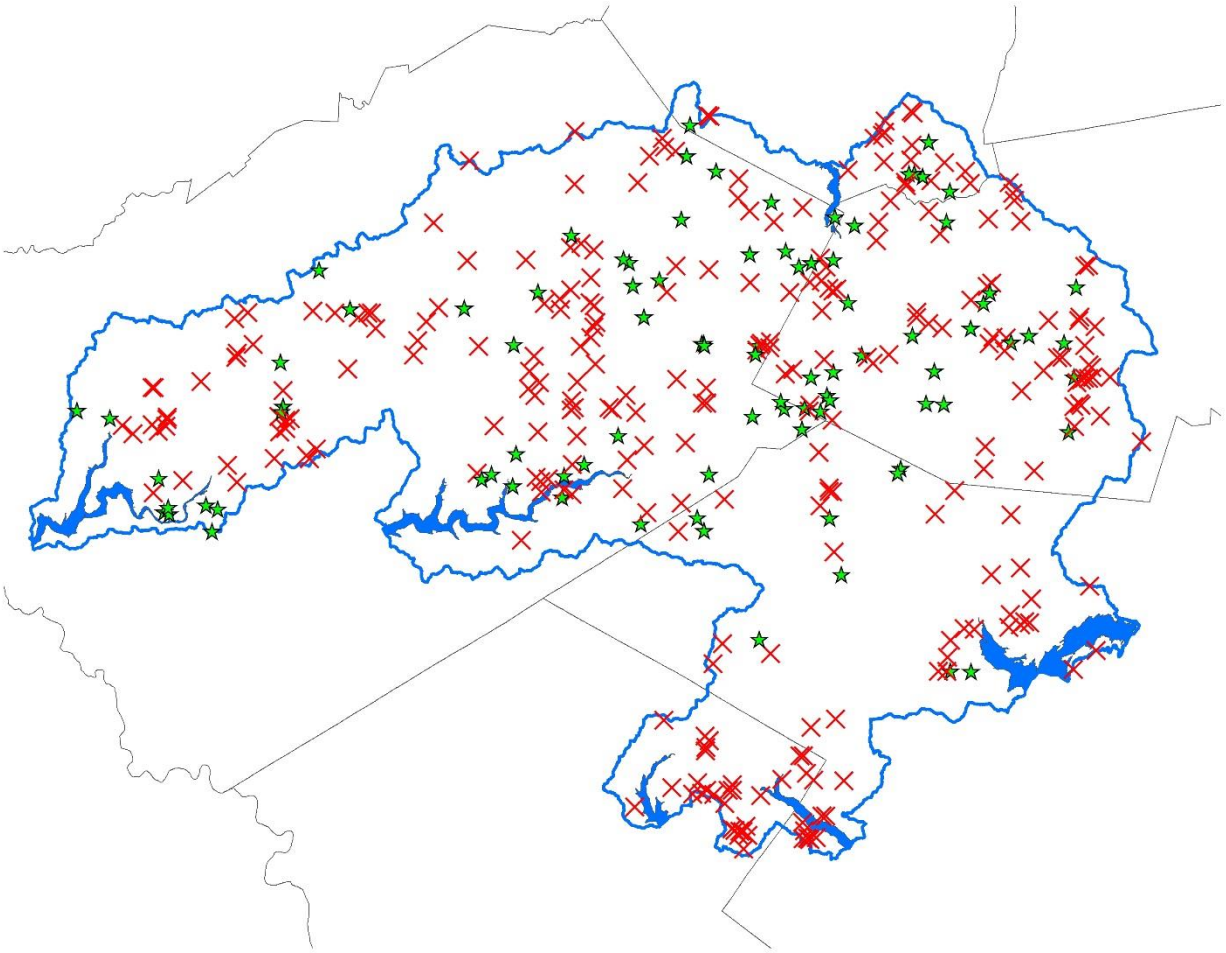
Assessing the BMP Program's Reach Using Aerial Photographs and ArcGIS

A Watershed Forestry Program Research Project



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Watershed Agricultural Council
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Executive Summary

The WAC homepage touts that the organization has 90% farm participation in its water quality programs. For years, no similar number has been knowable for timber harvests. That changed in 2016 when Kerry Livengood of Tennessee published a method for using ArcGIS to identify harvests using aerial photographs.

Forestry Program staff applied Livengood's method to the Catskill/Delaware Watershed to assess the reach of the BMP Program. Our project had four goals:

1. Determine the number of harvests that occur annually in the Catskill/Delaware Watershed.
2. Determine the percentage of harvests in the Catskill/Delaware Watershed that participate in WAC's BMP Program.
3. Determine the average size (acres) of harvests in the Catskill/Delaware Watershed.
4. Estimate the frequency and size (acres) of Catskill/Delaware Watershed harvests occurring within 100 feet of a stream.

Our project included all forestland in the Catskill/Delaware Watershed not owned by either the State or City of New York. Our study found:

- The Watershed averages 183 timber harvests annually, totaling 7,092 acres.
- WAC's BMP Program worked on 25% of those harvests. BMP harvests made up 2,854 acres of harvested area, 40% of the total.
- The BMP Program's impact is not uniform. Some areas had high participation, while others had no BMP projects at all. Areas without projects included the regions surrounding the Neversink, Rondout, and Ashokan Reservoirs.
- The average size of a harvest in the Catskill/Delaware Watershed is 39 acres.
- Total annual area harvested within 100 feet of streams was 347 acres, 5% of total harvested area. Harvesting was generally light, suggesting minimal water quality impact.
- The Catskill/Delaware Watershed loses 57 acres of forest annually to land clearing, a rate one tenth of New England's. This finding suggests Watershed land protection efforts are effective at reducing forest conversion, but more research is needed to establish causality.

Historically, the BMP Program has grown at a rate of 2.7 additional projects annually. Forestry staff previously restructured work plan tasks to accommodate this growth, but those opportunities have dwindled. At current staff levels, the BMP Program will max out capacity by 2022, midway through the next WAC-DEP contract. Opportunities exist to increase the BMP Program's reach, but they are not achievable given the current Forestry Program staffing model.

This report is intended to provide Committee members with the information they need to answer one fundamental question: **What percent of the total harvested acres in the Watershed should participate annually in the BMP Program?** Answering this question will set a goal for BMP Program participation and affect the allocation of future resources.

