



Ban on landfilling of wooden pallets in North Carolina: an assessment of recycling and industry capacity

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ABSTRACT

Pallets literally move the world and an estimated 2 billion of them are in use in the U.S. every day. However, pallets have a short life span and thus consume vast quantities of resources. They are also responsible for 2–3% of all waste landfilled in the United States. This is despite the fact that technologies and markets exist that allow pallets to be reused, recycled, converted into other products or turned into mulch, boiler fuels or alcohols (ethanol). The State of North Carolina's legislature debated a ban on landfilling pallets for several years and has now enacted legislation to ban this practice beginning in 2009. This study provided information used to help reach that decision.

North Carolina had 103 known pallet recycling operations that were surveyed in 2003–2004. Using 34 responses, the total pallet recycling capacity in North Carolina was close to 60 million units per year, while 34 million pallets were actually recycled in 2003. The average operation employed nearly 34 persons and recycled about 326,000 pallets per year. On average, 20% of the pallets received by a recycling operation were reused, 45% were refurbished, 19% were recycled, and 15% were ground. The industry generally thought that a ban on landfilling pallets was a good idea (56%) with 18% indicating it was a bad idea. Another 18% of respondents did not care and 9% had different ideas.

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1. Introduction

Pallets play an important role in today's economy by aiding in efficient and reliable transportation of goods. Pallets are rigid horizontal platforms that are easily portable by special equipment. They serve for storing, stacking, handling and transporting goods as a unit load [1]. A unit load describes "a single item, a number of items, or a bulk material, that is arranged and restrained so that the load can be stored, picked up, and moved between two locations as a single mass [2, p. 8]". Without pallets, many products would have to be manually lifted and kept together, resulting in higher handling costs or the necessity to use other, more expensive devices, thus increasing economic transaction costs.

Different materials are used for the production of pallets, such as solid wood, wood-based composites, paper, plastic and metal. While material preferences vary based on performance requirements and costs, solid wood pallets account for an estimated 90–95% of all pallets in use in the U.S. [3]. Low material and production costs combined with the relative abundance of solid wood are major reasons for wood's dominance. In fact, the

pallet industry often represents a critical market for the lower grades of hardwood lumber produced by sawmills, which might otherwise be difficult to sell. Other materials are used for technical or regulatory reasons. For example, the grocery industry uses plastic pallets to conform with sanitary regulations, while metal pallets are used in closed loop material systems for their durability.

Pallet size standards vary widely throughout the world. In Asia, the most widely used pallet size is 1100 × 1100 mm, in Europe 1200 × 800 mm (called a Euro pallet) and in the U.S. 1219 × 1016 mm (48 × 40 inches). The International Organization for Standardization (ISO) guideline 6780 [4] concerning flat pallets for intercontinental materials handling lists six sizes (the three mentioned before and 1067 × 1067 mm, 1140 × 1140 mm and 1200 × 1000 mm) as the accepted standard for intercontinental material handling. White [5, p. 5], realizing the logistical problems created by six different sizes, pointed out that six is "five too many". In contrast, U.S. companies rely on more than 400 different pallet sizes [5], with the 48 × 40-inches pallet being the most common [6]. Indeed, because of the varying size standards, unit loads often need to be unloaded and reloaded at borders of destination countries to accommodate local pallet size standards [7].

However, due to the lack of standardization and efficient pallet cycling systems (e.g., unload incoming material and reload with outgoing material), large numbers of pallets become unusable well

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before the end of their potential time of obsolescence and are discarded in landfills, ground into mulch, used for boiler fuel, or left to rot. In the U.S., an estimated 450 million new pallets are produced annually [3] and 1.9 billion pallets are in use at any moment in the U.S. [8], most of them wooden pallets. Thus, the U.S. pallet stock is replenished every four years, leaving the pallet industry and end-users with a large amount of material, mostly wood, to dispose of.

To produce 450 million new pallets annually, the pallet industry consumes vast quantities of resources. In 2005, it was estimated that 33% (3.8 billion board feet) of the total hardwood lumber produced in the United States was used for pallet manufacturing, making it the single largest use of hardwood lumber [9]. It is also known that wooden pallets represent 2% of all Municipal Solid Waste (MSW) and over 3% of all Construction and Demolition Waste (C&D) landfilled [10,11]. Technologies exist that allow for reusing and recycling of these discarded pallets, thereby improving the use of harvested forest resources and landfill space, creating opportunities to produce value added wood products, and adding employment opportunities to rural economies [12].

