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Executive Summary

Introduction

New York City gets its drinking water from three watersheds that are grouped into two systems – the Cronton system and the Catskill-Delaware (Cat-Del) system. For over a century, New York City did not have to filter any of its water, as these watersheds provided it with what was characterized as the "champagne of tap water." In the 1980s, it became clear that the quality of New York City's water was declining and the Environmental Protection Agency (EPA) might mandate filtration under the Surface Water Treatment Rule (SWTR) of the Safe Drinking Water Act (SDWA). New York City preemptively decided to filter the Cronton system. Building a filtration plant for the Cat-Del system (90% of the city's water by volume) was estimated to cost, in 1990 dollars, $4-8 billion in up-front capital costs and $250 million annually in operating costs (Appleton, 2006). The city looked for a way around this huge expense and began to explore watershed management.

Following years of negotiation between the city, farmers in the watershed, the watershed towns, and the EPA, a Memorandum of Agreement (MOA) was signed in 1997. Under the agreement, New York City is purchasing critical lands, regulating to some extent land uses, financing a watershed agricultural program, and investing to upgrade infrastructure, such as septic systems and waste water treatment plants. This is costing them substantially less, around $1.5 billion so far. In July, 2007 the city was granted 10 more years of filtration avoidance from the EPA as the program was working as intended and improving water quality.

This case focuses specifically on the watershed agricultural program (WAP). Under an agreement with farmers, a farmer-run institution, the Watershed Agricultural Council (WAC), was established to develop and implement best management practices (BMPs) on farms whose owners voluntarily participate. The city is financing the operating costs of the WAC and covering all the costs to farmers of adopting BMPs. In this sense, the WAP is an example of "payments for ecosystem services" (PES): the city is paying for the service of improved source water quality. This program has been analyzed by several academics and widely discussed in "gray" literature for its innovation and success. Agriculture is only one source of pollutants to the city's drinking water, however, and others, especially ex-urban development, continue to pose a threat.

Definition of the analysed EPI and purpose

The WAP was one component of the city's strategy to protect drinking water quality by improving source water quality. The source for New York City's drinking water is surface water in the Catskill-Delaware watersheds. The quality of this water was being threatened by dairy farming, which was growing more concentrated, and by exurban development. The goal of the WAP was to improve water quality in the Cat-Del system (to be achieved in combination with the other watershed management initiatives being undertaken by the city), in order to avoid filtration that could be required by the EPA.

Rationale for this Case Study

This case study is worth close examination for a couple reasons. First, at the time the policy was adopted, the idea of watershed management for water quality improvements and voluntary agreements to manage non-source water pollution were considered nice ideas in theory but unlikely to ever work in practice. New York City proved that these strategies can work on the ground. New York City's policy quickly became a poster child for those interested in ecosystem services. Despite this, the New York City approach has not been as widely replicated as many thought it would be. It thus appears that there were a unique set of circumstances that allowed for a successful policy in New York that may not be as easily copied as appears at first look. Deeper analysis is thus warranted to draw out lessons for water managers.

Legislative setting and economic background

Although drinking water is provided locally, in the United States it is regulated by the federal government, largely through the Clean Water Act and the 1974 SDWA. The SWTR, promulgated under the SDWA, requires filtration of surface water systems unless certain conditions related to water safety are met. Only a handful of local governments in the US have been able to avoid filtration by engaging in watershed protection efforts and New York City is one of them. This saved them the enormous costs of building and running a filtration plant, the cost of which would have easily doubled water and sewer rates for New York residents (Appleton, 2006). The watershed management approach was thus spurred by the desire for cost savings.

As a quirk of history, New York City has the authority to directly regulate the watersheds from which it obtains its drinking water (within a 125 mile radius of the city); however, it met enormous resistance when first attempting to do so. Farmers made clear to the city that regulations would force them to bear significant costs and were angered at this direct hit on profits solely for the benefit of urban-dwellers miles away. The city decided to back-peddle on direct regulations and instead entered into negotiations with the farmers. The end result was an agreement to compensate farmers in the region for upgrades that improve water quality. In addition, the city realized it preferred agriculture to development in the watershed and is working to keep farming in the region viable. The final agreement was voluntary at the level of the individual farmer, but had a required participation percentage, which, if not met, would trigger the city to begin regulatory actions.

A new institution was developed to run the farm program, the WAC, mentioned earlier. It is a locally controlled non-profit. The WAC and the improvements it oversees on farms are funded by the New York City Department of Environmental Protection (DEP), as well as some funds from federal agencies. Local control was critical to achieving farmer agreement. For farmers struggling economically, not only are they relieved of having to bear the costs of improving the city's drinking water (something argued as highly inequitable), but they are receiving aid for improvements that provide them with other benefits (discussed further below).

Brief description of results and impacts of the proposed EPI

The WAP program has saved the DEP billions of dollars. It has also worked to preserve agriculture in the Cat-Del watershed. Farmers were having a difficult time making a viable living and development pressure was forcing some farmers to sell their land to developers. New York City's commitment to agriculture—environmentally-friendly agriculture—has helped the local economy.

