The Greening of a Pulp and Paper Mill

International Paper's Androscoggin Mill, Jay, Maine

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Keywords

corporate social responsibility (CSR)
kraft pulping
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pulp and paper industry
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Summary

International Paper (IP), the world's largest forest products company, owns the Androscoggin Mill, a large pulp and paper mill in Jay, Maine, in the northeastern United States. This case study describes the transformation of the Androscoggin Mill from an object of public opprobrium and conflict to a showcase for environmental management. In the late 1980s, an 18-month strike had embittered workers and townspeople and left the mill's reputation in tatters. In response to mill environmental violations, some of which were considered crimes by state regulators, the town of Jay passed its own environmental ordinance to control mill emissions. Early in the 1990s, new management, including two former corporate-level employees, sought to change the mill's business approach and turn the Androscoggin Mill into IP's best environmental performer. The initial emphasis on establishing and maintaining compliance was expanded to include aggressive pollution prevention efforts that led to cooperative projects with the Maine Department of Environmental Protection, the U.S. Environmental Protection Agency, and stakeholder groups. The mill's approach in the 1990s evolved further to essentially follow principles of industrial ecology. New approaches focused on "closing the loop" by finding beneficial uses for previously landfilled wastes, replacements for most hazardous chemicals, and reductions in solid and hazardous waste generation. The mill also pursued the establishment of symbiotic relationships with a facility that began using a mill by-product on-site and an on-site natural gas burning facility that provided part of the mill's steam demand. IP also established a public advisory committee in 1992 to advise management on operational and "big-picture" issues, which later included the application of sustainability criteria to the mill. IP has since formed community advisory committees at each of their integrated pulp and paper mills.

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Introduction

From 1965, when it was built, until 1986, International Paper's (IP's) Androscoggin Mill, located on the Androscoggin River in Jay, Maine, was a typical large pulp and paper operation. It was the economic mainstay for Jay, a community of 5,000 in western Maine, and was considered no better or worse than other mills. A strike that began in 1987 and lasted into 1988 greatly changed the company's reputation, embittering mill workers and the Jay community. Environmental problems that had previously received little notice brought a quick and negative reaction. State and local authorities cited the mill for violating landfill and air emissions requirements. In July 1991, five criminal indictments were brought against the mill, alleging misrepresentations in its wastewater license application and the burning of unlicensed waste. The mill's ability to continue operating was also at risk, as its landfill was close to capacity at a time when it looked unlikely that it could obtain a permit for expansion.

Against this backdrop, the next decade saw a profound change in how the mill was managed; its relationship to its workers, the Jay community, regulators, and other stakeholders; and its environmental performance. In effect, IP's worst performer became its best. This article examines the drivers of change at the mill, specifically new management, the Jay environmental ordinance, the relationship of the mill with its regulatory agencies, and the activities of its public advisory committee (PAC). It shows the evolution of thinking on environmental issues as the mill began with end-of-pipe control measures, initiated pollution prevention projects, began treating mill by-products as useful materials, and worked with colocated facilities in an industrial symbiotic relationship (Ehrenfeld and Gertler 1997) to reduce or eliminate pollution. We explore the reasons for the establishment of a formal advisory process, the activities of the PAC, and its progression from nuts and bolts issues to a focus on sustainability. The conclusions focus on how this transformation occurred and the nature of the drivers for change in both the early stages and as the company's efforts matured in the 1990s on into the 2000s.

Background to Change

The Androscoggin Mill

At the end of 2001, the Androscoggin Mill employed about 1,200 people, 150 of whom were in salaried positions. The mill uses the kraft pulping process to produce about 1,600 tons of mostly coated paper per day, plus some specialty-grade papers and dried pulp. Pulping is the process of taking wood fiber and turning it into the raw material for making paper, paperboard, and cardboard. Appendix 1 describes the chemical pulping process. The Androscoggin Mill has two Kamyr digesters, two recovery boilers, one waste-fuel incinerator, two limekilns, two bleaching lines, five paper machines, a ground-wood mill, and a flash dryer. Pulp and paper mills are resource-intensive operations that can have a significant impact on the environment (Servos et al. 1996; Springer 2000a).

IP, the mill's owner, is based in Connecticut and is the world's largest forest products company, with about 117,000 employees worldwide. It is vertically integrated, owning the raw materials (forests and wood lots), producing intermediates (pulp and chemicals), and manufacturing products for business and consumer markets. Its businesses include manufacturing printing paper, packaging, building materials, and chemicals.

Corporate Level

In 1990, President George H. Bush established the President's Commission on Environmental Quality (PCEQ) to seek advice from the private sector on environmental issues (PCEQ 1990). IP and other major corporations were invited to become members. David Critchfield, IP's corporate director of regulatory affairs and recycling, typically attended meetings on behalf of John Georges, then chief executive officer. The PCEQ, staffed by Michael Deland, chair of the White House Council for Environmental Quality, urged companies to integrate pollution prevention principles into corporate environmental programs, test new strategies, and share results. Several commission recommendations became relevant to the Androscoggin Mill:

- Pursue pollution prevention projects
- Form public participation groups in communities where they operated and become more open to community involvement and input
- Take one facility and develop it into an environmental model, from which other facilities could learn

Most of the companies that adopted this last recommendation focused on improving well-performing facilities. In contrast, IP chose to take its worst facility, the Androscoggin Mill, and make a conscious effort to turn it into its best.