Wood, an environmentally friendly, sustainable and versatile raw material [13–15] with uncounted fields of applications [16], is easily recycled [17,18]. Landfilling discarded pallets thus is not foreordained [12]. Recycled products from wooden pallets include remanufactured pallets [19,20], wood flooring [21,22], wood-cement panels and bricks [23,24], mulch [25], boiler fuel [26,27] and alcohols like ethanol [28,29]. The increasing demand for woody biomass for consumption and energy generation [30,31] could create additional incentives to avoid landfilling wood pallets and parts by increasing the cost of the pallet raw material (lumber) and by offering higher returns for reusing or recycling discarded pallets.

North Carolina, the ninth fastest growing state in the U.S. [32], actively pursues waste minimization strategies to lessen the need for landfill capacity [33]. Over a million ton of unused wood residuals were documented by Buehlmann and Murphy [34] based on numbers from the North Carolina Department of Environmental and Natural Resources (NCDENR). However, these numbers likely underestimate the amount of wood residuals available, as Buehlmann and Kincaid [35] found up to 20 times the amount of wood residuals generated in some counties compared to the ones estimated by the North Carolina Energy Divisions' Wood Residue Report [36]. According to 1997 estimates, only 37% (151,661 tons) of the pallets discarded in North Carolina were reused or recycled, while the remainder was brought to landfills or turned into low value products such as mulch or boiler fuel [37]. Thus, 282,000 tons of wood were either used as fuel, mulch, or disposed of in landfills. Yet, many of the pallets that are discarded need only minor repairs to be reusable or can be easily disassembled and recycled into new pallets, thereby significantly lowering the amount of wood that is discarded. North Carolina, like many other states, faces limits on landfilling space due to more stringent environmental restrictions and a more critical public. Thus, the state is working on legislation that would reduce the amount of materials landfilled in the future. Among other things, the current draft of the NC Solid Waste Plan 2004–2013 lists a landfilling ban on pallets and untreated wood as a top priority [38]. This call was reinforced by the NC Division of Waste Management's forum issues concerning solid waste [37].

2. Objectives

To assess the ability of North Carolina's pallet recyclers to cope with the potential increase in material to be recycled, a study was commissioned by the North Carolina Department of Environment and Natural Resources, Division of Pollution Prevention. The study was designed to collect data about:

- the existing pallet recycling industry in North Carolina;
- the recycling industry's capacity to handle increased demand for services should a landfilling ban for wooden pallets be implemented;
- an assessment of the industry's position on such a ban.

3. Methods

The initial mailing list for the survey contained 155 North Carolina pallet recycling firms based on mailing lists maintained by NC State University's wood recycling team and the North Carolina Department of Environmental and Natural Resources, Division of Pollution Prevention. The initial mailing was conducted in October of 2003 and a follow-up mailing to nonrespondents was made in January of 2004. Twenty-five usable responses were received from the mail survey, 18 from the first mailing and seven from the second mailing. The adjusted mailing list contained 103 firms, after removing firms that did not recycle pallets or no longer recycled pallets ($n = 45$), were out of business ($n = 2$), or were duplicated in the original list ($n = 5$).

In an effort to increase the sample size, a random sample of nonrespondents was telephoned and surveyed over the phone in March of 2004. An additional nine responses were obtained in this manner. The phone survey also provided an opportunity to test for nonresponse bias since the phone respondents had not responded to the previous attempts to acquire information via the mail and were drawn from the pool of nonrespondents.

Table 1 shows that there were no differences between the respondents to the first questionnaire mailing and respondents to the second questionnaire mailing combined with the phone survey respondents. The nonparametric Wilcoxon test was used since the sample sizes for both groups were small. Since no differences were found, the phone respondents were combined with the mail respondents (for a total sample of 34) when summary statistics were calculated. This resulted in an overall response rate of 33%.

4. Results and discussion

The average pallet recycler in North Carolina employed nearly 34 people and recycled approximately 326,000 pallets per year (Table 2). Plants ran at an average capacity utilization rate of 58.3%, assuming that the average capacity was approximately 559,000 pallets per year.¹ While the variance was quite large for both the recycling and capacity distributions (Table 2), and the median was somewhat lower than the mean for both distributions (132,500 and 190,000, respectively), the skewness values for both distributions were not substantial (i.e., less than 2.0). Further, only three of the largest values in the recycling distribution and one in the capacity distribution were classified as mild outliers (using the typical definition of $1.5 \times$ the interquartile range or IQR) and none were considered extreme outliers (typically defined as $3.0 \times$ the IQR). Thus the mean was considered a reasonable measure of central tendency.