Water quality has been improved. New York City water is constantly monitored by the DEP. Their website notes that the department undertakes 330,000 tests of the water each year from 1,000 locations in the city as well as 230,000 tests in the watershed. Water quality has been high enough that the city has been able to avoid filtration in the 14 years since the original MOU was signed. That said, the issue cannot be considered "solved," as water quality threats remain, particularly from ex-urban development, which is not addressed in the farm program.

Conclusions and lessons learnt

The WAP is heralded as a template other localities should follow by a variety of groups from environmentalists to policy analysts. The WAP proved that voluntary programs can work—at least when everyone has something to gain from the program and supports its overarching mission. The WAP, in conjunction with the city's other efforts in the watershed, has also demonstrated that watershed management can cost-effectively produce high-quality drinking water. This can be done in a working agricultural landscape, and thus, the program has also shown that the economic viability of farming and environmental protection need not be at odds. It is unlikely the city's approach would have worked in a watershed that was much more developed, however. The only other cities in the US that have been able to avoid filtration through watershed management have a substantial portion or all of their watersheds in public ownership. Much of the Cat-Del watershed is forested, 20% is preserved in a state park, and the other development is not very intensive. New York City's policy is thus limited in applicability, as many other communities in the US draw water from heavily developed watersheds. Finally, it is unlikely New York City would have invested the time or resources in watershed management if not facing the unthinkably high costs of filtration if it failed to do so.

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1 EPI Background

As already mentioned, drinking water in the United States is regulated through the SDWA. In 1986, the EPA issued the SWTR in response to an amendment to that act. It is focused on controlling microbial contaminants. The SWTR sets forth requirements that water supply systems must meet in order to obtain a Filtration Avoidance Determination (FAD), which allows them to forgo filtration of drinking water. These include: monitoring of fecal coliform and total coliform; meeting certain testing requirements and concentration levels in the source water; providing adequate disinfection; meeting site specific criteria for presence of certain viruses, total coliforms, and disinfectant byproducts; meeting certain turbidity levels; developing and implementing a watershed control program; undertaking annual third-party inspections; and the system can never have been the source of a waterborne disease outbreak.

In the US, only a few major cities have been able to avoid filtration of their drinking water. These include San Francisco, Seattle, and Portland, where 100% of the land is in public ownership, and Boston, where 53% is in public ownership (United Nations Development Programme *et al.*, 2000). In contrast, at the time of the MOA, New York City owned less than 7% of the land (and most of this was the land under the reservoirs), and there was another 20% owned by the state. New York City thus faced a much greater challenge of having to find a way to manage land uses on private lands.

As stated earlier, 10% of New York City's water came from a watershed that had already experienced significant development, and filtration was unavoidable. For the 90% of the water that came from the Cat-Del system, the DEP looked for a way to avoid the enormous expense of filtration. In 1990, the DEP released a draft of watershed regulations ([1]) and in its 1993 report to the EPA for a FAD, New York City based its watershed protection approach on land acquisition and strict regulations. Watershed residents reacted with hostility to both regulations and land acquisition, as the city described them in the early 1990s. Watershed residents were concerned about a curtailing of economic development, a drop in property values, and a decrease in tax revenues for local governments (Platt et al., 2000). It was clear that the city would be unable to move forward with regulations or the particular approach to land acquisition it initially developed.

This case focuses on how the city went about addressing pollution from agriculture. Soon after the release of the 1990 regulations, a local farmer invited the DEP to his land to demonstrate how economically destructive the city's regulations would be to farmers in the watershed; DEP Commissioner Al Appleton accepted and from this visit realized that enforcing stringent regulations on farmers was not going to be the answer to the city's problem (Appleton, 2006). In addition, it would be

[1] It is a quirk of history that New York City does have authority to regulate the watershed from which they obtain their drinking water, subject to oversight from the New York State Department of Health (Finnegan,1997).

impossible for the city to monitor non-point source pollution from farms, and so it was clear that without landowner buy-in, the regulations would not be sufficient to protect source water quality.

Following the DEP visit to the watershed, the Deputy Commissioner of the New York State Department of Agriculture suggested that the farmers and the city begin a process of mutual education (Appleton, 2006). An Ad Hoc Taskforce on Agriculture was created, chaired by the DEP Commissioner and facilitated by Dennis Rapp from the New York State Department of Agriculture (Isakson, 2002). At the end of 1991, the Taskforce produced the so-called "Brown Book," representing the agreement between farmers and the city. Under the agreement, the farmers would be held harmless from regulations, except for willful polluters, and in exchange, the WAC would be established to implement Whole Farm Plans (WFPs) on watershed farms.