Background

The WAC homepage touts that the organization has 90% farm participation in its water quality programs. To date, no similar number has been known for timber harvests. Does the Forestry Program's BMP Program work on 5% of Watershed harvests, 95%, or somewhere in between?

This fundamental question has come up repeatedly in the Forestry Committee, yet for years we could not answer it. Unlike many other states, New York has no system of timber harvest notification. Lacking such a system, we had no practical way to assess where Watershed harvests occur or what percent of them use the BMP Program.

That changed in 2016 when Kerry Livengood published an article in the *Forestry Source* (Livengood 2016). The article described a method of using ArcGIS to identify timber harvests using aerial photographs. Livengood used this method to locate all timber harvests in the state of Tennessee.

In May 2017, the WAC Forestry Committee tasked the Forestry Program with applying Livengood's method to the Catskill/Delaware Watershed. The project had four goals:

1. Determine the number of harvests that occur annually in the Catskill/Delaware Watershed.
2. Determine the percentage of harvests in the Catskill/Delaware Watershed that participate in WAC's BMP Program.
3. Determine the average size (acres) of harvests in the Catskill/Delaware Watershed.
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Forestry Program staff conducted this analysis from July-September 2017. This report summarizes the project's methods and results. It also discusses BMP Program participation trends, staff capacity to increase BMP projects, and staff's recommendations for increasing the BMP Program's reach.

Methods

How Can You Identify Timber Harvests from Aerial Photos?

Livengood's method relies on an ArcGIS software extension called Feature Analyst. This software is able to "see" aerial photos and translate features on them into ArcGIS files suitable for analysis. We used this software to locate Watershed timber harvests.

To use Feature Analyst, we first added aerial photographs of the Watershed to ArcGIS. We used free aerial photos from the National Agriculture Imagery Program (NAIP) taken in 2013 and 2015. We chose them because they were the most recent "leaf-on" (growing season) images available to us. We needed leaf-on images to spot canopy gaps. In total, there were 157 aerial photos for each year to cover the Watershed. Most of the images were taken in July 2013 and July 2015, so we used those dates as our "start" and "end" times for the analysis. Because this range covered exactly two years, it allowed us to get annual figures simply by dividing all results by two. Results in this report are given in annual figures.

Once we had the aerial photos, we started the analysis by manually indicating a few examples of what we wanted Feature Analyst to find. Grouped together, these examples are known as a "training set." For our training sets, we used known BMP project locations to identify a few timber harvests scattered across the Watershed. We then created training sets that looked for canopy gaps—in general, spots of brown, bare ground surrounded by green tree canopy (Figure 1).

Figure 1. Part of a training set (the features shown in pink) used to teach Feature Analyst to identify canopy gaps in a known harvest location.

Based on the training set, Feature Analyst provided initial results. These results were often poor (Figure 2).

Figure 2. A first run based on the training set shown in Figure 1. Notice the many incorrect features such as highlighted roads, fields, and buildings.

To improve these results, we marked sample areas Feature Analyst got right or wrong. The software used this information to "learn" what we were looking for. Over several rounds of this learning, the software became better at identifying canopy gaps (Figure 3). Once it reliably found them, we used it to analyze multiple Watershed aerial images automatically.

Because the aerial photos were taken in different months, we repeated this process several times across the Watershed. For example, some photos were taken early in the growing season (May) and still had bare trees in higher elevations. Other photos were taken late in the season (September) and had some fall colors mixed in. These differences can trick Feature Analyst and lead to both missed harvests and false positives. By using a new training set and learning process for each date photos were taken, we achieved better results than we would have if we had set up only one training set for the whole Watershed.

Even after all this training, Feature Analyst isn't perfect. Once it finished its analysis, we went back and double-checked its results. We removed parcels it erroneously selected. We intentionally trained the software to be aggressive in identifying potential harvest sites, because while it was easy to remove incorrect parcels, there was no practical way to find ones the software missed.

Figure 3. A final run after three rounds of training.

What Was Included in the Analysis?

Because we were primarily concerned with the reach of the BMP Program, we focused on lands that are eligible for it. We excluded all state- and NYC-owned land from the analysis. The results for timber harvests in this report therefore represent private lands in the Catskill/Delaware Watershed with the rare exception of local government properties.

We defined a "timber harvest" as "the removal of trees from a forested area due to human activity and of sufficient intensity to create noticeable canopy gaps in an aerial photo." This definition excluded very light cuts, including nearly all TSIs. We know this because MAP-funded TSIs have their boundaries recorded in ArcGIS, and neither Feature Analyst nor our eyes could detect canopy change in them. The definition also excluded small firewood cuts, which, like TSIs, were too light to result in visible canopy change. Our results should therefore be interpreted as a conservative estimate of the number of timber harvests in the Watershed.

Losses of trees to natural causes like disease, insects, and blowdowns were not considered harvests. In practice, it was easy to differentiate trees that died of natural causes from those removed due to logging. Factors like alignment with tax parcel boundaries, presence of an access system (especially a landing), and the presence or absence of fallen logs in the aerial photo made it clear if logging had taken place.

Harvests do not happen overnight. They can take months. By contrast, the aerial photographs are instant points in time. This creates a problem. Should a harvest that was in process when the first aerial photo was taken be included or not? Our solution was to include the harvest if we could see additional canopy removal between 2013 and 2015. If we could not, we did not include that harvest. When we did include them, we recorded only the area of additional canopy removal as the area harvested.

We wanted to make sure as many relevant BMP projects as possible were included in the analysis. Again, harvests take time. To ensure we included all relevant BMP projects, we used skid trail GIS information recorded by WAC staff to identify all BMP projects with completion dates between 2013 and 2016. During the analysis, we removed projects whose approval and completion dates both fell outside (before or after) the dates for the aerial images. We also removed sites where it was clear harvesting finished before the 2013 photo or started after the 2015 one.

For harvests on the Watershed boundary, we recorded the entire harvest area if any part of it occurred in the Watershed. We did this because the BMP Program uses the same criterion.

What Did You Do When You Located a Harvest?

When we located a harvest, we saved the parcel where it occurred in a GIS layer. In addition, we used the aerial photographs to record the boundaries of the harvest itself. In most cases, the harvest did not cover the entire property. By recording the actual harvest boundaries, we were able to assess total acreage harvested as well as whether harvesting occurred in streamside areas.