New Mill Management

In 1990, IP asked Larry Stowell, then a corporate manufacturing manager, to become manager of the Androscoggin Mill. David Critchfield, in a September 2001 interview in Portland, Maine, said Stowell was basically asked to "turn the mill around and keep it out of the headlines." He said that IP corporate policy as applied to all mills meant that "we will comply with regulations, period, and we will strive to minimize our environmental impacts." In 1991 Thomas Saviello joined the mill as environmental superintendent and, in 1992, Stowell persuaded David Critchfield to leave his corporate-level position and join the mill as environmental manager, supervising Saviello. The three immediately focused on the need to set very high standards for the mill while, at the same time, working to engender the trust of regulators and the local community. Influenced by the PCEQ recommendations, they took on the challenge of making the Androscoggin facility, still reeling from violations and criminal indictments, into IP's model of environmental excellence. Also, as suggested by the PCEQ, they formed a PAC to provide an outside source of perspective that might help the mill mitigate the negative perceptions of the media and others. The PAC, however, chose to stay out of the public domain and evolved in its own way (see below).

David Critchfield described his approach to the Androscoggin Mill as systematic, regularly consulting a text on systems analysis (Churchman 1968): "To approach something as complicated as a paper mill, you have to be systematic. Otherwise you would find yourself trying to move in all directions at once. Too many problems needed a solution." Of necessity, his first priorities were improving a terrible safety record and bringing the mill into compliance with environmental regulations. Saviello had already reorganized the mill's environmental department, hiring specialists in air, water, hazardous waste, and solid waste to mirror the regulatory structure of the Maine Department of Environmental Protection (DEP).

The Early 1990s

The Jay Ordinance

As a result of citizens' poor regard of mill environmental performance, the town of Jay instituted its own environmental ordinance, subjecting the mill to more restrictive local regulations along with those already established by the state and federal governments. This local ordinance became a driver of change when it required more monitoring wells for the mill landfill than required by the state and mandated the adoption of technologies that were not required at other kraft mills. For example, the mill installed a regenerative thermal oxidizer in 1994 at the town's behest to capture and destroy odorous chemicals. Subsequently, the U.S. Environmental Protection Agency (U.S. EPA) has adopted a regulation that requires such emission controls by 2006.

Gaining Employee Cooperation

In a large pulp and paper mill, management of complex environmental programs requires the support and participation of workers and managers. This was difficult in an environment in which workplace communications were still poor after the strike and mill environmental infractions remained common. The recovery boilers were averaging 56 opacity[1] incidents a year. The incidents resulted from a lack of consistency in controlling boiler operations and recognizing which conditions would lead to an infraction. The number of opacity incidents began to decline when department managers, who had to report the infractions, began backing up repeated environmental staff requests for action and when each member of the boiler staff was given control over a specific section of equipment. As each came to know a section well, they developed the skill to maintain proper conditions. Later, external recognition, such as the governor's Pollution Prevention Award and IP's Corporate Award for Environmental Excellence, maintained employee motivation. Further improving performance and communications, staff also recognized that a failure to control one section contributes to control failures elsewhere. Recovery boiler opacity infractions dropped to zero.

Changing Relations with the Maine DEP

Although the new management team began to get the mill under control, exceedences of license limits of various types still occurred in 1992, and the mill continued to pay fines to settle earlier violations. But examples surfaced that demonstrated changing attitudes. One was to remove the lawyers previously standing between the mill and the Maine DEP: Saviello had initially taken lawyers with him to meetings at the Maine DEP, and the lawyers took charge of the meetings, a practice to which DEP personnel reacted with animosity. In an attempt to better relations, Stowell told Saviello in 1991 to stop inviting lawyers. This approach initially felt very different to Saviello, but he became increasingly comfortable with direct discussions with DEP personnel. And, as seen below, mill relations with DEP did improve.

Evolving Approaches to Managing Environmental Performance

Beginning at the End of the Pipe

To make wood pulp suitable for paper, mills must remove the lignin that binds cellulose in the fibers (Appendix 1). Lignin and other organic materials that end up in wastewater contribute to biochemical oxygen demand (BOD), a major pollutant produced by pulp and paper mills (Springer 2000b). Because of water-quality considerations, the Maine DEP Water Bureau issued a wastewater license in 1991 to the mill limiting BOD releases to the river to 10,500 lb/day, a level more than 2 times as restrictive as federal requirements. Although mill personnel did not believe that this limit could be achieved, they—again bypassing lawyers' advice—accepted the invitation of Stephen Groves, then director of the DEP's Water Bureau, to work collaboratively to solve the problem. The mill implemented a number of Maine DEP suggestions, including the installation of dozens of aerators in the wastewater treatment lagoon to achieve higher dissolved oxygen levels and promote greater microbial degradation of the BOD. The collaboration proved successful, as the mill quickly reduced BOD discharges to meet the permit and achieved a consistent level of approximately 4,000 lb/day or lower through 2001 (figure 1).

Moving up the Pipe

Mill and Maine DEP engineers formed an "environmental quality team" in 1992 to identify pollution prevention opportunities (Springer 2000d). One concern of the team was the impact of pulp-bleaching processes on emissions. Mill staff introduced two process changes in response to team recommendations that bleaching be minimized by reducing lignin in pulp (Springer 2000b). The mill combined extended delignification, which involved cooking wood chips for a longer period at lower temperatures, while maintaining pulp yield and quality (McDonough 2000), and oxygen delignification, treating pulp with high-pressure oxygen (Sjostrom 1981), to reduce lignin content and required bleaching. The result was lower quantities of adsorbable organic halide (AOX) (chlorine-containing byproducts formed during bleaching) compounds, dioxin, and furan in the mill's effluent and lowered chloroform emissions to air and water. Dioxin, furan, and chloroform emissions were ultimately eliminated following the mill's conversion to 100% chlorine dioxide bleaching[2] in 1995 (see Table 1).