Whole Farm Planning is not a concept unique to the New York City policy. The idea behind it is to assess farm operator goals and conditions, as well as all off-farm impacts from farming activities, and then develop a holistic plan to improve environmental impacts through the adoption of BMPs), while safeguarding the farmer's goals (Ervin and Smith, 1996). Plans are thus tailored to individual farms and BMPs are chosen that reduce pollution and are also compatible with farm management goals. Some examples of BMPs include stream bank fencing, developing a nutrient management plan, improving manure storage, developing animal trails, precision feeding, and installing a trough or tank.

The WAC is farmer-run, operated with financing from the city. Cornell University provides research support. A sticking point in the agreement, however, was whether participation by the farmers would be voluntary. The farmers wanted autonomy. The DEP was concerned that voluntary programs had historically been a failure. The DEP Commissioner and a Delaware County farmer finally came to a resolution: the program would be voluntary for individual farmers, but the WAC would guarantee a participation rate of 85% within 5 years, and if not attained, the city could revert back to traditional regulation (Appleton, 2006). This agreement was signed in 1991 and the WAC was established. This same year the city received its first FAD from the EPA, granted for two years. It received another three year avoidance at the end of 1993. The WAP first focused on establishing WFPs on large farms and in 2009, New York City extended the WAP to small farms, as well.

Although the WAC is the focus of this case study, it is worth briefly mentioning the rest of New York City's efforts at watershed management. Negotiations with other stakeholders did not go as smoothly as those with the farmers. Amid the outcry from watershed communities, Governor Pataki convened a group to negotiate a compromise. All details were finally agreed upon and outlined in 1997 MOA. The MOA was signed by New York City, the state, EPA, the Coalition of Watershed towns, 40 watershed communities, and 5 conservation organizations (Platt *et al*., 2000). It was the basis for the EPA issuing New York City another 5 year FAD. The MOA includes numerous activities to protect source water including land acquisition, regulations, upgrading wastewater treatment plants, and improving septic systems. The agreement with the farmers was included in the MOA as the Watershed Agricultural Program (WAP).

New York City received another 5 year FAD in 2002 and a 10-year FAD in 2007. Both required updating and improving its watershed protection efforts. The 2007 FAD included waterfowl management, land acquisition, land management, a watershed forestry program, stream management, riparian buffer protection, wetlands protection, Croton watershed management, Kensico water quality control, turbidity control, infrastructure upgrades (e.g. for septic systems, wastewater treatment plants), as well as on-going efforts of the WAP discussed in this case study (New York City Department of Environmental Protection, 2011). The continued issuance of the FAD from the EPA is a clear indication that the approach to watershed protection taken by the city is working at meeting drinking water quality standards.

Baseline before EPI Implemented

New York City's water supply system was put in place between the 1840s and the 1960s. It was a technological marvel, drawing pure source water miles from the city through a gravity fed system. The initial system tapped just the Croton watershed, but as the population grew, so did demand for water, and the city had to expand several times to the present day system ([2]). Once completed, this system provided the city with pristine water, and so it largely withdrew its attention from the watershed until changes in the 1980s began to seriously impact source water quality. In the Cat-Del watershed, family farming was becoming economically challenging and agriculture in the region moved more toward concentrated dairy farming (Appleton, 2006). Exurban development also began to increase in the Cat-Del watershed, focused in environmentally sensitive areas, as these are also locations with high amenities. Without intervention, there is no doubt they city's water would continue to decline in quality due to increased nutrient and other pollutant loadings associated with intensification of dairy farming and increased development.

Water quality in the reservoirs of the Cat-Del watershed was not enough to cause safety concerns at the time that the city began watershed management activities, but efforts were recognized as necessary to prevent threats to human health. While farmers may have been interested in farm practices that would have reduced pollution, economic hardship in the area prevented them from investing in such technologies. At the time the city began its watershed management efforts, all the reservoirs were receiving excess phosphorus, such that they were all categorized as mesotrophic or eutrophic (National Research Council, 2000). Phosphorus levels were seen to be increasing, with loads exceeding 20μg/L, an amount that causes eutrophication (National Research Council, 2000). As discussed further below, direct regulation, while legally possible, would not have curtailed the trends in declining

[2] It is worth noting that demand was once again spiking in the 1980s, but instead of seeking out costly new supplies, the city adopted an aggressive and innovative demand management plan, which successfully reduced water consumption in the city.

water quality as the city could not effectively monitor the numerous non-point sources of pollution.

2 Characterisation of the case study area (or relevant river basin district)

The New York City DEP oversees the delivery of safe drinking water to over 9 million people in New York City and surrounding areas. New York City's drinking water is supplied by a system that includes 19 reservoirs and 3 controlled lakes, with a storage capacity of about 2 billion cubic meters (New York City Department of Environmental Protection, 2011). Water from these storage areas is taken via aqueducts to terminal reservoirs, from which is can be piped into the city's distribution system. The watershed supplying the city with its drinking water is almost 2,000 square miles, located northwest of the city. It is divided informally into two sources – the West of the Hudson River watersheds and East of Hudson. The East of Hudson system is the Cronton River watershed, which provides 10% of the city's drinking water. This watershed has experienced significant amounts of suburban development, and the decision was made early to filter its water. The West of Hudson system, also referred to as the Cat-Del system as it is a combination of the Catskill and Delaware watersheds (water from both comingles at the Kensington reservoir before being piped to customers), however, has received a filtration avoidance determination from EPA. As this case study focuses on a program implemented by the city in the Cat-Del watershed, the section focuses on characterizing the Cat-Del watershed and does not address the Croton watershed.