In cases where harvests were spread over adjacent parcels under one ownership, we merged the parcels together into one ownership. We also combined the cuts that occurred on those parcels into one harvest even if they were geographically removed from each other.

Where contiguous harvests were spread across multiple adjacent ownerships, we treated the cut area as one harvest. This typically happened where a cluster of small residential parcels were all cut. We treated these harvests as one cut because if they were considered individually, the cuts likely would not have been economically viable.

For each harvest, we recorded whether or not it was a BMP project. This was determined using the skid trail information collected by WAC staff as part of the BMP inspection process.

We classified each harvest into one of four categories based on the intensity of the cut as seen in the aerial photograph. Note that these definitions are based only on how heavy the cut was, <u>not</u> its quality or silvicultural merit, which could not be determined from aerial photos:

1. **Light** – Less than 50% canopy removed (Figure 4)
2. **Heavy** – More than 50% canopy removed (Figure 5)
3. **Clearcut** – 100% canopy removed (Figure 6)
4. **Land Clearing** – Land use change to non-forest use (Figure 7)

Harvests classified as Land Clearing were recorded but excluded from the analysis because these operations are ineligible for the BMP Program. By contrast, Clearcuts were included because they are eligible and because they are intended to have the area return to forest cover.

While it may seem impossible to separate Land Clearing for land use change from Clearcut timber harvests, in practice it was easy to make this distinction. We used factors such as the size of the cut, its location relative to roads, the size of the parcel, the addition of any structures, and whether any other harvesting occurred in the same parcel to make these determinations.

When harvest intensity varied across an ownership, we treated that as multiple harvests. The most common example was where a Clearcut occurred in one portion of a property, with a Light cut happening elsewhere. We treated these as multiple harvests because there was no other way to capture the presence of Clearcuts in particular. These situations happened rarely, so their impact on final calculations is minimal.

Last, we identified all the areas where timber harvesting occurred within 100 feet of a stream. We identified these areas by intersecting the final Watershed timber harvest layer with a 100-foot buffer of Watershed streams. We used the National Hydrography Dataset (NHD) stream layer to produce this buffer because it is very accurate and includes smaller streams than similar layers.

Figure 4. Light harvest before (left) and after (right). More canopy remains than was removed by cutting.

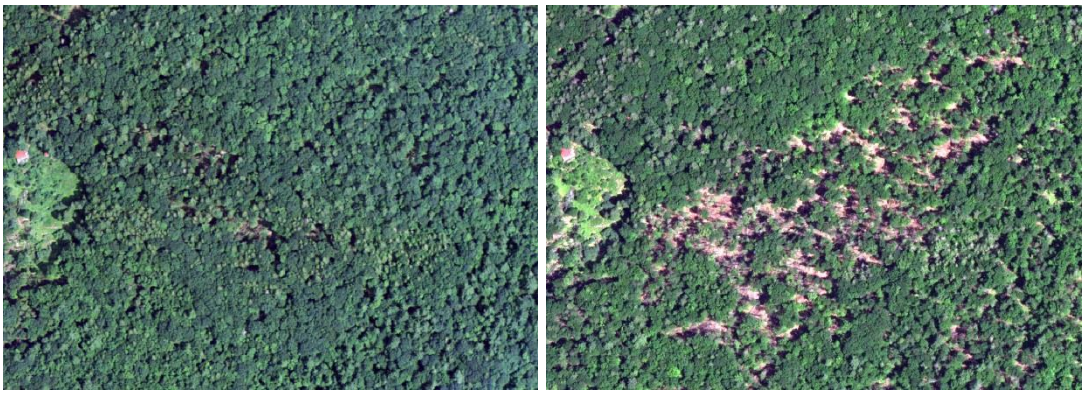

Figure 5. Heavy harvest before (left) and after (right). Less canopy remains than was removed by cutting.

Figure 6. Clearcut before (left) and after (right). All the canopy has been removed.

Figure 7. Land Clearing before (left) and after (right). Note the closeness to the road and addition of a structure. These factors distinguish this Land Clearing from a Clearcut.

Results

Goal 1 – Determine the Number of Harvests that Occur Annually in the Catskill/Delaware Watershed

The analysis located 491 harvests between July 2013 and July 2015. Of those, 126 were Land Clearing and excluded from the analysis. That left 365 actual timber harvests totaling 14,183 acres. Dividing these results by two gives annual figures. Thus, the Catskill/Delaware Watershed has 183 timber harvests annually, covering an area of 7,092 acres. This area is about 1.25% of the approximately 567,000 acres of private forestland in the Catskill/Delaware Watershed (Watershed Agricultural Council Forestry Program 2013).

Of these harvests, the vast majority (81%) were Light. Light cuts also represented 93% of total harvested acres. Heavy cuts made up 6% of the acreage, while Clearcuts represented just 1% (Figure 8).

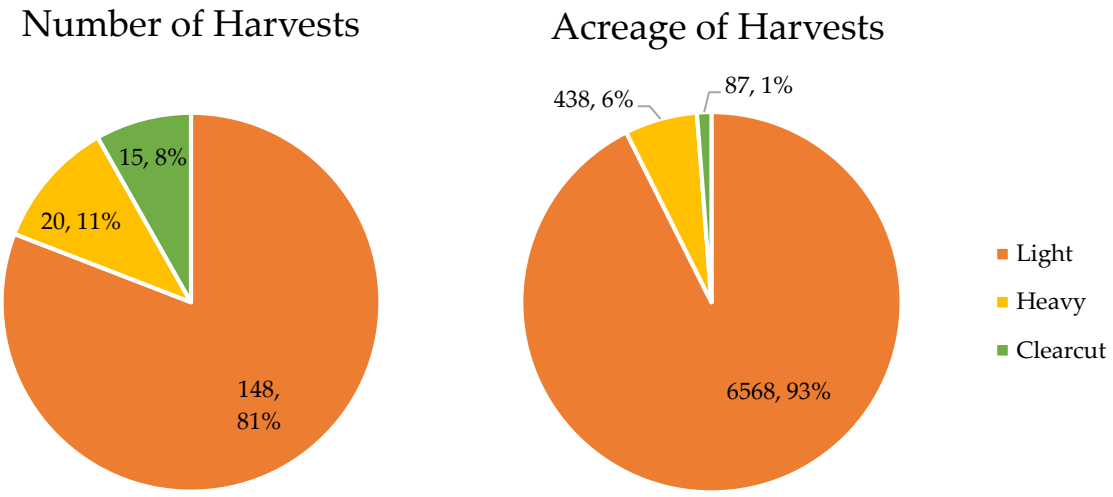

Figure 8. Annual number (left) and acreage (right) of timber harvests of various intensities in the Catskill/Delaware Watersheds. In all, 183 harvests occur annually, covering an area of 7,092 acres. Acreages may not sum perfectly due to rounding.