Additional pollution prevention projects resulting in process changes continued in 2002 in conjunction with the mill's two U.S. EPA XL projects.[3] Although several pollution prevention efforts, such as extended delignification/oxygen delignification, were not unique to this mill, the

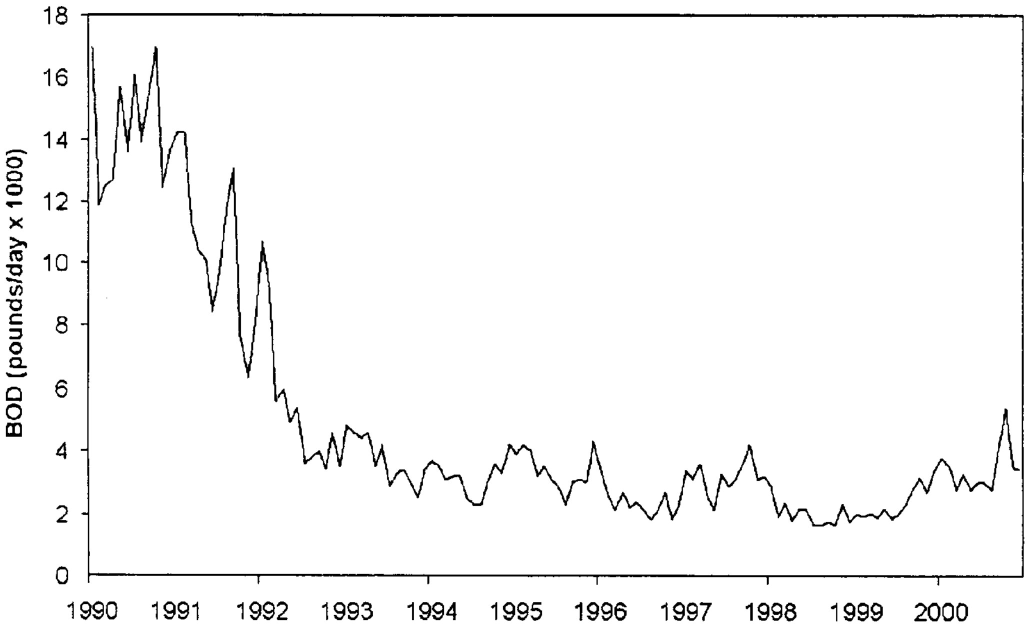

Figure 1 Biochemical oxygen demand (BOD) loss to mill effluent (pounds per day).

XL projects resulted in the development of new technological approaches to pollution prevention. Indeed, one criterion that U.S. EPA uses to judge XL projects is the likelihood of developing technology that is transferable to similar facilities. The use of a computer model of the mill's waste-fuel incinerator developed under the direction of Thomas Saviello prompted process changes that to date have reduced particulate emissions by 50%. In the second XL project, the mill began modifying production processes to reduce spent liquor in wastewater, which can affect effluent color and chemical oxygen demand.[4] Both XL projects involved a stakeholder team as well as a technical team, the latter including paid consultants.

Addressing Pollution through Supply Chain Management

Tests in April 1998 by the mill revealed that the concentration of mercury in upstream river water was 6.5 parts per trillion (ppt), whereas the effluent concentration was 19.2 ppt. Investigation revealed two contaminated feedstocks. One was alkali purchased from a chloralkali plant using a mercury process. The mill found a supplier that did not use the mercury cell process. The second supply chain issue was the mill's purchase of sulfuric acid from a Canadian lead smelter that converted its captured sulfur dioxide emissions to sulfuric acid, with mercury as an unintended contaminant. The mill switched suppliers to purchase uncontaminated sulfuric acid from a nickel smelter. By August 2000, without end-of-pipe control, effluent mercury was reduced to 3.4 ppt, equivalent to the river background of 3.9 ppt (figure 2).

Toxics Use Reduction

Although it requires only reporting of toxics use and hazardous waste generation, the Maine Toxics Use Reduction Act was the initial driver in identifying opportunities to eliminate or at least reduce the use of hazardous substances in a variety of operations. The use of elemental chlorine, transported by tank car into the mill over most of its operating life, posed an ongoing danger to workers and the community if a leak developed. By 1995, the mill completed a switch to 100% chlorine dioxide bleaching. Chlorine dioxide also poses a risk, but because it is generated on-site as needed, the risk associated with trans-

Table 1 Mill pollution prevention example

	Year	*AOX and dioxin discharges to effluent*
Dioxin (2,3,7,8-TCDD)	1988	88 pg/L
	1996	Nondetect[a] and remains so[b]
Furan (2,3,7,8-TCDF)	1988	420 pg/L
	1997	Nondetect and remains so[b]
AOX[c]	1994	1.44 lb/ton bleached pulp/day
	2000	0.52 lb/ton bleached pulp/day

[a] Nondetect is less than 10 pg/L.

[b] Neither dioxin (2,3,7,8-TCDD) nor furan (2,3,7,8-TCDF) are detected in the bleach-plant effluent where, if present at all, they would occur at the highest concentration.

