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Industrial Ecology, Spring 2006
Final Paper

A Characterization of the Recycling Sector in Puerto Rico

Abstract

Puerto Rico faces a waste management crisis. Landfills are reaching capacity and alternative infrastructure for solid waste disposal does not exist. Furthermore, the Legislature has repeatedly set a recycling goal of 35 percent, which has never been met. Given the issue's importance, this study aims to characterize the recycling sector on the island. Data for this analysis were collected from the literature. In addition, our group conducted a series of interviews in Puerto Rico with different recycling stakeholders from March 6, 2006 to March 10, 2006. It was found that solid waste management in Puerto Rico is heavily dependent on landfills. The island lacks a sufficient market for recyclable materials, and so the main companies in the sector collect and sort material for export. It is estimated that the overall recycling rate for the island is 7-10 percent, with specific rates varying by material. Aluminum is most efficiently collected with a recycling rate of 52 percent. The factors influencing recycling are complex and stem from political, economics, and culture issues, as well as a critical lack of infrastructure. These factors are explored in detail. Finally, recommendations for improving recycling performance in Puerto Rico are given.



Table of Contents

1. Introduction	3
2. Government Agencies and Waste Management	6
3. History of Solid Waste Management Regulation in Puerto Rico	7
4. Solid Waste Flows in Puerto Rico	11
5. Estimated Recycling Rates for Puerto Rico	12
6. Recycling Business in Puerto Rico	14
7. Discussion	17
8. Recommendations	20
9. Conclusion	22
References	23
Appendix 1 – Recycling Companies in Puerto Rico	25
Appendix 2– Recycling Rate Calculations	28

1. Introduction

Industrial Ecology researchers from the Yale School of Forestry and Environmental Studies began material flows analyses in Puerto Rico in 2001. The tools of industrial ecology are particularly well-suited to island contexts because their small areas and well-defined boundaries make tracking material flows less complex. Puerto Rico is a Commonwealth of the United States and has in the past half century become extremely industrialized. For example, sixteen of the top twenty prescription drugs in the United States are manufactured in Puerto Rico (Deschenes & Chertow, 2004). These factors make Puerto Rico an ideal candidate for study. Research in past years has uncovered several examples of industrial symbiosis in specific geographical areas. However, island-wide material flows have not yet been assessed.

Material flows are of central concern to industrial ecologists. In order to determine how resource utilization can be optimized, it is important to understand how and in what quantities materials flow through the industrial system. As shown in Figure 1, for any industrial material, there are four primary stages in the life-cycle, namely, production, manufacture and fabrication, use, and waste management (Graedel, 2006).