Goal 2 – Determine the Percentage of Harvests in the Catskill/Delaware Watershed that Participate in WAC's BMP Program

Of 183 annual harvests, 45 (25%) were BMP projects. In other words, based on the raw number of harvests, WAC funds BMPs on 1 out of 4 Watershed timber harvests.

From a water quality protection view, it makes more sense to evaluate the BMP Program's reach on how many harvested acres it is involved with. Although factors like harvest intensity and stream crossings can affect water quality even on small harvests, everything else equal, a 200-acre harvest is likely to have greater water quality impact potential than a 20-acre one.

When we assess reach based on acreage, the BMP Program's impact becomes greater. Of 7,092 acres harvested annually, 2,854 (40%) occurred on BMP projects.

BMP Program participation varied by harvest intensity. Nearly all BMP projects occurred on Light harvests (92%, Figure 9). Loggers doing Light cuts were twice as likely to use the BMP Program as those doing Heavy cuts, and four times as likely as those doing Clearcuts (Figure 10).

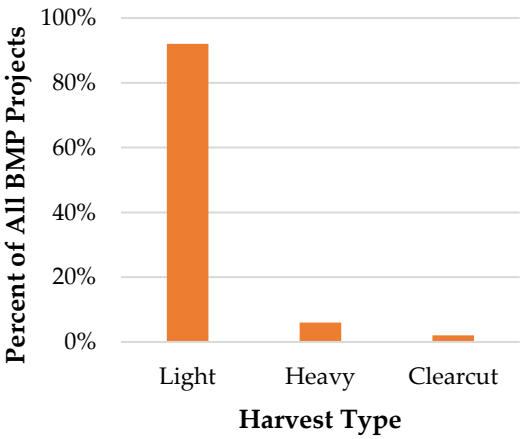

Figure 9. Percent of BMP projects by harvest type. Nearly all BMP projects were Light. Heavy cuts and Clearcuts made up 19% of harvests but were only 8% of BMP projects.

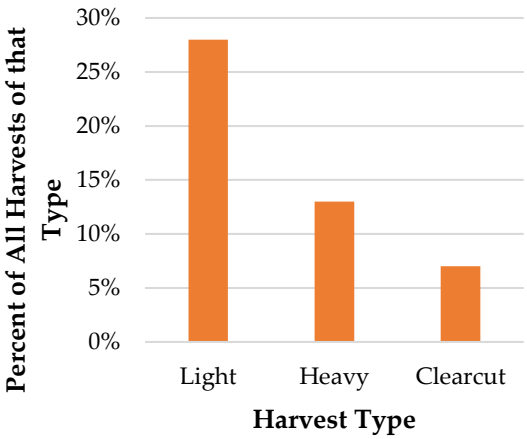

Figure 10. Percent of each harvest type that were BMP projects. Loggers were much more likely to use the BMP Program when doing a Light harvest than they were when doing a Heavy harvest or Clearcut.

Program participation was also inconsistent across the Watershed. BMP Projects often clustered in certain areas, such as around Arkville. There were also regions where the BMP Program had no projects at all, such as the southern tip of the Watershed around the Neversink and Rondout Reservoirs (Figure 11).

In some ways these results make sense. Arkville is home to a frequent BMP Program participant. By contrast, the southern portion of the Watershed is far from the WAC office. Loggers there may not be familiar with WAC or the BMP Program.

That said, there are also areas of the Watershed close to WAC offices where involvement is low. Walton, Bovina, and Andes all had numerous logging jobs, yet they had comparatively few BMP projects.