[c] Adsorbable organic halide, chlorine-containing by-products formed during bleaching.

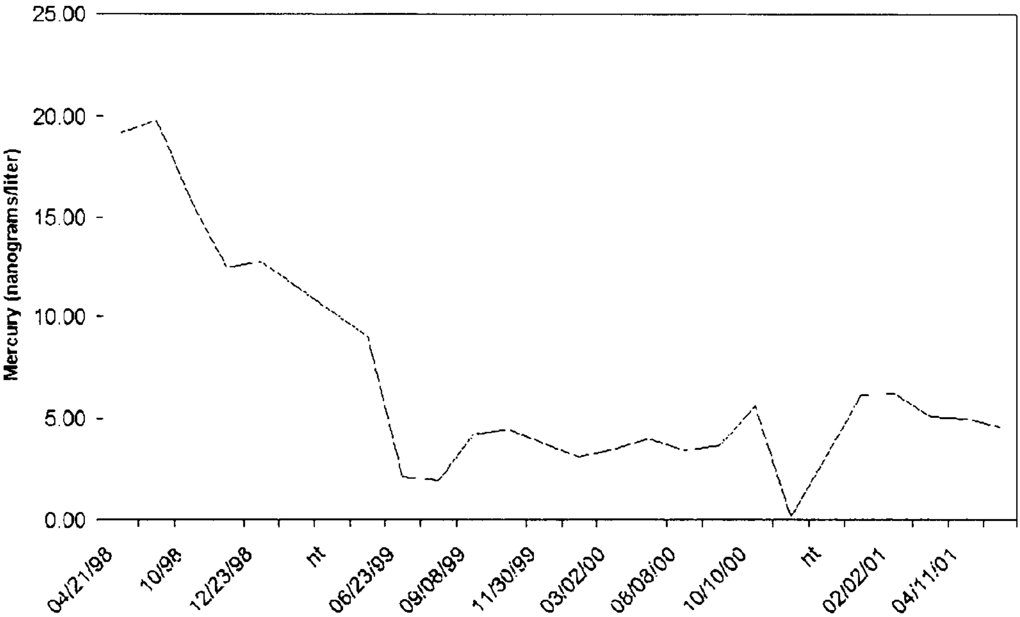

Figure 2 Mercury in mill effluent (nanograms per liter).

portation and the use of large quantities is substantially lessened. Another product, Nalco Chemical Co. TRI-ACT 1804, used to inhibit corrosion in recovery boiler tubes, contained the hazardous chemical cyclohexylamine. This was replaced with a proprietary Nalco product (TRI-ACT 1826) not containing any hazardous constituents.

The mill also replaced two hazardous products that had provided nitrogen and phosphorus nutrients to promote the growth of microorganisms that degrade organic materials in mill wastewater (Springer and Maxham 2000). Anhydrous ammonia as a source of nitrogen was eliminated because of Jay officials' concerns about shipping safety and U.S. EPA's requirement for risk management planning (U.S. EPA 2001). It was replaced with the much less hazardous nitrogen-containing chemical, urea. Use of phosphoric acid as a source of phosphorus declined 57% between 1993 and 2000 as a mill team progressively reduced the amount added to the lowest level that would still support optimal microbial growth. Additional reductions occurred when the mill switched to a single product that blends urea with ammonium polyphosphate, eliminating the phosphoric acid use in this application.

Mill efforts to reduce hazardous waste generation included greater attention to preventing caustic liquor spills, the substitution of barium chloride with a nonhazardous chemical for use in a titration analysis (eliminating 7,000 lb of hazardous waste each year), screening of paint products before purchase to avoid hazardous constituents, and purchasing low-mercury fluorescent bulbs to minimize hazardous waste generation when relamping. These and other actions reduced hazardous waste generation from a high of 60,000 lb in 1990 to a low of 3,260 lb in 2000 (see figure 3).

Changing Approaches to Wastes

Pulp and paper mills generate a large variety and quantity of wastes (Springer 2000e), much of which may be landfilled, including tree bark, flume grit (dirt and contaminants carried with logs into the mill), sludge from wastewater treatment, green-liquor dregs and lime mud,[5] wood knots and screenings,[6] mill garbage, and some waste metal and paper. In 1988, the mill operated an on-site landfill that averaged 1,643 cubic yards (yd^3) of new waste a day and was close to capacity. Intensive efforts at recycling, pollution prevention, incineration, and beneficial reuse resulted in average daily landfill rates in 2001 of 150 yd^3, a 91% reduction (figure 4). Mill programs included the following:

- Recycling wood, metals, and paper
- Compacting nonrecyclable paper into burnable pellets
- Improving limekiln operations to allow firing of all lime mud produced
- Selling flume grit to a contractor that processed it into landscape material (similar to peat or perlite used for potting media and erosion control)
- Burning bark and sludge and incorporating the ash into AshCrete, a product developed at the mill (see below)
- Incorporating green-liquor dregs into AshCrete

Sludge and Ash

The Androscoggin Mill produces about 10% of the 1 million tons of sludge produced each year from wastewater treatment plants at Maine's pulp and paper mills. Sludge use on IP timberlands as a soil supplement was discontinued because of the high cost of transporting sludge that was only 40% solids by weight (Springer 2000e). Adjusting the waste-fuel incinerator allowed all sludge except for that used as landfill cover (where it replaced virgin clay) to be burned. A portion of the mill ash is shipped to a contractor

