Watersheds*. 312 p.

**Description:** This report brought together 16 studies that explored parcelization, land use change, and their impacts in the New York City Watershed. The report modeled land use change in the Watershed and found that parcelization and development will continue for the foreseeable future. The report called on Watershed stakeholders to discuss where development in the Watershed is desirable, how it can be managed to reduce nutrient delivery from impervious surfaces, and how landowners can get the tax relief they need to keep rural land in rural uses.

**Impact:** Many of the individual projects described in this report went on to become peer-reviewed articles, including Anderson et al. (2012), Caron et al. (2012), and Stone and Tyrrell (2012). Like them, this report bolstered the case for focusing on 480-a and linked the economic viability of forestry to water quality protection.

4. Irland Group, The, and Pan Atlantic Consultants. 2006. Evaluation of Economic Development Grant Program WAC 2000-2005. Report to Watershed Agricultural Council. 85 p.

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**Description:** Often referred to as “the Irland Report,” this report evaluated WAC’s Economic Action Program, or EAP. EAP funded 50% cost-share grants to wood-using businesses to help them purchase equipment or market their products. The Irland Report evaluated this program by interviewing 51 of the 57 EAP recipients at the time the study was conducted. The report assessed EAP’s impact on both the regional Watershed economy and the forest resource. The report found among the firms that received EAP grants, 50 jobs were added, a significant result given that job losses occurred in the same sector statewide during that time period. However, the report was unable to attribute the job gains entirely to EAP. The report did conclude that the “the availability of grant funding was critical to the survival and expansion of several major

employers.” Overall the Irland Report found EAP an effective program and recommended its continuation.

**Impact:** WAC continued EAP after the Irland Report came out. When the program ultimately had its budget zeroed out in Congress, WAC adopted other, cheaper measures championed in the Irland Report, such as Catskill WoodNet and trade missions to New York City.

5. Richmond Energy Associates, LLC. 2009. Biomass Opportunities in the Catskills. Report to the Watershed Agricultural Council. 61 p.

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**Description:** This study discussed biomass heating at Catskills schools and businesses as part of WAC’s Watershed Woody Biomass project. That project offered funding for regional facilities to get “pre-feasibility studies” to assess whether biomass heating using wood chips or wood pellets could make economic sense for them. This study summarized the results of that effort and made recommendations for next steps. Among the study’s recommendations were to identify potential wood fuel suppliers and pursue additional pre-feasibility studies

**Impact:** WAC went on to both expand its regional fuel suppliers list and do a third round of biomass pre-feasibility studies. Those studies led to biomass heating units being installed at Catskill Craftsmen and Frost Valley YMCA.

6. Summit Ridge Investments, LLC. 2009. WAC Forest Bank: Preliminary Review and Analysis. Report to the Watershed Agricultural Council. 60 p.

## \$

**Description:** This project examined the financial feasibility of a Forest Bank in the Watershed. The project applied results from a Nature Conservancy forest bank in Indiana to the Watershed. The resulting financial analysis found that a NYC Watershed Forest Bank would need ongoing subsidies in order to operate. Moreover, a key revenue stream came from withdrawal penalties from landowners leaving the program. Nevertheless the report concluded that the NYC Watershed was well-suited for a forest bank assuming capital could be obtained and a large landowner base would enroll.

**Impact:** This report spurred WAC to work with Matt Kelly and SUNY-ESF to dig deeper into the landowner enrollment assumption. That research's results, combined with the challenges revealed in this study, convinced WAC not to pursue a forest bank.

7. Tyrrell, M.L., M.H.P. Hall, and R.N. Sampson. 2004. Dynamic Models of Land Use Change in Northeastern USA: Developing Tools, Techniques, and Talents for Effective Conservation Action. GISF Research Paper 003. 87 p. Available online at [http://gisf.yale.edu/sites/default/files/files/landuse\\_complete.pdf](http://gisf.yale.edu/sites/default/files/files/landuse_complete.pdf).

**Description:** This project used a land use modeling tool called GEOMOD to illustrate local and regional land use changes in the recent past and then to predict future land use change. This project tested GEOMOD on two sites: the Thames River Watershed in New England and the Catskill/Delaware Watersheds here in New York. In the Catskill/Delaware, the model found that private forests were being converted to non-forest use at a rate of a little over 1% per year in a fragmented pattern. Areas close to roads, other development, and flatter slopes in the valleys were most vulnerable. The report concluded that “without strong conservation intervention, that rate [of conversion] is likely to proceed for the next decade, resulting in the loss of another 162,000 acres of private forestland, and a much more fragmented forest resource, by the year 2011.”