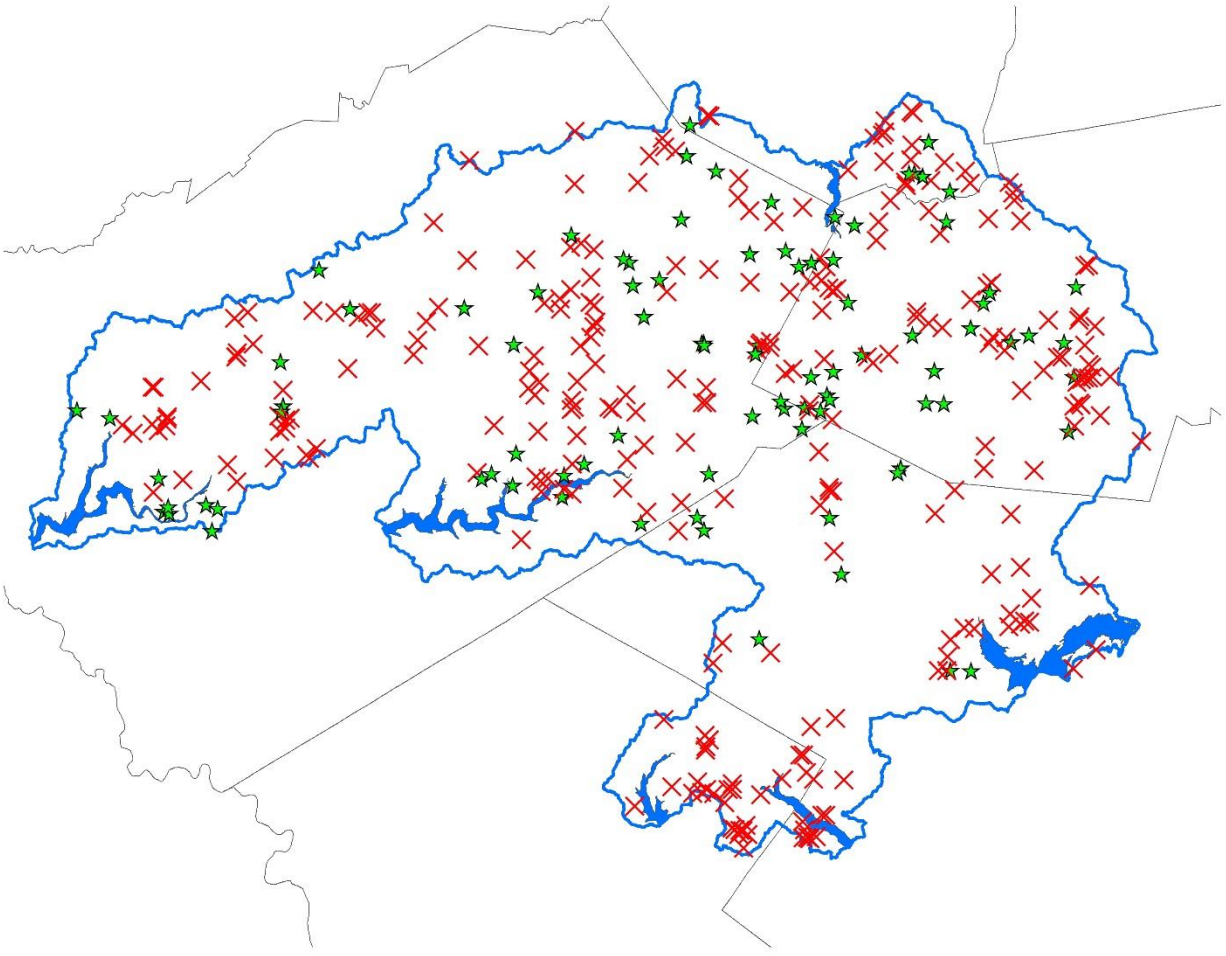

Figure 11. On this Watershed map, stars show BMP project harvests and X's show non-BMP project harvests. BMP projects often clustered geographically. Some areas had many projects, while others had none. Of particular concern is the near absence of BMP projects in areas close to the Neversink, Rondout, and Ashokan Reservoirs.

Goal 3 – Determine the Average Size (Acres) of Harvests in the Catskill/Delaware Watershed

With 183 timber harvests totaling 7,092 acres annually, the average size of timber harvests in the Catskill/Delaware Watershed is 39 acres. The smallest harvest was a 0.1-acre Clearcut, and the largest was a 360-acre Light cut.

Average harvest size varies with cut intensity. Overall, the heavier the cut, the smaller the average acreage (Figure 12).

The average ownership size for properties where harvesting occurred was 115 acres. The smallest ownership with a timber harvest was 4 acres, and the largest was 1,108 acres.

Harvesting occurred overwhelmingly on bigger properties. 62% of harvesting landowners owned more than 50 acres. 87% of harvested acres occurred on properties larger than 50 acres (Figure 13).

BMP projects were more likely to occur on larger harvests. The average area of a BMP project harvest was 63 acres, twice the average area of non-participating harvests (31 acres). That said, there were many large harvests that were not BMP projects, among them the largest harvest in the study.

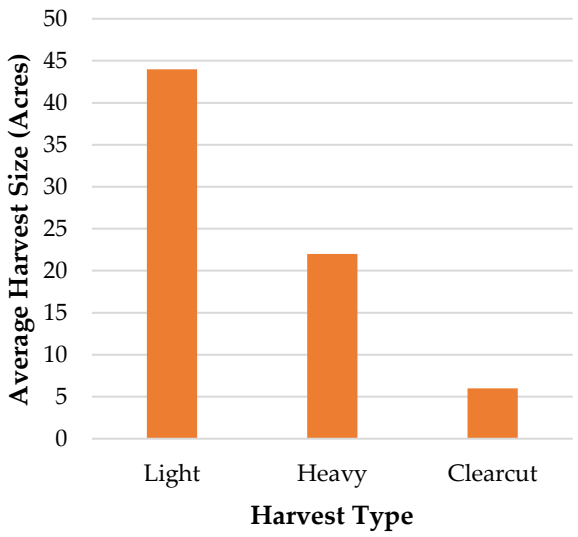

Figure 12. Average harvest size varied with cut intensity. Clearcuts averaged 6 acres, 14% of the average Light harvest size (44 acres).

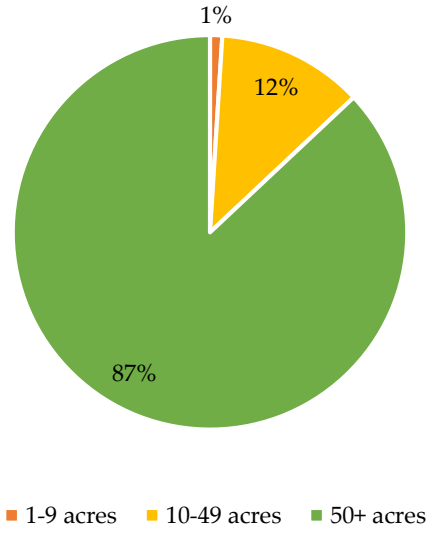

Figure 13. Timber harvesting occurred overwhelmingly on bigger properties. 87% of harvested acres occurred on properties larger than 50 acres.

Goal 4 – Estimate the Frequency and Size (Acres) of Catskill/Delaware Watershed Harvests Occurring within 100 Feet of a Stream

Of 183 harvests annually, 76 (41%) had at least some area within 100 feet of a stream. In total, 347 acres of harvesting occurred within 100 feet of a stream (5% of total harvested acres). The average acreage of riparian area cut in harvests that had riparian cutting was 5 acres.

Of the harvests that had riparian cutting, the BMP Program was involved with 26 (34%). Harvested acres in these jobs accounted for 138 acres (40%) of the 347 riparian acres harvested.

As cutting intensity increased, the amount of harvesting in riparian areas went down. While 5% of Light acres occurred in riparian areas, just 3% of Heavy acres and 1% of Clearcut acres happened within 100 feet of a stream (Figure 14). This is good news for water quality. Multiple studies conducted at Frost Valley Model Forest have examined the relationship between cutting intensity and stream chemistry (Siemion et al. 2011, Wang et al. 2006, Burns and Murdoch 2005). These studies found that when less than 40% of the basal area is removed, increases in common water pollutants like nitrates are minimal and short term. However, as intensity increases to 68% and beyond, those increases become significant and long-lasting, particularly for nitrates.

The Frost Valley studies' 40% figure is close to the Light definition in this project, and 68% and above are close to the Heavy and Clearcut designations. The minimal riparian harvesting at Heavy and Clearcut levels therefore suggests that cutting trees specifically is not a threat to water quality in the NYC Watershed. That said, the impacts of the access systems needed to remove trees from the woods—even in Light harvests—are and should remain a concern.