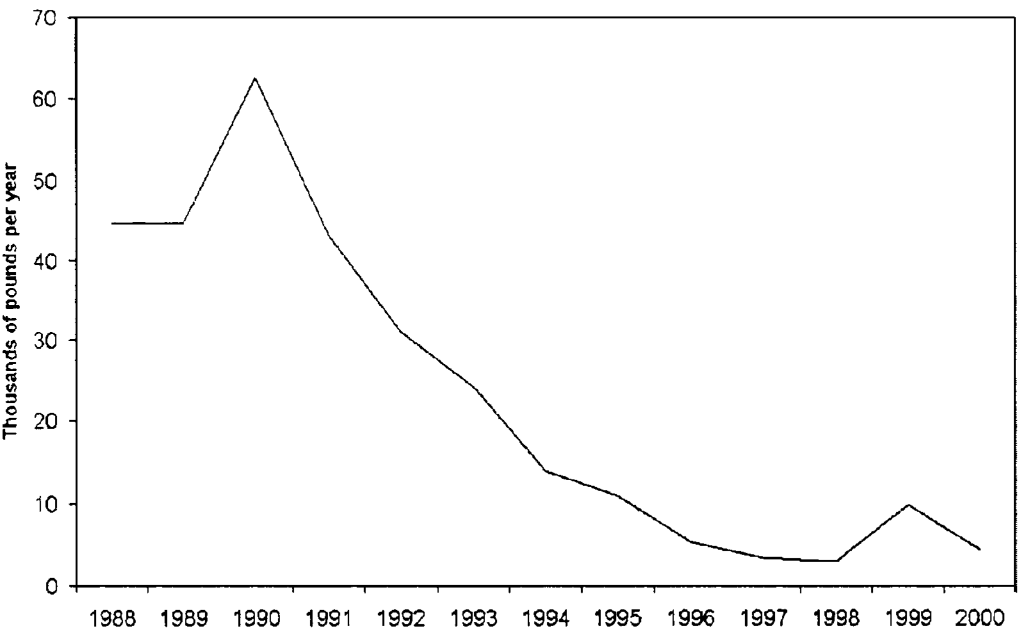

Figure 3 Hazardous waste disposal (thousands of pounds per year).

Figure 4 Solid waste landfilled (cubic yards per day).

in Unity, Maine, which uses it in composting municipal sewage sludge for farm application.[7]

Most ash from sludge and bark incineration, however, is incorporated into a product called AshCrete, developed in 1998 by Stephen Groves.[8] A contractor makes AshCrete on-site from ash, green-liquor dregs, and other proprietary by-products. For the next 15 years, all of the AshCrete is expected to be used to reduce the size of the wastewater lagoon, which had been designed and built when the mill produced substantially more BOD. Approved by the Maine DEP, AshCrete use negates the need to purchase gravel to fill the lagoon. The DEP also approved the use of AshCrete in closing the mill landfill and as a subbase for a concrete pad. Two southern IP facilities also now produce AshCrete with a somewhat different formula. They use it as a berm and dike material and, similar to the Androscoggin Mill, to reconfigure or close wastewater treatment lagoons.

Facilities Colocated with the Androscoggin Mill

Much like Kalundborg, Denmark (Ehrenfeld and Gertler 1997), a small "industrial ecosystem" has evolved slowly around the mill, with several companies locating facilities at the site to take advantage of by-products and market opportunities.

- Specialty Minerals, Inc. produces precipitated calcium carbonate (PCC) by reacting carbon dioxide with calcium oxide in a proprietary process. Specialty Minerals needed a source of carbon dioxide and an outlet for PCC and set up operations at the mill in 1997 using carbon dioxide emissions from a limekiln.[9] In return, the mill buys PCC at an attractive price and eliminates transportation costs.
- A contractor operates an on-site facility owned by the mill to process the ash produced from burning mill sludge and bark into AshCrete.
- Androscoggin Energy is a natural-gas burning facility, generating electricity with high-temperature steam (sold off-site) and selling low-temperature steam to meet a portion of the mill's needs. The mill boilers, which had burned number-six fuel oil containing 1.8% sulfur, went into standby mode, resulting in lower sulfur dioxide, nitrogen oxides, particulate, and carbon dioxide emissions. (Mill recovery boilers,

which burn spent pulping liquor as part of the chemical and energy recovery operations, along with the waste-fuel incinerator, furnish the rest of the mill's steam needs, as well as providing electricity.)

The Public Advisory Committee

Members, Mission, and Early Challenges

In developing a PAC in 1992, IP followed through on a recommendation of the PCEQ. The PAC originally defined its mission as to "... help identify environmental issues the Androscoggin Mill must address, and proactively assist in choosing the options. This will be accomplished by developing trust and respect for each other." By 2000, members expanded that mission to "... act as a public board to identify and respond to the environmental, social, economic, and community issues that the Androscoggin Mill must address, and proactively assist in choosing sustainable options." According to David Critchfield, the mill in 1992 sought members who "would not pull punches, but who also had a strong constructive side." Members included environmentalists, forestry and business experts, a mill customer, and a member of the mill's hourly staff (table 2). Initial PAC meetings included the mill environmental manager, its environmental superintendent, and frequently the mill manager. (The current mill manager, Michael Craft, has attended all recent meetings.) Subsequently, the mill engineer responsible for developing energy conservation and efficiency measures became a regular participant. The PAC also hears from other mill personnel as necessary.