Environmental Characterization

The Cat-Del watershed is 1,597 acres. The Catskill part of the Cat-Del system, located east of the Catskill crest, is largely forested, with some farming and vacation homes (Appleton, 2006). The Delaware River basin has rolling hills, some forested areas, and a significant amount of dairy farming (Appleton, 2006). Around 20% of the land area in the Cat-Del watershed is in the New York State Catskill Forest Preserve. Close to three-quarters of the watershed is forested, 85% of which are privately owned ([3]). Farming, centered in the valleys, is the second largest land use after forests, making pollutant loadings from agriculture key to watershed management for potable drinking water. There are 40 towns with some land area in the Cat-Del watershed (National Research Council, 2000). Urban extent, while small in the watershed, still harms water quality through contaminated runoff, septic systems, and waste-water treatment plants.

Total annual runoff (the depth to which the drainage area would be covered if yearly runoff was uniformly distributed across it) estimated from stream gauges in the Cat-Del system ranges from around 30cm to over 150cm (New York City

[3] Information available on the WAC website: http://www.nycwatershed.org/aw_watersheds.html

Department of Environmental Protection, 2011). The ground is highly permeable and there are often steep gradients, producing rapid lateral subsurface flow (National Research Council, 2000). The region receives frontal storms from the west and north, coastal storms from the south, and local thunderstorms, producing an average precipitation of 47 inches (National Research Council, 2000). Large storms, rain-on-snow, and snowmelt contribute most of the flood risk on the 2,000 miles of watercourses in the Cat-Del watershed (National Research Council, 2000).

The city's reservoirs drain a much larger area than do natural lakes. Water entering the reservoirs largely comes from high-order streams, which results in erosion, large sediment loads, and contaminant loadings, and further, inflows to reservoirs are often channelized without buffer zones, leading in-flow to be highly related to precipitation events that can result in large pulses of pollutant loadings to the reservoirs (National Research Council, 2000). The city reservoirs have faced problems with eutrophication. Nitrogen and phosphorus can both lead to eutrophication, but phosphorous is of much more concern because it is the limiting factor for the growth of algae (National Research Council, 2000). Loadings come from waste water treatment plants, septic systems, agriculture, and urban runoff.

Economic Characterization

At the time of the 1997 agreement, New York City owned about 7% of the watershed (largely the land under its reservoirs), the state and conservation organizations owned another 20%, and the rest was in private hands, with agriculture and forestry the dominant land uses (Platt *et al.*, 2000). Much of the watershed has steep slopes that are not well-suited for development (Hoffman, 2008). Still, farming has occurred in this region for over 200 years (Bryant *et al.*, 2008). While not the majority of jobs, farming is a large part of the community of the watershed (Isakson, 2002). In 2000, there were 351 large farms (defined as having a gross annual salary of at least $10,000) in operation in the Cat-Del watershed, 90% of them being dairy farms with between 50 and 200 animals (National Research Council, 2000). Only 39% of farmers in watershed counties, however, claim farming as their principal occupation (Isakson, 2002).

This is a poor region. A survey of watershed farmers found that of those with a gross annual income over $10,000, a quarter earn less than $20,000, although around 40% do report earning over $150,000 (Isakson, 2002). Over half the jobs in the Cat-Del watershed are relatively low-wage service industries (Hoffman, 2008). The aggregate income in the Cat-Del watershed in 1999 was around $1 billion (Hoffman, 2008). The average quarterly wage in the watershed in 2003 was $6,483 (Hoffman, 2008). The Cat-Del watershed has a population that varies seasonally between 50,000 and 200,000 (National Research Council, 2000). The year-round resident population has varied very little over the last century. While rural and not heavily populated, the entire New York City watershed still has the highest population density of any unfiltered watershed in the U.S. (Finnegan, 1997). The Catskill system is estimated to have a population density of 24 people per square kilometer and the Delaware system is estimated to have a population density of 17 per square kilometer (Pires, 2004).

Geographic Characterization

The entire New York City water supply system is shown in Map 1.1. The Cat-Del watershed, shown in more detail in Map 1.2, lies within in part of five New York counties: Delaware, Greene, Schoharie, Sullivan, and Ulster. The watershed encompasses more of Delaware and Green County, comprising 55% and 45% of their land area respectively (Finnegan, 1997).