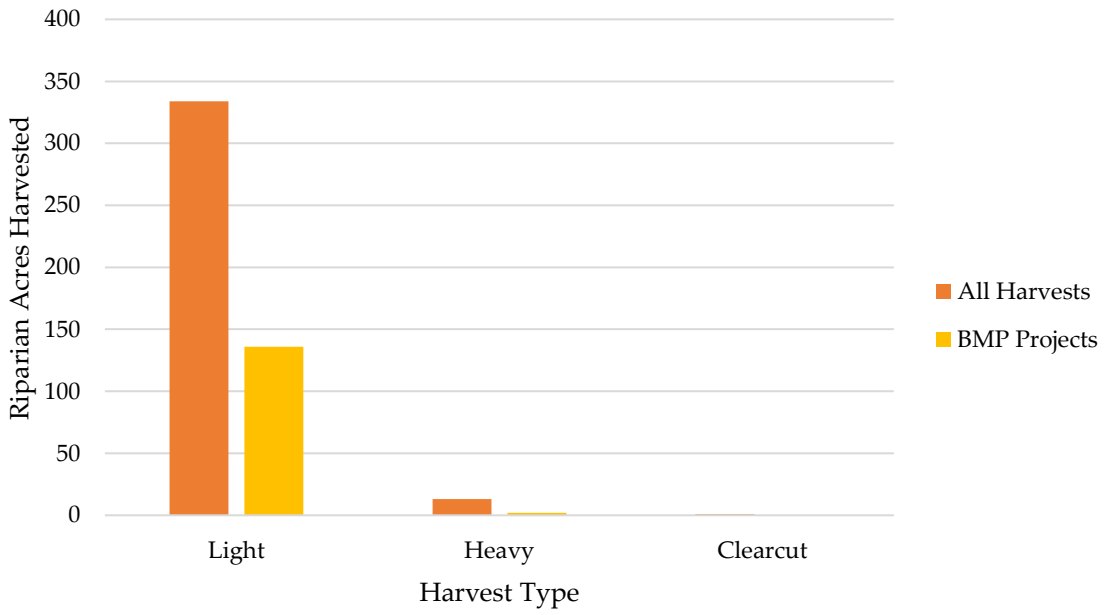

Figure 14. Annual acreage harvested within 100 feet of a Catskill/Delaware stream by harvest type.

Critically, our analysis could only look at whether a streamside area was in the cut itself. It was not possible from the aerial photos to determine if cutting was less intense in streamside areas (for example, if riparian buffers were used).

It was also not possible to assess the reach of the BMP Program's Stream Crossing cost-share funding. Access systems in general did not show up in this analysis. When they did, only portions could be seen. As a result, there was no way to assess where stream crossings occurred. In addition, access systems and harvest areas often do not line up. Many Catskills harvests have long skid trails leading from the landing to the harvest area. These skid trails may have stream crossings, but because no harvesting occurs along them, they could not be included in our analysis (Figure 15).

Although the percentage of stream crossings WAC cost-shares could not be quantified, the percent acreage of riparian area harvested on BMP projects was identical to the percent acreage of total area harvested on BMP projects (40%). From this, we can assume that loggers are no more or less likely to work with the BMP Program when they have riparian areas in their harvests. It is therefore likely that the reach of the Stream Crossing portion of the BMP Program is comparable to the reach of the program overall.

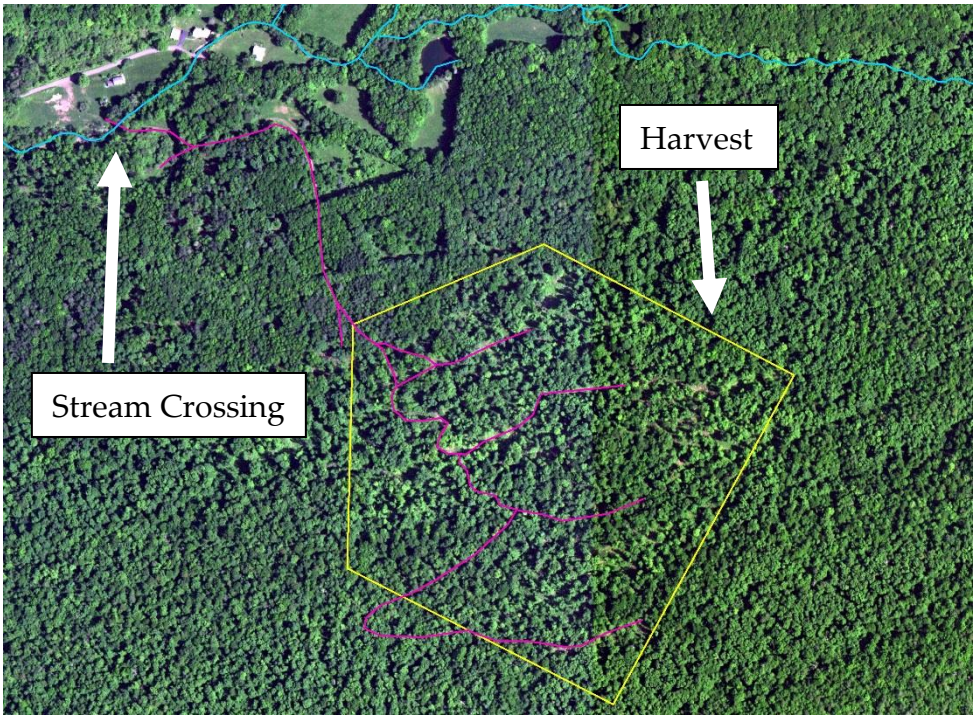

Figure 15. An example skid trail layout (pink) from a BMP project. Note the long skid trail to get into the harvest. A stream crossing occurs on this trail at the spot indicated by the arrow, but there is no way to include it in the analysis because there was no cutting along the trail. Because we could not reliably identify all access systems for all harvests, our analysis could not quantify the percentage of stream crossings the BMP Program cost-shares.

Other – Forest Loss Relative to New England

Although it was not a project goal, an unexpected benefit of this research is that it revealed how much forest cover the Catskill/Delaware Watershed lost to other land uses between July 2013 and July 2015. By comparing that loss to similar figures recently published for New England, we gained a sense of how the Watershed is faring in regards to a key water quality threat: forest fragmentation. The results speak well of the Watershed's conservation work.