Of the pallets received for processing, responding firms indicated that, on average, 20% were reused, 45% were refurbished, 19% were recycled and 15% were ground (Table 3). Interestingly, when measured as a proportion of total pallets recycled by respondents, the figures are similar to the firm averages, although reuse volume is slightly lower than the firm

¹ While this capacity utilization rate was based on the mean values for pallets recycled and capacity, it should be noted that the 90% confidence intervals for these means overlapped, suggesting that the theoretical rate could be much higher.

Table 1

Summary of medians and nonresponse tests (Wilcoxon) comparing respondents to the first questionnaire mailing ($n = 18$) to those responding to the second mailing and phone survey ($n = 16$)

Variable	First respondents (median)	Second & phone respondents (median)	Z approx.	Sig.
Number of employees	20.5	20.0	-0.207	0.836
Pallets recycled	57,500	148,000	1.519	0.129
Recycling capacity	125,000	250,000	-0.872	0.383

average (suggesting smaller firms are engaged more in reuse), and recycling volume is slightly higher than the company average (suggesting that larger firms are more engaged in recycling). More than 70% of the residual material was converted to either mulch or boiler fuel (Table 4), with larger companies engaged more in mulch production and smaller companies engaged more in boiler fuel production.

Seventy-seven percent of all pallets resold are furnished to manufacturing industries, followed by private customers (8%) and food retailers (8%). Over 85% of respondents indicated that they could sell more pallets if they were available. Of these 29 companies, over half indicated they could sell at least 50% more than current volume.

Nearly 56% responded that a landfill ban on pallets in North Carolina was a good idea, with 18% each indicating it was not a good idea or that they did not care (Table 5). The remainder (9%) had other ideas or opinions, ranging from surcharges on pallets to mandatory grinding of pallets. Thus, pallet recyclers were not unanimous in their favorability toward a ban on pallets in NC's landfills. There was general agreement from comments on the questionnaires, however, that landfilling of pallets was an inefficient use of resources. Opposition to a ban came mainly for two reasons. One reason was smaller recyclers' inability to afford a grinder to process pallet parts that are no longer usable. The other reason was an unease of some pallet recyclers with the resulting increase in supply of pallets in the marketplace, which could possibly lower pallets prices in the market.

Results from this survey suggest that the NC pallet industry could recycle more pallets than it does at present: by extrapolating from the study sample,² approximately 33.6 million pallets (range of 20.1–47.1 million based on the 90% confidence interval) are recycled each year in North Carolina with a full capacity of 57.6 million pallets (range of 34.6–80.6 million), or 58% average capacity utilization. If the recyclers ran closer to 80% capacity, then nearly 46 million pallets potentially could be recycled. Given that nearly 56% of the companies surveyed plan to expand their pallet recycling capacity in the near future (Table 2), North Carolina could soon be recycling close to 50 million pallets a year. In fact, nine companies stated that they intend to at least double their capacity in the near future. Given the existing capacity and plans for expansion of the pallet recycling companies surveyed and the ease of implementing additional recycling capacity, a ban on landfilling pallets would not seem to lead to an overburden on recyclers.

The capacity utilization rate found in this study is well below the historical (1972–2006) overall industry average (81%) [39]. The pallet industry's low capital investment into plant and equipment and the low training costs for their employees help explain this

² From data provided by respondents (Table 2), a ratio of 9682 recycled pallets per employee per year was developed. Assuming there were 103 pallet recyclers with an average size of 33.7 employees, there were approximately 3471 total employees. Multiplying total employment (3471) by the ratio of pallets recycled per employee (9682) resulted in 33,606,222 recycled pallets.

Table 2

Number of employees and recycling volumes and capacity of, responding North Carolina pallet recyclers ($n = 34$)

Variable	Mean response	Std. dev.	90% Conf. interval, lower	90% Conf. interval, upper
Number of employees	33.7	29.5	25.2	42.3
Pallets recycled	326,304	451,549	195,247	457,361
Recycling capacity	559,545	719,871	336,228	782,861
Have plans to expand operations	55.9%	–	–	–

observation. When capital and training investment in plant, equipment and labor are low, an industry (company) can afford to have excess capacity without paying a steep financial penalty. Most workstations in the typical pallet recycling operations are relatively simple. Thus, the industry can afford to have excess capacity, an observation that was confirmed by this study. Pallet recyclers, thus, can expand their production volume by increasing their utilization rate with relatively little financial and human resources investment, allowing them to absorb a potential surge in volume in the near term.