Map 0.1 - Map of New York City Water Supply System

Source: From the New York City Department of Environmental Protection, online at: http://www.nyc.gov/html/dep/html/drinking_water/wsmaps_wide.shtml

Map 0.2 - Map of Cat-Del Watershed

Source: From the New York City Department of Environmental Protection, online at: http://www.nyc.gov/html/dep/html/dep_projects/catdel_wide.shtml

3 Assessment Criteria

3.1 Environmental outcomes

The DEP has a watershed monitoring program to continually monitor the state of its water. This program is designed to achieve compliance with drinking water requirements and also to meet the requirements of the FAD (New York City Department of Environmental Protection, 2011). The monitoring, and also water quality modeling undertaken by the DEP, are done looking at final drinking water quality. This is a combination of not only the WAP, but the many other activities undertaken by DEP to ensure clean drinking water. This case study focuses more specifically on the direct impacts of the WAP, which are more difficult to measure.

Perhaps surprisingly, New York City established no explicit environmental goals for the WAP. Instead, all success metrics were based on observable actions, such as number of farms enrolled. This is in recognition that these actions would alter the driving force of agriculture on water quality impacts. On these metrics, the program has been a huge success. Since 1992, the WAP has established WFPs on over 416 farms (New York City Department of Environmental Protection, 2011). Around 95% of all the "large," commercial farms in the Cat-Del watershed have WFPs (New York City Department of Environmental Protection, 2011). In 2010, the WAP met a goal of the FAD to have 90% of participating large farms meet "substantially implemented status." In addition, the WAP has secured over 18,000 acres of conservation easements on watershed farms (New York City Department of

Environmental Protection, 2011). The EPA has used these metrics to evaluate compliance with FADs (e.g., USEPA Region 2 New York City Watershed Team, 2006).

In a review, the National Research Council (2000) noted that these metrics, however, do not give an indication of the total impact on water quality, and that monitoring is needed to achieve this. The report recommended that phosphorus load reduction goals be established and farm-scale monitoring undertaken. Even without farm specific monitoring of soil and water quality, planning teams monitor all farms for maintenance of the BMPs (National Research Council, 2000).

Still, the watershed approach is working as judged at a more system level. The Kensico Reservior, which is an endpoint for water from the Cat-Del system, has consistently met all turbidity and fecal coliform standards established under the SWTR. Moving further back in the system, the Cannonsville Reservoir has not been listed as phosphorus-restricted since 2002 and this is attributed to a combination of the WAP and upgrading of waste water treatment plants and septic systems (Beureau of Water Supply, 2006). (Reservoirs that do not meet state phosphorus guidance values are labeled phosphorus-restricted and stricter regulations apply, such as no new waste water treatment plants (Porter, 2006)).

Despite the DEP focus on reporting observable actions, over the years there has been a substantial amount of research on the impact of BMPs on water quality. A total of 10% of the WAC budget in the first phase was devoted to research and monitoring (Willett and Porter, 2001), but there is no longer funding the WAC budget for research. The research built on work done in the 1970s and 1980s in the Cat-Del watershed focused on the source of phosphorus loadings and the impact of BMPs (National Research Council, 2000). Since then, USDA Agricultural Research Service scientists and Cornell University scientists have been working together to document the impacts of selected BPMs on reducing phosphorus loadings to surface waters (Bryant *et al*., 2008). And Cornell scientists have developed models that can be used as planning tools for the WAP (National Research Council 2000).

Some of the results of specific scientific investigation are reported here. Monitoring in the Cannonsville Reservoir watershed conservatively indicates, after accounting for reductions from other sources, that the WAP decreased dissolved phosphorus by 50% and decreased total phosphorus by 17% when the period 2000-2004 is compared with the period 1992-1999 (Bryant *et al*., 2008). An extrapolation of observations of four dairy farms in the Cannonsville Reservoir watershed estimated that in stream deposits from pasture cattle contribute 10% of watershed phosphorus loadings (James *et al.*, 2007). An eleven year investigation of a dairy farm adopting BMPs (2 years before adoption and years after) and a control site, a reduction was found in based loads of phosphorus and NH_3 (Bishop *et al.*, 2007). A study looking at reducing herd access to streams found reduced phosphorus loadings (James *et al.*, 2005). Between 2000 and 2002, a water quality monitoring project was designed to develop a baseline of stream quality in the watersheds for future research (Blaine *et al.*, 2006).

3.2 Economic Assessment Criteria

A filtration plant to handle the large volume of water from the Cat-Del system was estimated to cost $4 billion to $8 billion in 1990 dollars, combined with an annual operating cost of $250 million (Appleton, 2006). If filtration was undertaken, it would easily have doubled New York City water and sewer rates, something unthinkable for residents and the city housing market (Appleton, 2006). In the 1980s and early 1990s, due to an increase in capital expenditures, water and sewer rates were increasing at around 15% a year and there was huge outcry (Appleton, 2006). Another period of large increases was not going to be tenable.

The DEP thus chose to pursue a FAD, requiring them to develop a watershed management plan, of which the WAP was a part. This was the least cost solution to the drinking water quality regulations the city faced from EPA. Initially, the city wanted to directly regulate land use in the watershed. This would have been cheaper for the city, but was not politically feasible. New York City first applied for a filtration waiver in 1991. Between that first application and 2010, the city spent over $1.5 billion on source water protection in the Catskill and Delaware watersheds (New York City Department of Environmental Protection, 2010). This is substantially less than the costs of a filtration plant.