In 2017 forest researchers from Harvard University released an update of their conservation vision for New England, known as Wildlands and Woodlands (Foster et al. 2017). Their findings were sobering. From 1990 to 2010, New England lost 24,000 acres of forest to development annually. With about 32 million acres of forested land, New England is losing 0.075% of its forest cover every year. At the same time, annual state and federal funding for land protection in New England has declined 50% since 2008. This loss of funding slowed the pace of land acquisition (primarily in conservation easements) by two thirds. Land acquisition in New England went from more than 150,000 acres per year in the early 2000s to just 50,000 acres per year since 2010.

By contrast, the Catskill/Delaware Watershed fared well in terms of forestland lost to development. According to the NYC DEP, the Catskill/Delaware Watershed has about 800,000 acres of forest (Terry Spies, pers. comm. 11/16/2015). Our study found the Catskill/Delaware Watershed loses 57 acres of forest to another land use annually. At that pace, the Catskill/Delaware Watershed is losing 0.0071% of its forest cover annually—a rate one tenth of New England's.

Most of New England's forest loss occurred in the suburban areas around its coasts. Yet even the state farthest from these areas, Vermont, still lost forest at a rate more than four times faster than that in the Watershed. Vermont lost on average 1,500 acres of forest annually out of 4.5 million acres of total forest, or 0.033% per year (Brown 2017).

These results suggest that Watershed land protection efforts like the DEP's Land Acquisition Program, WAC's Conservation Easements Program, and the Forestry Program's 480-a Focus are effective at reducing forest conversion in the NYC Watershed. These programs provide a conservation-minded alternative to subdivision and development, which are most commonly prompted when landowners face financial pressure (Stone and Tyrrell 2012).

That said, it was not the goal of this study to establish a causal link between Watershed land protection efforts and reduced fragmentation. Additional research is required to determine whether lands purchased or eased by Watershed organizations would have been subdivided and developed if those organizations had not protected the land.

Discussion

Using aerial photographs and ArcGIS to identify timber harvesting in the Watershed allowed us to conclude that 25% of logging jobs and 40% of harvested acres participate in WAC's BMP Program annually. As a result, there is the potential to increase the number of participating logging jobs and harvested acres in the future. The question for the WAC Forestry Program Committee is – do we want to increase participation in the BMP Program? Committee members may find the following background information useful in answering this question.

Are BMPs Effective at Reducing Water Pollution from Timber Harvesting?

Before we decide to spend more time and money expanding participation in the BMP Program, we should revisit the ultimate goal of installing Best Management Practices (BMPs) – protecting water quality.

BMPs installed through WAC's BMP Program are effective at reducing water pollution from timber harvesting. A recent review of 81 BMP evaluation studies from across the US concluded that "forestry BMPs protect water quality when constructed correctly and in adequate numbers" (Cristan et al. 2016). In the northern region of the US specifically (including New York), 20 BMP studies found overall that when BMPs were used, logging's effects on water quality, macroinvertebrate communities, and fish populations were all minimal (Cristan et al. 2016). In paired watershed studies in the Mid-Atlantic States, forestry BMPs have been shown to reduce sediment delivery to streams by 53 to 94%, total nitrogen to streams by 60 to 80%, and phosphorous to streams by 85 to 86% (Edwards and Williard 2010).

Forestry BMPs are particularly valuable at stream crossings. A Virginia study simulated rainfall to assess how BMPs affected sediment delivery at stream crossings. The authors found that mean sediment delivery was 45% lower at crossings that had BMPs compared with crossings without them (Morris et al. 2016).

Does the BMP Program Result in Loggers Installing More BMPs than They Would Have Otherwise?

A formal, in-woods comparison of BMP project and non-BMP project harvests has never occurred in the Watershed. That said, comparing BMP tallies from funded projects against other regional BMP evaluations makes it clear that the BMP Program does result in more and better BMPs. Previous Watershed BMP evaluations (VanBrakle et al. 2013, Munsell et al. 2006, Schuler and Briggs 2000) all found low BMP implementation in two categories in particular: stream crossings and water diversion devices. In the case of water diversion devices, BMP implementation was all but absent. These studies all had few BMP Program participating harvests in them.

The BMP Program is designed largely to address the two BMP problem areas these studies identified. Although the program funds other BMPs, two core elements of the program are funding for waterbars and proper stream crossings.

That focus has paid off. In contrast to the poor results in the above studies, the BMP Program cost-shares a large number of both stream crossings and water diversion devices. In 2016 alone, the BMP Program paid for 3,284 waterbars and 21 stream crossings. The very fact that WAC cost-shares so many of these BMPs makes it clear that more BMP work is happening on cost-shared projects than on non-participating harvests.

What Are the Trends in BMP Program Growth?

The BMP Program has had an impressive and steady rate of growth over the past fifteen years. The chart below comes from the *2016 BMP Program Evaluation & Summary* report and shows historic trends in the number of BMP projects approved and paid annually. Since the inception of the BMP Program, we have seen a growth of approximately 2.7 additional projects each year. This growth suggests that even without additional marketing, the BMP Program can expect to see more loggers working with the BMP Program on more harvests in the coming years.

Figure 16. Annual BMP Program projects approved and paid over time. Starting from nothing in the 1990s, the BMP Program has a growth trend of 2.7 more projects every year.

Are There Opportunities to Accelerate the BMP Program's Reach Faster than Its Historic Growth?

If capacity existed to complete more BMP projects, staff have discussed a variety of techniques that could expand the BMP Program's reach. Some of these techniques involve increasing WAC's marketing of the BMP Program to help non-participating loggers learn more about it. Other ideas center on improving the BMP Program to make it more attractive to loggers. Ideas discussed by staff include:

Marketing Opportunities

1. Hang brochures on logging equipment staff sees at non-participating landings. Similar simple marketing efforts worked for the program in the past but have not been used in recent years.
2. Survey landowners who harvested timber (as determined by this study) and ask them who their logger was. Use this information to identify loggers who work in the Watershed but who don't participate with the BMP Program.
3. Survey loggers to find out why they do or don't participate with the BMP Program on certain jobs.
4. Emphasize the message that the BMP Program is available even on small jobs. WAC wants to be involved on firewood cuts, small-acreage cuts, and flat harvests just as much as it wants to be involved on large, steep jobs.
5. Contact 480-a landowners in advance of scheduled timber harvests to let them know about the BMP Program.