**Impact:** The Forestry Program has taken no direct action based on this study. The GEOMOD methodology has not been repeated in the Watershed to determine changes in development. However, the loss of forestland since this report came out appears to be much less than this study predicted. The Watershed remains heavily forested, although parcel size does continue to decline. “Strong conservation intervention” has certainly occurred, such as the Land Acquisition Program, WAC’s Easements Program, and the Forestry Program’s emphasis on 480-a. However, the housing crisis likely also had a lot to do with slowing the pace of Watershed development.

8. VanBrakle, J.D. and T. Pavlesich. 2017. Assessing the BMP Program’s Reach Using Aerial Photographs and ArcGIS: A Watershed Forestry Program Research Project. # pages.



**Description:** Since the creation of the BMP Program, a fundamental question has dogged it: what percentage of timber harvests is the program involved in? For most of the program’s existence, WAC had no way to answer this question. That changed with the development of a method using an ArcGIS extension called Feature Analyst, which

can identify features on aerial photographs and translate them into ArcGIS layers suitable for analysis. Josh VanBrakle duplicated this method for the Catskill/Delaware Watershed to identify timber harvests on private land that happened between July 2013 and July 2015. The study found that the BMP Program is involved in 25% of Watershed timber harvests and 40% of harvested acres. The study also found that nearly all harvested acres in the Watershed remove less than 50% of the tree canopy, and minimal harvesting occurs within 100 feet of a stream.

**Impact:** This report came out at the same time this document was being developed, so no impacts have occurred yet. However, the paper made several important conclusions about the future of the WAC Forestry Program. It found, for instance, that the BMP Program could not expand to cover even 50% of harvested acres without the addition of another staff forester. It also found that a riparian protection incentive was unnecessary given the low level of harvesting in Watershed riparian areas. Finally, it found that the Catskill/Delaware Watershed is faring extremely well in regards to forest fragmentation, with the region losing only 57 acres of forest annually to development, a rate one tenth of New England's during the same time frame.

9. VanBrakle, J.D. 2017. Learning from Others: Private Landowner Outreach in Wisconsin's Driftless Area. 8 p.



**Description:** This report summarized observations from a field tour of Wisconsin's Driftless Area. The Driftless Area is a similar region to the NYC Watershed with a heavy emphasis on landowner outreach. The report highlighted the work the Driftless Area did to increase its outreach effectiveness. Among its findings, the report noted that diverse outreach tools are needed to reach audiences, and on-the-ground forester visits are effective but intimidating for unengaged landowners. The Driftless Area found that starting with a passive printed guidebook was an easier initial outreach tool. Landowners were more than twice as willing to get a forester visit after getting the book.

**Impact:** None at this time.

10. VanBrakle, J.D. 2015a. Conservation Awareness Index: A New Cornerstone for Evaluating Forestry Program Landowner Education? A Watershed Forestry Program Research Project. 20 p.



**Description:** This study assessed Watershed landowners' awareness of and experience with four conservation decisions. The four decisions evaluated were Forest Tax Law, Conservation Easements, Timber Harvesting, and Estate Planning. The study scored landowners on familiarity, knowledge, experience, and professional contacts. The study used the Conservation Awareness Index (CAI), a peer-reviewed survey tool developed by researchers at the University of Massachusetts. 920 surveys were returned for an effective response rate of 35%. The survey found that landowners had little awareness or experience related to the four conservation decisions. For example, more than half of Forest Tax Law eligible landowners had never heard of the program.

**Impact:** This study provided baseline data WAC can use to evaluate its landowner education efforts over time. The 2017 Filtration Avoidance Determination includes a deliverable to repeat CAI in the Watershed every five years to see whether scores increase. The conservation decisions in CAI were also incorporated into the Forestry Program's landowner education efforts as "priority knowledge." This step has focused landowner education efforts to make them more efficient and effective.

11. VanBrakle, J.D. 2014. Girdling, Herbicide, and the Management Assistance Program: Results from a Mini-Research Project. 8 p.



**Description:** This study resulted from concerns that timber stand improvements done using girdling or herbicide were ineffective compared with traditional felling. The study found that herbicide was very effective for timber stand improvement, reliably killing almost 100% of treated trees after 3 years. Girdling was less effective, killing about 70% of treated trees after 3 years. The study also suggested that foresters may be over-prescribing TSI. It found that many TSIs occurred on sites with too low of a pre-harvest relative density and too few acceptable growing stock trees. Foresters may be prescribing TSI in stands that silviculturally are too degraded and should be regenerated.