Conversations with industry participants brought to the forefront that their concerns are not with manufacturing capacity issues, but a general uneasiness about the market for recycled pallets. Industry participants fear that prices for recycled pallets could drop with an increase of recycled pallets coming to the market. However, several recyclers also pointed out that opportunities might arise regarding the pallet "disposal" fees charged to industry, as landfilling will no longer be an option.

A ban on pallets would alleviate some of the strain on NC's available landfill space. A ban might also stimulate increased recovery of the value of the material contained in used pallets. Depending on the quality and the size of a pallet, recyclers may either charge users to pick up used pallets, pick them up for free, or pay up to \$1.50 for good quality, standard size pallets. Assuming a median selling price of \$4.75 per recycled pallet (prices range from \$3.00 to \$6.50 according to various industry participants), the industry's current annual business volume (based on a recycling volume of 33.6 million pallets) is nearly \$160 million, excluding the value generated from products made from ground pallets. Assuming that roughly 50% of pallets in North Carolina are recycled today, the industry potentially could grow to over a \$300 million business over the next few years.

5. Subsequent outcomes and conclusion

On September 7, 2005, approximately two years from the onset of this study, North Carolina enacted House Bill 1465, which is "an act to prohibit the disposal of motor oil filters, rigid plastic containers, wooden pallets, and oyster shells in landfills" [40]. This law will take effect on October 1, 2009.

Table 3

How received pallets were processed by responding North Carolina pallet recyclers

Processing method	Percent (mean) by company	Percent of total volume
Refurbished (some parts exchanged, pallet not disassembled)	44.8	42.9
Reused (no parts are exchanged, only minor fixes)	20.4	10.9
Recycled (new pallet built from disassembled parts of other pallets)	18.6	29.8
Ground (pallet could not be used due to damage or size)	15.4	16.5
Other	0.9	0.0

Table 4
Products made from pallet residuals by responding North Carolina pallet recyclers

Product	Percent (mean) by company	Percent of total volume
Boiler fuel	42.6	22.0
Mulch	29.6	48.2
Animal litter	0.1	0.6
Other	27.7	29.3

While debating the proposed ban in the NC legislature, home-builder related interests sought to obtain an exemption to the ban for builders. Their argument goes that small builders doing small jobs would face challenges finding an outlet for their pallets used on the job site. The legislature agreed with this exception. At the same time, the North Carolina Department of Environment and Natural Resources (NCDENR), Division of Pollution Prevention and Environmental Assistance has started cooperating with local C&D landfills to collect and recycle those pallets at the landfilling sites [41].

Two large pallet recyclers in NC were visited in December 2007 to review their preparations and concerns about the landfill ban. Only one operation was aware of the upcoming ban, the other operation had not yet heard of this ban. However, both pointed out that they are not concerned about the pallet ban, as their operations are flexible enough to adapt. However, one pointed out that smaller operations who do not have grinders for the unusable pallet parts, may still need to landfill those unusable parts. With pallet parts still being accepted at C&D landfills, there should be an alternative for those industry participants. Ultimately, time will tell what impacts the NC pallet ban will have on the pallet recyclers and on the overall pallet industry in the State. However, based on available data and observations, recyclers should be positioned to deal with the increased volume once those pallets can no longer be discarded at a landfill.

Actions relating to addressing climate change, as well as increasing energy costs, are introducing a new dynamic into the issue of landfilling natural resources such as wood fiber from discarded pallets. While wood covers up to 90% of total energy demand in some developing nations, it provides only 2% of total energy demand in developed nations [42]. Plans for CO₂ emission reductions, especially in Europe, call for significant increases in the use of wood (biomass) as a fuel [31,43,30]. As a consequence, demand for wood chips and pellets has increased throughout the world, including the U.S. [44,45]. Some traditional buyers of wood residues from sawmilling operations (farmers, paper mills) are increasingly being priced out of the market [46,44].