Between 1994 and 1999 (the initial phase of the WAP after a brief pilot period), the city contributed $32.5 million for the WAP, with $19.7 million being used for the adoption of BMPs (Platt *et al*., 2000). New York City provides core funding for the WAC, although the WAC has also been able to draw on funds from the USDA, EPA, and the US Army Corps of Engineers. For most years, however, New York City provides around 90% of total funding (Smith and Porter, 2010). Over time, as investments have been made, funding for BMPs has decreased somewhat. The audited financial statement available on the WAC website states that over $4 million was spent on BMPs in 2011. At the end of December 2010, the WAC had invested $39 million in purchasing conservation easements. As participation is voluntary, the WAC is presumably making the famers better off, or they would not choose to participate. In order to improve the cost-effectiveness of the WAP, participation was initially limited to only the largest farms. It was thought these would have the most "bang for the buck." In 2009, as already stated, small farms were allowed to participate in order to obtain further gains in water quality, since most large farms had already enrolled.

No analysis has been done to monetize the value of the water quality benefits that New York City receives or of the willingness-to-pay of water users in the city. Since the city faced a regulatory trade-off between filtration and watershed management, it was clear from a cost-effectiveness standpoint that watershed management was preferred, but it is impossible to say if, at the margin, an extra dollar from the city spent on improvements is worth the cost.

3.3 Distributional Effects and Social Equity

Socio-economic data is not collected at a watershed level, making inferences difficult at that scale. It is clear the Cat-Del region overall is largely agricultural and poor. In the early 1990s, 30% of the population of Delaware County, a large portion of which is in the watershed, was on welfare and rural poverty was widespread (Appleton, 2006). More recently, it has been estimated that roughly 20% of watershed residents live in poverty (Isakson, 2002). It is clear, as will be discussed, that at the level of the individual farmer, the WAP has helped many farmers and at least not hurt any, although the magnitude of benefits varies. It is less clear if there have been any detectable impacts at the watershed scale. One study by Hoffman (2008) isolated employers in the Cat-Del watershed and analyzed trends between 1990 and 2003. Hoffman found that New York City's watershed protection programs have not reduced investment in the watershed and might have generated net gains for employers. Of course, this analysis is on the entire suite of activities being undertaken by the city, not just the WAP.

The WAP programs are designed to not impose any costs on participating farmers, as the installation of all BMPs is paid for by New York City. The farmers also receive numerous co-benefits from participation in the WAP. Many of the BMPs improve herd health; for example, providing cattle with troughs to drink from instead of streams limits their exposure to infections (James *et al*., 2005). New barnyards have anecdotally reduced hoof problems and rates of mastitis in cow udders (Isakson, 2002). Other BPMs save money—for instance, increasing the efficiency of nutrient use allows farmers to buy less fertilizer. Some also save the farmer time, and often time from the particularly unpleasant task of handling manure (Appleton, 2002). By participating in the WAP, farmers have also been able to preserve their autonomy, build social capital, and have a voice in the future direction of the watershed (Isakson, 2002). Finally, the WAP helps them avoid the costs of other regulations. Not only are they exempted from New York City's regulations, but they are better positioned to meet federal regulations, such as a 2009 Animal Feeding Law requiring WFPs (Isakson, 2002).

Farmers that participate in the WAP are also eligible for other federal programs that can be beneficial, such as the Conservation Reserve Enhancement Program. This program pays farmers to create buffer strips along streams that cattle cannot access. Payments are made on a per acre basis and the payment exceeds the average per acre farm income in the watershed. There are capital costs to joining, such as installing fencing, and the program covers 40% of those costs. These capital costs are paid in full by the city for WAP participants, however, so when they join, they get to pocket the 40% cost share as a bonus payment (Isakson, 2002).

Spun-off from the WAC include programs designed to help promote watershed agriculture, such as the Natural Resource Viability Program and the Catskill Family Farms Cooperative. These programs may provide additional economic benefits to farmers. It has been noted, however, that the Catskill Family

Farms Cooperative experienced significant management problems (discussed in Isakson (2002)), that limited its initial ability to help watershed farmers.

It appears, then, that overall the WAP has improved the livelihood of participating watershed farmers. The only possible negative impact is a concern by some that the WAP might lower real estate values, but local real estate agents say there has been no impact on resale values (Isakson, 2002). Despite clear benefits overall, a closer analysis suggests these benefits are not distributed evenly among farmers. The largest farms seem to benefit the most from WAP programs. This is partly due to the initial focus on large farms, and also because funding is dependent on the size of the farm and the level of production of key pollutants (Isakson, 2002). This can be seen in farmer surveys. Two thirds of farmers earning over $100,000 said the program helped their economic well-being but for farmers earning under $20,000, just over a quarter claimed economic benefits from the program (Isakson, 2002). Those with low incomes from farming, however, may have supplemental income and so farm income does not necessarily correlate highly with total household income. The WAP program is also targeted at dairy farmers, which some other farmers resent (Isakson, 2002). The actual number of farmers that have experienced significant benefits may thus be a more limited subset of watershed farmers.