**Impact:** This study led to changes to MAP. For herbicide, it allowed immediate payment before trees die as long as the forester marked the boundary of the TSI work. For girdling, it required foresters to use double-girdles. The study suggested more data collection of traditional felling TSI projects before making changes related to site selection.

12. VanBrakle, J.D. 2013. Do Forest Management Plans Lead to Sustained Yield Management on Family Forests? A Formative Evaluation in the New York City Watershed. 15 p.



**Description:** This report described the results from the sustained yield management portion of the management plan effectiveness research conducted by WAC staff. It was written as a scientific paper, but VanBrakle never pursued publication due to time constraints and the project’s limited scope. The study found that properties with plans did not have significantly better management than those without plans. Properties enrolled in 480-a, however, did have better management. The study also found an absence of regeneration harvests, continuing a trend from John Munsell’s “Tale of Two Forests” PhD work.

**Impact:** This article and the peer-reviewed VanBrakle et al. (2013) together made the case for WAC to transition away from traditional management plans. The finding that 480-a led to better management became part of the argument in favor of focusing management plan funding on 480-a enrollment.

13. VanBrakle, J. 2010b. Reevaluating the Role of WAC in Forest Certification Systems in the New York City Watershed. 8 p.



**Description:** In 2007, WAC explored getting involved in forest certification, but concluded certification was unreasonable due to certification systems’ focus on large properties. But in July 2010, the Forest Stewardship Council (FSC) released a new forest certification standard with “family forest indicators” meant to make certification more accessible to small acreages. That change prompted WAC to reevaluate its decision. This report reviewed the new standard. VanBrakle compared the FSC standards against WAC’s management plan requirements and summarized the differences between the two. Although the two had similar requirements, the report concluded that forest certification was still not a good fit for WAC. The issue was not the management plan, but the onerous, mandatory, and ultimately cost-prohibitive requirements certification posed on landowners.

**Impact:** After this report, the Forestry Program concluded that it would keep on its current course with management plans rather than focus on certification. The report also



informed future discussions on revisions to the Forest Tax Law Program. The report highlighted the reasons why forest certification was unlikely to occur on family forest lands even with a tax incentive.

## Theses and Dissertations

1. Kelly, M.C. 2015. Logging Operations of the Northeast United States: Assessing Harvest Costs, Productivities, Delays, Management Strategies, and Impacts of Best Management Practices. PhD Dissertation. State University of New York – College of Environmental Science and Forestry. 213 p.



**Description:** This thesis came out of a request from WAC to better understand the cost of Best Management Practices. It was hoped that this research would reveal potential changes to the Forestry Program’s BMP cost-share values. The research involved detailed interviews with loggers, journals of productivity on actual harvests, and a logger survey that assessed BMP costs on a hypothetical job. The study found that BMP costs and impacts on productivity were highly variable. The highest costs were borne by single operators, because they took the greatest hit to productivity.

**Impact:** This project revealed that more by accident than by design, the Forestry Program’s BMP cost-share rates are close to the actual cost of installing BMPs. As a result, BMP cost-share rates did not need to change based on this study.

2. Kelly, MC. 2012a. Family Forest Owner Attitudes and Preferences for Forest Conservation Programs in the New York City Watershed. M.S. Thesis. State University of New York – College of Environmental Science and Forestry. 139 p.



**Description:** This is the thesis connected to the same research project as Kelly et al. (2015). The study was conducted at WAC’s request because of WAC proposals to pilot either a Forest Easement or Forest Bank Program in the Watershed. The researchers surveyed landowners about their willingness to enroll in four simulated programs. The programs varied based on the rights conveyed, the amount of payment, and the length of the contract commitment. The study found that expected enrollment rates in the Forest Bank Program were extremely low, because landowners gave up control of how timber was harvested on their properties. By contrast, traditional easements had much higher projected enrollments, as high as 15%.

**Impact:** This project confirmed that the Forest Easement, and not the Forest Bank, was the correct program for WAC to pursue. WAC’s Forest Easement Program is now

closing on its first easements and appears poised to move beyond a pilot into a long-term program.

3. Munsell, J. 2003. The Diffusion of Forestry Best Management Practices among Catskill/Delaware Watershed Nonindustrial Private Forestland Owners. M.S. Thesis. State University of New York – College of Environmental Science and Forestry. 180 p.