Program Improvement Opportunities

1. Encourage loggers doing smaller harvests to participate by providing additional cost-share funding for landings. We would accomplish this by raising our rates for gravel, geotextile fabric, and hay and grass seed. This extra landing incentive would boost the cost-share funding available for small harvests, which have landings but typically little skid trail length and few waterbars.
2. Make it easier for loggers to know if an upcoming harvest is in or out of the Watershed. Many non-participating harvests were located close to the Watershed boundary. WAC staff are currently developing an online GIS tool that will allow loggers and others to quickly determine if a tax parcel is in the Watershed and eligible for funding.
3. Provide a bonus cost-share payment to first-time participants to encourage them to try the BMP Program.
4. Create a "finder's fee" or referral program for participating loggers who bring new loggers into the program.
5. Hold logger focus groups to get additional ideas for improving the BMP Program and to provide them chances to interact with WAC foresters.

Does the Forestry Program Have the Staff Capacity to Increase the BMP Program's Reach?

In the FY18Forestry Program work plan, 60% of one FTE is allocated to implementing approximately 46 BMP projects annually. This represents 30% of the total Forestry Program WOH field staff capacity (2 FTE's). The Management Assistance Program requires 52% of one FTE, or 26% of the total WOH field staff capacity. The remaining 44% of WOH field staff capacity is allocated to the WFMP Program, logger training, and administrative tasks.

Historically Forestry staff has been able to restructure work plan tasks to accommodate the annual growth of 2.7 additional BMP projects. However, this strategy is nearing its end as opportunities to restructure contract and grant responsibilities dwindle. Aggressively assuming an additional 22% of WOH field staff capacity can be diverted from the WFMP Program, logger training, and administrative tasks, we will still be unable to accommodate normal annual projected growth in BMP projects by 2022, halfway through the next WAC/DEP contract.

To put it simply, in the next few years we will be unable to fund BMP projects because we will lack the staff capacity to work with that many loggers. This limit will be reached even sooner if the Committee directs staff to capitalize on the opportunities for BMP Program growth identified above.

How Much More Staff Capacity Will It Take to Continue to Grow the BMP Program's Reach?

The Forestry Program work plan currently allocates 2.7 staff days per BMP project. However, increasing the reach of the BMP Program beyond the normal growth trend will take additional effort beyond what staff do currently. Although growth in the program has been steady, expanding ever higher will create diminishing returns. The most willing logger participants will already be participating, leading to more small jobs with less interested participants. It is therefore reasonable to assume that additional BMP projects will require more time. Staff assume that this increase will amount to an additional day per project, with the average staff time cost increasing to 3.7 days per BMP project as we expand.

We can use this 3.7 days per project figure along with the results from the GIS analysis to determine how much additional staff time it would take to reach various levels of harvest coverage. The chart below breaks down those levels. At 40% harvest area covered (our current accomplishment), no additional staff time is needed. To raise that area covered even to 50%, however, requires an additional 20% of an FTE. Raising our harvest acreage covered to 90% would require more than one additional full-time forester (Table 1).

Based on this assessment, it is clear that the BMP Program cannot achieve significant growth in its reach with the Forestry Program's current staffing model. There is not enough slack in the current staffing model to increase the BMP Program's reach even to half the eligible harvested acres in the Watershed.

% Harvest Acres Covered	Number of Additional BMP Projects Needed Annually	Additional Staff Time Needed Annually (Days)	% FTE	Projected Cost-Share Payment Increase (Does Not Include Cost of Staff)
40% (current)	0	0	0%	$0.00
50%	11	41	20%	$38,065.43
75%	39	144	72%	$134,959.26
90%	55.5	205	102%	$192,057.41
100%	137.5	509	254%	$475,817.90

Table 1. An assessment of how much additional staff capacity would be needed for the BMP Program to reach various percentages of harvested acres in the Catskill/Delaware Watershed.

A Key Strategic Forestry Committee Question

This report is intended to provide Committee members with the information they need to answer one fundamental question: **What percent of the total harvested acres in the Watershed should participate annually in the BMP Program?** Answering this question will set a goal for BMP Program participation and affect the allocation of future resources. Setting strategic goals can be difficult, so when considering different answers for this question, Committee members should remember what makes a goal SMART:

SMART Goals	
S	Specific (simple, sensible, significant)
M	Measurable (meaningful, motivating)
A	Achievable (agreed, attainable)
R	Relevant (reasonable, realistic and resourced, results-based)
T	Time bound (time-based, time limited, time/cost limited, timely, time-sensitive)

Literature Cited

Brown, J.E. 2017. Report: Vermont losing 1,500 acres of forest every year. The University of Vermont, University Communications. Available online at: https://www.uvm.edu/newsstories/news/report-vermont-losing-1500-acres-forest-every-year.

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.

Cristan, R., W.M. Aust, M.C. Bolding, S.M. Barrett, J.F. Munsell, and E. Schilling. 2016. Effectivenss of forestry best management practices in the United States: literature review. *Forest Ecology and Management* 360: 133-151.

Edwards, P.J. and K.W.J. Williard. 2010. Efficiencies of forestry best management practices for reducing sediment and nutrient losses in the eastern United States. *Journal of Forestry* 108(5): 245-249.

Foster, D., et al. 2017. *Wildlands and Woodlands, Farmlands and Communities: Broadening the Vision for New England*. Harvard University, Petersham, MA. 44 p. Available online at: http://www.wildlandsandwoodlands.org/sites/default/files/W%26W%20report%202017.pdf.

Livengood, K. 2016. Extracting harvest sites from imagery. *Forestry Source* 21(6): 16-17.

Morris, B.C., M.C. Bolding, W.M. Aust, K.J. McGuire, E.B. Schilling, and J. Sullivan. 2016. Differing levels of forestry best management practices at stream crossing structures affect sediment delivery and installation costs. *Water* 8(3): 92-109.

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.

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.

Siemion, J., D. Burns, P. 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.

Spies, T. 2015. Re: Watershed % Forest Cover. Email communication. Terry Spies is Section Chief, GIS, at the NYC Department of Environmental Protection.

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.

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.

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.

Watershed Agricultural Council Forestry Program. 2013. "Annex 3: Spatial analysis of NIPF in the NYC Watershed" in *MyWoodlot.com: A Refinement to the Watershed Forest Management Planning Program*. 35 p.