While benefitting farmers economically, it also seems that the magnitude of benefits may not be enough to actually preserve farming as a viable way to make a living in the watershed. In the Cannonsville Reservoir watershed, for example, in 2008, there were around 45 inactive large farms, indicative of the decline in agriculture during the preceding decade (Bryant *et al*., 2008). The WAC also notes in its Strategic Plan for 2011-2014 that farming is declining in the region due to diminishing returns from agriculture, with the number and size of farms falling (Watershed Agricultural Council, 2011). The WAP program is focused on improving water quality, albeit in a way that does not pose economic harm on farmers. If the goal was to preserve farming as a dominant land use, more investment from the city may be needed, although this would then be subsidizing a potentially economically inefficient activity, unless the social benefits were deemed to be worth it.

3.4 Institutions

The WAP established a new institution to oversee the PES program: the Watershed Agricultural Council. The WAC is a locally controlled non-profit. The key features of this institution (Level 2) are what made the compromise between the farmers and the city possible. The farmers in the watershed insisted that the program be farmer-run. The board of directors is composed almost exclusively of local farmers, with one representative from the DEP. The WAC has a dual mission of improving surface water quality and supporting the economic viability of farms. Participation in the WAC's programs are voluntarily for farmers in the watershed, but the WAC agreed to ensure a participation rate of at least 85%, which they have exceeded. When a farmer joins, the WAC helps them develop a WFP, identifying appropriate BMPs (Level 3 and 4).

While New York City provides the majority of the funding, the WAC does also receive some federal money as well. They receive technical assistance from Cornell University, County Soil and Water Conservation Districts, and the USDA Natural Resource Conservation Service. Their website lists dozens of organizations they partner with to achieve their goals.

3.5 Policy Implementability

Not all parties involved in New York City's decision to pursue a FAD over filtration believed it was the best approach. Some stakeholders had to be convinced that a watershed approach could maintain safe drinking water. In addition, a key to achieving consensus on this strategy was reframing the watershed policy as the cost-effective choice (Appleton, 2006). It is also the case that two key pathogens of concern to New York City, cryptosporidium and giardia lambia, cannot be completely controlled with standard filtration plants and would require watershed management in addition to the filtration, as would control of toxic chemicals and pesticides (Finnegan, 1997). Even among those supportive of watershed management, the manner in which it would be undertaken was debated. As discussed above, the city first tried a tactic of direct regulation and land acquisition that would make use of eminent domain and this approach failed politically.

There was long-standing animosity towards New York City from watershed residents who saw the history of the establishment of New York City's drinking water system as one in which the city repeatedly hurt, abused, and alienated them (Finnegan, 1997). Residents were evicted from the land to establish the new water system in a manner that watershed residents describe as unkind and lacking in respect (Isakson, 2002). This history led to years of resentment that were difficult to overcome. This anger from watershed residents is what prevented New York City from simply aggressively regulating the watershed and set the stage for the negotiations between the city and watershed groups.

Participants in the negotiations between the city and the farmers all note that a key to coming to an agreement was developing a clear vision that all parties could agree on: this was that drinking water protection and economic returns from farming could be consistent goals (Smith and Porter, 2010). Participants agreed on this through the sessions of mutual education undertaken by the city and watershed farmers. The discussions made each side realize the legitimate concerns of the other and the outcome was the starting point that agriculture could be "watershed friendly" (Appleton, 2006). Realizing the city and the farmers could agree on an approach led to the implementability of the WAP program. A survey of watershed farmers found the three main reasons for joining the WAP were to improve the farm, become a better environmental steward, and to be held harmless from New York City regulations (Isakson, 2002). Also essential to its implementation was the fact that the way in which pollutants are reduced is tailored to each farm such that maximum water quality gains can be had while not jeopardizing other management goals.

3.6 Transaction Costs

The transaction costs of establishing the New York City PES program include the costs of negotiations with the farmers. Estimates of the man-hours for these negotiations are unavailable, but anecdotal evidence suggests they were significant. The DEP took trips to the watershed to meet with farmers and observe how their proposed regulations may impact the economics of farming operations. Farmers and the DEP then spent many days in a program of mutual education and negotiation. These costs, however, are likely small compared to what the city would have spent on filtration, although it is important to note again, that the WAP is only one small component of the overall watershed management approach taken by the city.

The costs of the WAP include the costs of directly implementing the BMPs, but also the costs of developing the whole farm plans, the administration of the WAP, and the research that supports its activities. For example, research and monitoring undertaken by Cornell University and the New York State Department of Environmental Conservation were initially around 10% of the WAP costs and led to direct support of WFPs (Smith and Porter, 2010). Farms are monitored annually for compliance. The WAC currently employees 19 people in its main office (although a few of these work on the forestry program, not discussed in this case study). The 2010 Annual Report for the WAC shows that program administration accounted for just under 12% of total expenditures the previous fiscal year.