**Description:** This thesis used a combination of landowner surveys and field visits to assess landowner knowledge, attitudes, and implementation of BMPs in the Watershed compared with Oneida County, New York. Mail survey results suggested that Watershed landowners had higher knowledge of BMPs than landowners in Oneida County. However, BMP implementation was low and no higher than in Oneida County. The results suggested a disconnect between landowner BMP awareness and BMP use.

**Impact:** This thesis and the papers that stemmed from it collectively informed WAC's BMP Program approach of focusing on loggers for BMP implementation rather than on landowners.

4. Munsell, J. 2007. Timber Management on Mississippi and New York Non-Industrial Private Forestland: An Integrative Study of Sustained Yield Practices and Possibilities. PhD Dissertation. State University of New York – College of Environmental Science and Forestry. 147 p.



**Description:** This dissertation combined several of Munsell's peer-reviewed articles into a single document. It focused on landowner interviews and field measurements of recent timber harvests in the Watershed and in Mississippi. The major conclusions in the Watershed were: 1) sustained yield management is lacking, 2) regeneration harvests are absent, 3) owner characteristics are less important than broader landscape context in influencing harvest decisions, and 4) low-grade markets, such as those for biomass, could help encourage more use of silviculture.

**Impact:** This dissertation and the papers that stemmed from it collectively led the Forestry Program to pursue economic viability projects related to woody biomass. The

harvest data also became an important resource for changing WAC's management plan efforts when they were added to Josh VanBrakle's datasets.

5. Regula, J.L. 2017. Assessing the Economic Viability of Loggers Operating Tree-Length Harvest Systems in New York and Northeastern Pennsylvania. M.S. Thesis. State University of New York – College of Environmental Science and Forestry. 159 p.



**Description:** This study went beyond Matt Kelly's look into BMP costs and examined the factors that influence logger profitability in New York and Pennsylvania. To determine those factors, Regula looked at 23 timber harvests across the region. She interviewed the loggers; recorded their revenue, costs, and working days at the harvest; and then input those numbers into PATH. PATH stands for Planning and Analysis in Timber Harvesting, a free software designed to help loggers understand their costs. Based on the PATH results, almost half the loggers lost money on the job Regula evaluated them on. Total harvest site acreage, total access system distance, cubic feet harvested per acre, and hours spent implementing BMPs were all found to be statistically significant when predicting net profit and operation costs.

**Impact:** This thesis put new attention on logger economic viability in the Watershed. New logger training classes on PATH have been developed to provide loggers with more information on their profitability. Potential new programs to help loggers use and apply PATH in their businesses are in early stages of discussion and are areas of potential future growth for the Forestry Program.

6. Schuler, J.L. 1999. Assessing Application and Effectiveness of Suggested Forestry BMPs in the Adirondack and Catskill Regions of New York. M.S. Thesis. State University of New York – College of Environmental Science and Forestry. 78 p.



**Description:** This is the thesis that led to Schuler and Briggs (2000). As noted for that listing, the project evaluated 42 BMPs on 61 timber harvests in the Catskills and 53 harvests in the Adirondacks between 1997 and 1998. It was the first study to evaluate BMPs in the NYC Watershed. The study found that BMP implementation was 78% for haul roads, 87% for landings, 59% for skid trails, 88% for equipment maintenance/operation, and 73% for buffer strips. The study found that the most

common BMPs not found were water diversion devices like waterbars. The study advised more emphasis on these practices in particular. The study also found that where BMPs were used, they were effective. In the Catskills, 27 of the 33 BMPs tested showed a statistically significant relationship between BMP application and prevention of sediment movement. Moreover, imperfect application of BMPs reduced their effectiveness. The study found, for instance, that road drainage structures generally failed to adequately control erosion when spacing between them was excessive.

**Impact:** Unknown.

7. VanBrakle, J.D. 2010a. The Effectiveness of Forest Management Plans in Promoting Best Management Practices and Sustained Yield Management on Nonindustrial Private Forestland. M.S. Thesis. State University of New York – College of Environmental Science and Forestry. 111 p.



**Description:** This thesis built on the work of John Munsell by adding more visited properties and comparing the results for BMPs and sustained yield management between properties with and without management plans. The thesis also examined whether improvement had occurred since Munsell's original data collection. Overall the thesis found that while both BMP and sustained yield management use had improved since 2002, management plans made no difference in their application.

**Impact:** This thesis led Forestry Program staff in 2011 to expand the dataset further with even more property visits. In total, more than 100 visits to Catskills timber harvests occurred, with the finding that Watershed Forest Management Plans did not result in better BMPs or silviculture. This result led to the Forestry Program moving on from its traditional management planning approach in favor of 480-a and MyWoodlot.