At the present time, pallet recyclers obtain a higher return from using recycled pallets to supply their own pallet re-assembly operations. Thus, pallet recyclers are supplying the wood fuel markets only as a secondary choice after having exhausted other venues (in the present study only about 15% of recycled pallets were ground, and about half of the ground material went to mulch for landscaping). However, the current reshuffling of demand for wood chips for wood energy and the resulting changes in prices could lead pallet recyclers to supply more of their output to these markets

Table 5
Opinions on banning pallets in landfills from responding North Carolina pallet recyclers

Opinion	Percent of respondents
Good idea	55.9
Do not care	17.6
Not a good idea	17.6
Other ideas or opinions	8.8

and provide new opportunities for the increasing supply of recycled pallet material in North Carolina and elsewhere.

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References

- [1] MHIA. Reusable container and pallet association glossary. Material Handling Industry of America (MHIA), <http://www.mhia.org/industrygroups/rpcpa/glossary>; 2008 [accessed 07.05.08].
- [2] White MS, Hamner P. Pallets move the world – the case for developing system-based designs for unit loads. *Forest Products Journal* 2005;55(3):8–16.
- [3] Anonymous. Pallet talk. Alexandria, VA: National Wooden Pallet & Container Association; April 2000.
- [4] International Organization for Standardization. Flat pallets for intercontinental materials handling – principal dimensions and tolerances. ISO 6780:2003.
- [5] Brindley C. It's a small world after all – will global standards impact local markets?. Pallet Enterprise, www.palletenterprise.com; 2002 [accessed 27.11.07].
- [6] Clarke JW. Pallet user education series – pallets 101: industry overview and wood, plastic, paper&metal options. Pallet Enterprise, <http://www.palletenterprise.com/articledatabase/view.asp?articleID=1409>; 2004 [accessed 27.11.07].
- [7] Raballand G, Aldaz-Carroll E. How do differing standards increase trade costs? The case of pallets. *The World Economy* 2007;30(4):685–702.
- [8] Anonymous. Pallet talk. Alexandria, VA: National Wooden Pallet & Container Association; June 1999.
- [9] Hardwood Market Report. 2006: The year at a glance. In: 10th annual statistical analysis of the North American hardwood marketplace, Memphis, TN; 2007. 172pp.
- [10] Bush RJ, Corr DT, Araman PA. Fewer pallets reaching landfills, more are processed for recovery. Pallet Enterprise; May 2001. p. 18–21.
- [11] McKeever DB. Solid wood waste in the United States: an important, changing resource. In: Wood waste utilization conference presentation, May 4–5, 2000, Omaha, NE.
- [12] Araman PA, Bush RJ, Hammett AL, Hager EB. Wood pallets and landfills – status and opportunities for economic recovery and recycling. In: Proceedings from WASTECON/ISWA world congress 1998. Charlotte, NC: Solid Waste Association of North America (SWANA); October 26–29, 1998. p. 345–58. Publication # GR-G 0036.
- [13] Fenning TM, Gershenson J. Where will the wood come from? Plantation forests and the role of biotechnology. *Trends in Biotechnology* 2002;20(7):291–6.
- [14] Sutton WRJ. Wood in the third millennium. *Forest Products Journal* 2000; 50(1):12–21.
- [15] Koch P. Wood versus nonwood materials in U.S. residential construction: some energy-related global implications. *Forest Products Journal* 1992;42(5):31–42.
- [16] Sutton WRJ. The world's need for wood. In: Proceedings of the conference on the globalization of wood: supply, processes, products, and markets. Forest Products Society; 1993. p. 21–8.
- [17] Buehlmann U. Wood reuse and recycling – recycled products. In: Yearbook of science and technology. New York, NY: McGraw Hill; 2003. p. 392–5.
- [18] Sherman-Huntoon R. Wood waste study provides clues to recycling success. *BioCycle – Journal of Composting & Organics* July 2001:68.
- [19] Bejune J, Bush RJ, Araman PA, Hansen B, Cumbo D. Pallet industry relying more on recovered wood material. Pallet Enterprise; October 2002. p. 20–7.
- [20] Clarke JW, White MS, Araman PA. Performance of pallet parts recovered from used wood pallets. *Forest Products Journal* 2001;51(2):55–62.
- [21] Anonymous. Companies that show recycling means business. In *Business May/June* 2005:28.
- [22] Muller P, Buehlmann U. From landfill to living room: turning pallets into flooring. *NCSU Bulletin* April 2, 2004:3.
- [23] Anonymous. Wood cement board offers wide range of applications. *Wood Technology* October 1998;25(8):26–7.
- [24] Defo M, Cloutier A, Riedl B. Wood-cement compatibility of some Eastern Canadian woods by isothermal calorimetry. *Forest Products Journal* 2004; 54(10):49–56.
- [25] Olawski J. Pallet remanufacturer diversifies to handle growth. In *Business March/April* 2001:16–7.
- [26] Aruna PB, Laarman JG, Araman PA, Cabbage F. An analysis of wood pellets for exports: a case study of Sweden as an importer. *Forest Products Journal* 1997; 47(6):49–52.
- [27] Aruna PB, Laarman JG, Araman PA, Coulter E, Cabbage F. Used pallets as a source of pellet fuel: current industry status. *Forest Products Journal* 1997; 47(9):51–6.