A major challenge to the PAC in early years was to understand mill operations, environmental matters, and issues associated with local, state, and federal agencies. To assist in the challenge of dealing with a substantial amount of information, the PAC developed a report card with data on effluent quality, solid waste generation, energy and water use, and process- and energy-related air emissions (including carbon dioxide). The report card also provided comparisons with the previous month, license limits, and annual goals and provided a focus and data to help monitor performance. The mill used the report card as a way to monitor itself by putting the goals and progress in constant view. The mill also used it on occasion with customers to demonstrate the mill's environmental commitment.

An ongoing discussion at early meetings centered on the town of Jay and its environmental regulations. PAC members strongly advised the mill to accommodate Jay's concerns, to make a strong effort to establish a working relationship with Jay, to be candid in all dealings with the town, and to not see it as an adversary. Over the years, the relationship with Jay became positive. Jay citizens served on the PAC and Project XL stakeholder teams. They also served on the collaborative stakeholder team formed for relicensing the mill's dams, and the team developing the mill's federally mandated risk management plan. The Jay ordinance was a driver of early change, but, over time, the impetus for change increasingly came from the mill. The ordinance remained in existence, but the PAC did not deal with compliance issues after the first few years.

Moving beyond Compliance

Over time, PAC members began to think beyond issues of compliance to sustainability issues. In particular, because a pulp and paper mill is not viable without a sustainable wood supply, PAC members began considering mill wood supply. Where did it come from, and what was the condition of the forests supplying it? Did loggers practice responsible forestry? Because IP forests are administered separately from the mill, the PAC invited forestry personnel to its meetings, and members also visited some of IP's forests. IP follows the Sustainable Forestry Initiative (SFI) standards of the American Forest and Paper Association[10] (AFPA 1994) and was the first American forest products company to earn ISO 14001 certification of its forest management system.[11]

IP forestland supplies barely 20% of the Androscoggin Mill's fiber requirements, however, because most wood goes to higher-value uses, especially lumber. The other 80% of the wood comes from independent loggers, who must complete SFI training and agree to abide by SFI standards. Some loggers have chosen not to provide wood to the mill because of these requirements. In other cases, the mill has refused to buy wood

Table 2 Public advisory committee members, 2002

Member	*Affiliation and location*
Deborah Burd*	Western Mountains Alliance, Farmington (regional sustainable community development)
Harold Burnett	Two Trees Forestry, Winthrop (forestry consulting)
Richard Cormier	Franklin Savings Bank, Jay
Carla Dickstein	Coastal Enterprises, Inc., Wiscasset (community development)
William Harlow	Androscoggin Mill (hourly employee) and Jay Planning Board, Jay
Marquita Hill*	Department of Chemical Engineering, University of Maine, Orono
Donald Hopkins*	Hearst Corporation, New York City (mill customer)
David Kraske†	Retired University of Maine professor and paper-company executive, Canton, Maine
Patrick Flood	IP, regional forestry operations
Daniel Sosland*	Environment Northeast and environmental lawyer, Rockport

* Members who served since the inception of the PAC in 1992. Sosland served as chair since shortly after the inception of the PAC.

† Kraske did not work for IP.

from loggers they believe are in violation of SFI standards. Although PAC members were basically satisfied that IP was genuine in its efforts to maintain sustainable forests, they continued to follow the topic closely. Among the PAC members was an independent forester; and to further assist the PAC in its efforts, the manager of IP's regional forestry operations became a PAC member in 2001.

Valuing the PAC

IP's policy is to have a PAC at each of its integrated pulp and paper mills. Except for the Androscoggin PAC, other committees are community based. Committees provide a means for IP to promote an understanding of how the company operates, in the belief that knowledgeable communities will be more supportive. Environmental staff at the Androscoggin Mill viewed the PAC as helpful in the internal effort to understand the mill's environmental performance and to identify issues that might otherwise be missed. PAC members brought a different set of perspectives to these issues, avoiding "group think" that can blind internal staff to critical problems. The PAC was also a means of bringing external accountability to the mill, which can reestablish a "franchise to operate" when it is threatened, as it was in Jay.

PAC members found it rewarding to have contributed to the positive changes at the Androscoggin Mill. Other values important to members were opportunities to delve into mill issues and obtain a greater understanding of the complexities often involved, seeing how the mill operates, how management works, and sharing perspectives and information among themselves and between the PAC and mill administration. At another level, some organizations, including the University of Maine, see participation in an activity such as a PAC as part of its public service mission.

At the Androscoggin Mill, the PAC's role began to change in the late 1990s. Providing feedback and assistance on compliance and pollution prevention was no longer central. The mill was well run and well regarded. PAC members began to turn to the longer-term issues and quickly came up with a difficult set of questions: How do PAC members define sustainability and effectively discuss it with the mill? How does the PAC tell the mill that it should be setting higher goals, requiring a greater stretch to reach them? What is an appropriate level of natural resources for the mill to use and how can it get there? And how can the mill get corporate authorization for more environmental capital investments?

In April 2002, the PAC was disbanded. Mill management believed that it had fulfilled its mission. Moreover, it felt a need for a local community advisory committee whose major purpose would be to promote good communication with the Jay community. It expects to start a community advisory committee in the summer of 2002. To minimize bias in member selection, the mill will hire a contractor to recommend members. PAC members supported management's decision while also voicing regret. Members believed they served as that "extra pressure" pushing for positive change. But they also believed that the mill has come so far that, especially with its image of environmental leader, it was unlikely to backslide. Additionally, there is a continuity of environmental staff, and Michael Craft (mill manager since 1999) comes from an environmental management background. Moreover, XL projects are still ongoing, and two PAC members are participants in those committees. The mill is also part of the U.S. EPA Star Track Program (U.S. EPA Star Track Program 1997).