## Other

1. Jayasuriya, M.T., R.H. Germain, and E. Bevilacqua. 2016. Is a Functional Approach for Delineating Riparian Areas Really Necessary for First and Second Order Streams? Poster Presentation at New York Society of American Foresters Conference, Syracuse, NY, January 27-29, 2016.



**Description:** This project compared fixed-width buffers along streams against the functional definition of a riparian area from New York's BMP field guide. The goal was to see if a fixed-width buffer could approximate a functional riparian area width well enough to create simpler guidance for loggers. The project looked initially at streams at Frost Valley Model Forest, then expanded those results using GIS to apply to the entire Catskill/Delaware Watershed. The study found that for first-order streams, a 100-foot buffer did a very good job of approximating the functional riparian area. For second-order streams, however, the 100-foot buffer often underestimated the riparian area's width.

**Impact:** Combining this research with outside research on buffers conducted by the Stroud Water Research Center, Forestry Program staff edited the New York BMP field guide to recommend a 100-foot riparian management zone. This change made riparian area identification in the field easier for loggers without sacrificing water quality.

2. Munsell, J. and R.H. Germain. 2007. Measuring Best Management Practices Knowledge and Implementation among Catskill/Delaware Watershed Nonindustrial Private Forest Landowners. Pages 183-191 in *Proceedings of the International Conference on Transfer of Forest Science Knowledge and Technology*. US Forest Service General Technical Report PNW-GTR-726.



**Description:** This article accompanied a conference presentation and as such did not go through formal peer review. However, this article better explains the BMP evaluation methodology John Munsell and later Josh VanBrakle used to score BMPs on Watershed timber harvests. The study found that BMP use was not better in the Watershed compared with harvests in Oneida County. This was despite finding that awareness of BMPs among Watershed landowners was high, according to a survey done for this project.

**Impact:** The data in this article were added to the data from VanBrakle et al. (2013) to determine the impact of forest management plans on BMP usage. As a result of both studies, it became clear that Watershed Forest Management Plans were not getting WAC what it wanted: better BMPs on the ground.

3. Paashaus, E.J., R.D. Briggs, and N.H. Ringler. 2004. Partial Cutting Impacts on Macroinvertebrates in Ephemeral Streams in Southern NY. Pages 38-40 in *Proceedings of the New England Society of American Foresters 84<sup>th</sup> Winter Meeting*. US Forest Service General Technical Report GTR-NE-314.



**Description:** This study examined changes in macroinvertebrates in Frost Valley streams following partial harvesting at the model forest. The study assessed a variety of factors related to the abundance and diversity of macroinvertebrates: index of biotic integrity, Hilsenhoff improved biotic index, family level biotic index, North Carolina biotic index, functional feeding groups, and Shannon H and Simpson D diversity indices. The study found no evidence that partial harvests harmed water quality or macroinvertebrates.

**Impact:** This article demonstrated that partial harvests—by far the dominant logging method used in the Watershed—can occur without harming water quality. As long as BMPs are used on the access system, the tree removal itself is not a water quality threat.

4. VanBrakle, J.D. 2011. Manomet: Time to Turn Up the Heat on Woody Biomass. *Journal of Forestry* 109(4): 244-245.



**Description:** This commentary article responded to a report by the Manomet Center for Conservation Studies. Manomet’s report found that biomass releases more carbon dioxide per Btu than coal when used to produce electricity. This finding led many in the media, including the *New York Times*, to declare that biomass was “worse than coal.” VanBrakle’s article drew on the Manomet study to refute those incorrect generalizations. While the Manomet study did find that biomass was inefficient for electricity, it found that biomass was very efficient for heating applications, particularly when the wood

came as a byproduct from other timber harvests. NOTE: Although this article was published in the *Journal of Forestry*, it did not go through peer review because it was a commentary. That is why it is included in “Other” rather than with “Peer-Reviewed Articles.”

**Impact:** This article helped focus WAC’s biomass promotion efforts on heating applications.



### Additional Resources

Arscott, D.B., C.L. Dow, and B.W. Sweeney. 2006. Landscape Template of New York City's Drinking-Water-Supply Watersheds. *Journal of the North American Benthological Society* 25(4): 867-886.

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Hoffman, J. 2008. Watershed Shift: Collaboration and Employers in the New York City Catskill/Delaware Watershed from 1990-2003. *Ecological Economics* 68: 141-161.

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