- [28] Lynd LR, Cushman JH, Nichols RJ, Wyman CE. Fuel ethanol from cellulosic biomass. *Science* March 1991;241(4999):1318–23.
- [29] Anonymous. From geeks to greens – business and the environment. *The Economist*. Online edition, <http://www.economist.com/> 2008 [accessed 28.02.08].
- [30] Perlack RD, Wright LL, Turhollow AF, Graham RL, Stokes BJ, Erbach DC. Biomass as feedstock for a bioenergy and bioproducts industry: the technical feasibility of a billion-ton annual supply. U.S. Department of Energy and U.S. Department of Agriculture; April 2005. 78pp.
- [31] Ericsson K, Nilsson LJ. International biofuel trade – a study of the Swedish import. *Biomass and Bioenergy* 2004;26:205–20.
- [32] NC State Demographics. State population growth: April 1, 2000 to July 1, 2007. North Carolina State Demographics, <http://demog.state.nc.us/>; 2007 [accessed 27.01.08].
- [33] Anonymous. Summary of forum issues concerning solid waste management (SWM) in North Carolina. North Carolina Department of Environment and Natural Resources. Division of Waste Management, <http://www.wastenotnc.org/swhome/forsum.pdf>; 2004 [accessed 08.07.04].
- [34] Buehlmann U, Murphy R. Availability of wood residuals for North Carolina. Extension report. Raleigh, NC: North Carolina State University, Department of Wood and Paper Science; December 2002. 23pp.
- [35] Buehlmann U, Kincaid J. Scrap wood availability in the Triangle J region. Raleigh, NC: North Carolina State University and Triangle J Council of Government; 2001. 64pp.
- [36] Anonymous. North Carolina wood based residue inventory. Raleigh, NC: North Carolina Energy Division; 1999. 124pp.
- [37] Anonymous. Wood: wooden pallets. Raleigh, NC: North Carolina Department of Environment and Natural Resources, Division of Pollution Prevention, <http://www.p2pays.org/search/pdf/frame.asp?pdfurl=/ref/02/0162238.pdf>; 1998 [accessed 08.07.04].
- [38] Mouw S. Personal communication. Raleigh, NC: North Carolina Department of Environment and Natural Resources, Division of Pollution Prevention; July 8, 2004.
- [39] Federal Reserve. Industrial production and capacity utilization. Federal Reserve Statistical Release, G.17, <http://www.federalreserve.gov/releases/g17/Current/default.htm>; 2007 [accessed 19.12.07].
- [40] General Assembly of North Carolina. An act to prohibit the disposal of motor vehicle oil filters, rigid plastic containers, wooden pallets, and oyster shells in landfills. Session Law 2005-362, House Bill 1465. Raleigh, NC: General Assembly of North Carolina, <http://www.p2pays.org/ref/38/37333.pdf>; September 7, 2005 [accessed 26.11.07].
- [41] Mouw S. Personal communication. North Carolina Department of Environment and Natural Resources, Division of Pollution Prevention; December 18, 2007.
- [42] Trossero MA. Wood energy: the way ahead. *Unasylva* 2002;211(53):3–12.
- [43] European Parliament and Council. Promotion of electricity produced from renewable energy sources in the internal electricity market. Directive 2001/77/EC, Bruxelles, Belgium. Official Journal of the European Union; September 27, 2001. L283/33–40.
- [44] *Hardwood Review Express*. Rising returns for wood waste – northern sawmills and manufacturers benefit most. *Hardwood Review* April 25, 2008; 7(30):1–3. Charlotte, NC.
- [45] Jameson A. South Wales power station will burn wood chips. *Times Online*, http://business.timesonline.co.uk/tol/business/industry_sectors/natural_resources/article2917931.ece November 22, 2007 [accessed 12.12.07].
- [46] Millman J. Sawdust shock: a shortage looms as economy slows. *Wall Street Journal* March 3, 2008; CCL(51). p. A1 and A10.