Discussion and Conclusions

Although crisis stimulated change at the Androscoggin Mill, the outcome could have been less positive. Critical to the successful outcome was the IP corporate decision to find capable individuals and charge them with turning the mill around. The early leadership in this effort focused on making the Androscoggin Mill the best facility at IP. They were willing to risk giving the Maine DEP greater access to the mill, to form a PAC, and then to be responsive to both. External demands on the mill, especially in the early 1990s, played a critical role as well. Jay's environmental ordinance, highly unusual for a small community, was a significant driver for change, along with the town's unremitting pressure on the mill.

The mill, after its success in reaching out to the DEP, to the PAC, and increasingly to Jay, continued its outreach by forming collaborative projects, as when it relicensed its dams on the Androscoggin River in the mid-1990s and the U.S. EPA XL projects, which continue into the present. Each had membership from inside and outside the mill, from Jay, and from stakeholders outside the immediate community. Although stakeholders had different perspectives, all held a common interest in the success of the project with which they were involved. Thus, many people came to care about mill success: employees, PAC members, Jay citizens, the Maine DEP, U.S. EPA personnel, and members of participating nonprofit organizations. Rather than simply finding fault with the mill, these collaborative efforts brought a sense of collective investment to finding solutions.

The PAC's contribution to the mill's environmental successes was substantial if not public. Its access to current environmental data provided a means to constantly challenge the mill to improve. Relatively little turnover in the PAC meant that members were in a position to press mill management if change on a particular issue seemed too slow. Conversely, the turnover in mill managers (four in the PAC's first decade) created some confusion and delays. The tenure of environmental staff, however, helped smooth transitions and provide some constancy in the interface between the PAC and the mill.

The environmental improvements at the Androscoggin Mill did not emerge from a formal system, but important elements of a systems approach were in place. The mill benefited from a combination of talented individuals with vision, support, and pressure from within and outside the mill and hard consistent effort. This case demonstrates the value of management developing long-term goals and a framework for change, built on high standards and a desire to gain the trust of regulators and the community that lead to environmental excellence.

Acknowledgments

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Notes

1. Opacity is an optical measure of particulate emissions.
2. The mill has not calculated chloroform emissions since 1995, when it completed the switch to 100% chlorine dioxide bleaching. The National Council for Air and Stream Improvement of the pulp and paper industry indicates that chloroform is not formed in 100% chlorine dioxide bleaching, a conclusion accepted by both the U.S. EPA and the Maine DEP. The procedure for calculating chloroform emissions is given in the *NCASI Handbook of Chemical Specific Information for SARA Section 313 Form R Reporting Chemical-Specific Information for Chloroform:* Section 3.1 Manufacture the Toxic Chemical. This reference is updated yearly.
3. U.S. EPA XL projects are designed to enhance environmental protection while introducing regulatory flexibility and innovative environmental approaches at exemplary facilities (U.S. EPA XL Projects 2000).
4. Chemical oxygen demand is the measure of oxygen required to oxidize organic and inorganic compounds in effluent. It can adversely affect organisms in receiving waters.
5. Green-liquor dregs and lime mud result from chemical recovery operations: After burning black liquor in the recovery boiler, a smelt that contains sodium carbonate results. When dissolved, the smelt forms green liquor, leaving behind green-liquor dregs, which are removed. Green liquor is reacted with lime (calcium oxide) to regenerate white liquor and precipitate lime mud (calcium carbonate). The mud is fired in the limekilns to regenerate lime. After adjusting its chemical composition, the white liquor is again used in cooking operations (Smook 1992, 149–153).
6. Wood knots are overthick chips or other irregular wood pieces that are difficult to digest during cooking. Screenings are particles of wood that may contaminate pulp and paper if not screened out before cooking operations.
7. The Maine DEP sets standards and requires testing for heavy metals and other hazardous contaminants in ash and sludge as a condition of approval for beneficial reuse, such as land application. It also sets limits on the amount of heavy metals and other contaminants that can be applied to a parcel of land. Code of Maine Regulations, Chapter 419, "Agronomic Utilization of Residuals" (effective December 19, 1999).
8. Groves left the Maine DEP to work at the mill in 1994, becoming environmental manager in 1995.
9. Limekilns recover calcium oxide (lime) from calcium carbonate by driving off carbon dioxide. Used as a coater and filler, PCC use is not unique to the Androscoggin Mill. Some coated papers contain 30% PCC by weight. SMI sells about 60% of its output to the mill and the rest to other paper mills.
10. There is disagreement over competing standards in forest management. The primary alternative to the American Forestry and Paper Association's SFI is the Forest Stewardship Council's standard. See the comparison prepared by the Meridian Institute (2001) for further details.
11. The Androscoggin Mill also has an environmental management system that is audited and approved by the Maine DEP and the U.S. EPA.

References

AFPA (American Forest and Paper Association). 1994. Sustainable forestry initiative program. www.afandpa.org/iinfo/iinfo.html. Accessed May 2002.

Churchman, C. W. 1968. *The systems approach.* New York: Dell.