3.7 Uncertainty

When the WAP program began there was scientific uncertainty on the exact impact of BMPs on water quality. Still, as discussed above, the WAP chose to develop success metrics based on adoption and participation and not actual water quality levels. Simultaneously, they allocated 10% of the budget to scientific investigation of the relationship between different on-farm changes and nutrient loadings to surface waters. WFPs were designed to be flexible, so that the suite of BMPs would adjust over time based on new scientific findings.

The WAP did not engage in comprehensive, farm-level monitoring. Thus, years later, there is still uncertainty about the net impact of the WAP on surface water quality. Resolving some of the uncertainty would require individual monitoring of BMPs on each farm; this is costly and time consuming, however, many argue it is essential (National Research Council, 2000). The National Research Council recommended that the WAC partnership with Cornell be continued until there is reliable information on how pathogens are reduced for specific BMPs, how phosphorus loading rates are reduced for specific BMPs, and how BPMs and WFPs reduce watershed-scale loading rates for both pathogens and phosphorus (National Research Council, 2000). The WAP has since eliminated funding for research. Even before this happened, some argued that BMPs may be adopted with little scientific support and that the WAP undervalues synthesis research (Willett and Porter, 2001)

Still, overall, drinking water quality is measured by the city extensively, and a high level of safety is being maintained. The WAP, in combination with the city's other watershed management efforts, has allowed New York City to continue to receive FADs. While its efforts to date have maintained safe drinking water, there is still uncertainty as to how long filtration avoidance can be continued. In the WACs 2011 – 2014 Strategic Plan, they mention as an "internal challenge" the possible loss of funding if or when New York City fails to have its FAD renewed (Watershed Agricultural Council, 2011).

4 Conclusions

4.1 Lessons Learned

The case of New York City's WAP has been told many times, in part because it overturned two commonly held assumptions about environmental policy in the US: that voluntary programs don't work and that watershed management could effectively and consistently generate high-quality drinking water (Appleton, 2006). The New York City case is often cited as proof in the concept of ecosystem services—that natural systems do generate economic value and that with proper policies, this can be captured, harmonizing ecological and economic objectives.

The process New York City went through to achieve this holds lessons for other localities seeking to harness the economic benefits provided by natural systems. First, some forms of agriculture and the provision of potable drinking water need not be at odds with each other. In working landscapes, it is possible to identify areas of overlap between the goals of environmental protection and economic development. As Al Appleton, the DEP Commissioner at the time reflected, "the ecosystem must be seen as including both its natural and human resources. One cannot be sacrificed to the other" (Appleton 2002). Instead of imposing one-size-fits-all regulations, if water quality improvements can be tailored to the farm, they can be harmonized with management goals.

That said, the second lesson from New York City is that cities can't expect watershed residents to bear the costs of maintaining source water quality. On-farm investments or changes in agricultural practices required to reduce pollutant loadings are often expensive and especially in communities where farmers are struggling economically, the beneficiaries of these changes must be prepared to help cover the costs. As this case demonstrates, however, these costs may sometimes be much less than the cost of alternatives.

Finally, the WAP program highlights the importance of well-structured dialogue and negotiations. The city and farmers were able to first engage in mutual education and then work together to identify common ground and solutions to both groups' problems. This is not easy, however, and should not be under-appreciated.

This case is by no means "over." New York City will need to continually monitor and invest in watershed management efforts to control pollutants and excess nutrient loadings. While the WAP is fairly well established, such that agriculture is no longer a leading threat to the city's water, other threats remain. In particular, exurban development continues to be a problem, particularly as economic hardship continues in the area and people sell out to developers building second homes. This often creates more pollutant problems than agriculture. It may be more cost-effective for the city to buy out some farms to preserve as open space and prevent ex urban development, but such land acquisition has met with objections from watershed communities.

4.2 Enabling / Disabling Factors

New York City was able to engage in watershed management because the watersheds from which is obtains 90% of its drinking water were not yet highly developed. Perhaps one reason there has not been much emulation of the city's approach is because localities that obtain water from already developed watersheds have no other option but to filter their water. Once they are expending the money to do this, they may see little added value to also investing in watershed protection. It was EPA's threat of forcing filtration, and thus a huge cost on the city, that pushed it into watershed management. The city did not engage in such efforts outside the threat of regulatory action by the EPA.

As is often the case with innovative policies, key individuals proved decisive in establishing the WAP. These individuals are often referred to in academic literature as "public entrepreneurs." For instance, Al Appleton, the DEP Commissioner, recounts how it was a conversation between him a watershed farmer, who was also a leader in the community, that found the compromise of making participation in the WAP voluntary for the farmers, but with a required percentage participating to ensure clean water for the city.

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Annex I: Contributors to the report/Acknowledgments

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