Ehrenfeld, J. R. and N. Gertler. 1997. Industrial ecology in practice: The evolution of interdependence at Kalundborg. *Journal of Industrial Ecology* 1(1): 67–79.

McDonough, T. 2000. Pulping and bleaching technologies for improved environmental performance. In *Industrial environmental control, pulp and paper industry.* Third edition. Edited by A. Springer. Atlanta: TAPPI Press.

Meridian Institute. 2001. *Comparative analysis of the Forest Stewardship Council© and Sustainable Forestry Initiative®certification programs.* Washington, DC: Meridian Institute. http://madison.merid.org/meridian/home.nsf/projectarea. Accessed August 2002.

President's Commission on Environmental Quality (PCEQ). 1990. Executive Order 12737, December 12, 1990, 55 F.R. 51681.

Servos, M. R., K. R. Munkittrick, J. H. Carey, and G. J. Van Derkraak, eds. 1996. *Environmental fate and* *effects of pulp and paper mill effluents*. Delray Beach, FL: St. Lucie Press.

Sjostrom, E. 1981. *Wood chemistry*. New York: Academic Press.

Smook, G. A. 1992. *Handbook for pulp and paper technologists*. Second edition. Bellingham, WA: Angus Wilde Publications.

Springer, A. 2000a. *Industrial environmental control, pulp and paper industry*. Third edition. Edited by A. Springer. Atlanta: TAPPI Press.

Springer, A. 2000b. Impact of water pollutants on the pulp and paper industry. In *Industrial environmental control, pulp and paper industry*. Third edition. Edited by A. Springer. Atlanta: TAPPI Press.

Springer, A. 2000c. Air pollution: A problem without boundaries. In *Industrial environmental control, pulp and paper industry*. Third edition. Edited by A. Springer. Atlanta: TAPPI Press.

Springer, A. 2000d. Pollution prevention. In *Industrial environmental control, pulp and paper industry*. Third edition. Edited by A. Springer. Atlanta: TAPPI Press.

Springer, A. 2000e. Management of residuals. In *Industrial environmental control, pulp and paper industry*. Third edition. Edited by A. Springer. Atlanta: TAPPI Press.

Springer, A. and J. Maxham. 2000. Secondary aerobic biological treatment. In *Industrial environmental control, pulp and paper industry*. Third edition. Edited by A. Springer. Atlanta: TAPPI Press.

U.S. Environmental Protection Agency (EPA) Chemical Accident Prevention and Risk Management Programs. 2001. www.epa.gov/swercepp/acc-pre.html. Accessed August 2002.

U.S. EPA Star Track Program. 1997. *StarTrack Environmental Performance Report*. www.epa.gov/region01/steward/strack/eprip.pdf. Accessed May 2002.

U.S. EPA XL Project. 2002. *What is Project XL?* www.epa.gov/projectxl/file2htm. Accessed August 2002.

Appendix 1: Kraft Pulping and Pollution Associated with It

Background

Wood, the source of the fiber used to make most paper, contains two major components. One is carbohydrate (cellulose and hemicellulose). The other is lignin, which binds tightly to the carbohydrate and imparts strength to the wood. In chemical pulping, fiber (cellulose and hemicellulose) is separated from lignin by cooking wood chips with inorganic chemicals at high temperature and pressure.

The paper industry typically used two chemical-pulping technologies in the 1950s and 1960s, sulfite and kraft. Sulfite mills of that time discharged spent cooking liquor into rivers to avoid the cost of recovering cooking chemicals. In contrast, the kraft process incorporates an economic recovery of 97% to 98% of cooking chemicals (Smook 1992). The result was the closure of a growing number of sulfite mills in the 1950s as kraft mills came on line. Kraft mills, although more economical to operate, produce a dark pulp (the color of a typical grocery bag), which requires stronger bleaching. This led to the use of elemental chlorine as a bleaching agent.

Chemical and Energy Recovery

The spent pulping liquor that results from kraft cooking contains about half the wood's organic substance, especially lignin-containing chemicals, as well as the degradation products of the inorganic cooking chemicals. In the kraft process, the inorganic chemicals are recovered in a closed-loop process that relies on energy generated by the burning of lignin-rich liquor: The spent liquor initially contains about 15% solids. This is concentrated in evaporators to about 75% solids and then burned in recovery boilers to generate steam. The steam is used to evaporate and concentrate additional spent liquor, continuing the cycle and also providing electricity and steam to the paper mill. The smelt left after burning the liquor contains the inorganic chemicals. These are recovered and converted back to cooking chemicals that can be used again.

Making Paper

The cooked chips (separated from the bulk of the liquor) are disintegrated into their component fibers, the pulp. The pulp is washed and then often undergoes further treatment such as oxygen delignification. It is bleached and washed again. Finally, the pulp is diluted and fed along with additives into the machines producing paper products.

Pollutants Produced by Kraft Pulping

Wastewater treatment plants generally cannot be 100% effective, and some pollution still reaches rivers. Pollutants from kraft mills include BOD, pigments (primarily from the dark color of lignin), and total suspended solids. The use of elemental chlorine to bleach pulp results in AOXs, including trace amounts of dioxins, in mill effluents. Chlorine dioxide bleaching significantly lowers AOX generation and virtually eliminates dioxin formation (McDonough 2000). Kraft mills produce air pollutants that are typical of many industrial facilities. Those most annoying to nearby communities are malodorous sulfur-containing chemicals, such as methyl sulfide, that result from the cooking process. Stringent emissions controls are required to avoid releases (Springer 2000c).

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