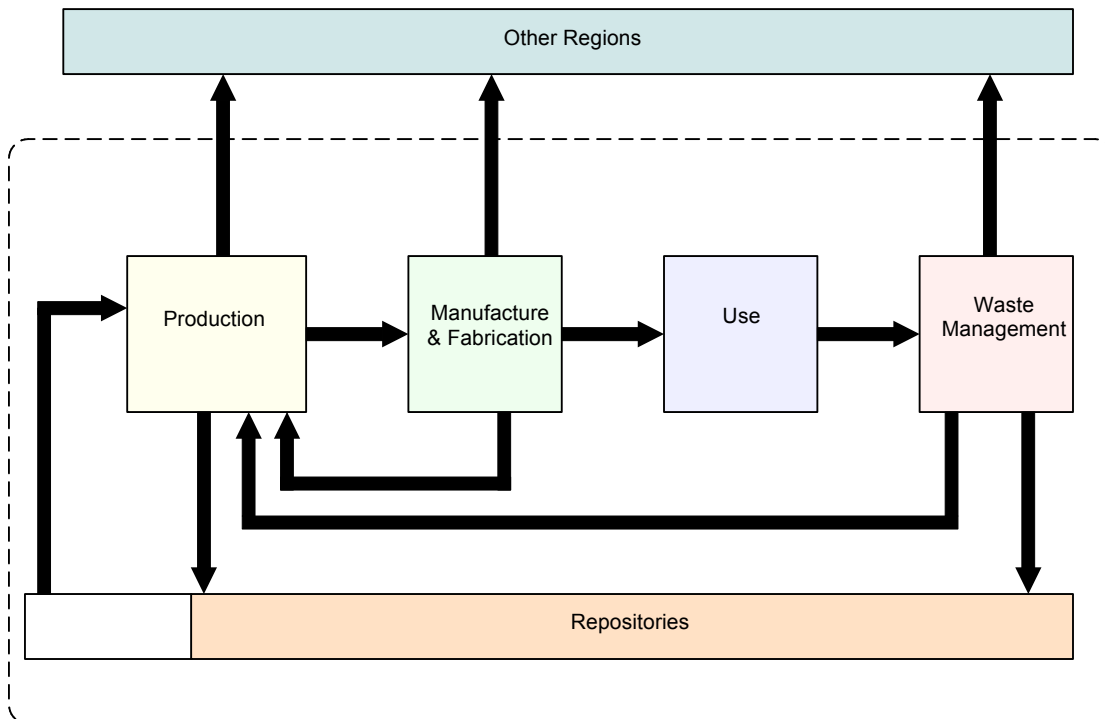


Figure 1 Material flow illustration (Graedel, 2006)

Characterizing and quantifying flows through waste management can lead to a greater knowledge of material cycles and help to increase resource efficiency. Waste management also serves as the

primary boundary between the industrial ecosystem and the larger natural ecosystem. In other words, material that is not recycled from waste management is disposed of in the environment. These emissions are generally the primary concern of environmentalists, policy-makers, and the wider population.

As affluence has increased on the island, waste management has become a central concern to the citizens and government of Puerto Rico. Puerto Ricans currently discard 3.9 pounds of municipal solid waste (MSW) per capita per day, much higher than the national average of 3.15 lb/person/day (ADS, 2003). Disposing of all this material has become particularly difficult, given the island's high population density and relative lack of solid waste management (SWM) infrastructure. According to recent data, the Commonwealth of Puerto Rico has a total population of 3.9 million with average population density measured at 434 persons per square kilometer (CIA, 2006). If treated as an independent U.S. state, Puerto Rico would rank first in population density in the United States and fourteenth in the world (Wikipedia, 2006). This high density increases competition for inhabitable land and reduces the availability of suitable landfill sites. Currently there are only 29 landfills in Puerto Rico serving 78 municipalities. Furthermore, there are no incineration facilities on the island, which means that all wastes are either landfilled or recycled. It is widely accepted that Puerto Rico faces a crisis in its waste management system, as several more landfills are predicted to close in the coming decade (Juarbe, 2002; Freytes, 2006).

Given the importance of the issue for Puerto Rico, as well as the latent interest in the subject from the perspective of the industrial ecologist, this study aims to characterize the recycling sector on the island. Recycling has been strongly encouraged in government plans as a way to divert some of the material from the overburdened landfills. Yet recycling activities on the island are extremely limited. The main objectives of the study are as follows:

- Determine the overall recycling rate on the island, as well as rates for specific materials
- Identify the major recycling firms on the island and map material flows and recycling infrastructure
- Examine the policies influencing recycling and make recommendations to improve recycling programs on the island

Data was collected from the literature and from a series of interviews conducted during a research visit during March, 2006. The specific interviewees are shown in Table 1 and the interview location in Figure 2.

Table 1 List of Interview Subjects

<i>Private Recyclers</i>	
Mr. Guillermo Tous, President	IFCO Recyclers, Inc.
Mr. Gabriel Vasquez, General Manager	Pronatura Inc.
Mr. Harry Fernandez	Caribbean Hi-Tech Recyclers, Inc.
<i>Government Agencies</i>	
Mr. Antonio Rios, Program Officer	Autoridad de Desperdicios Solidos (ADS)
Mr. Carlos Lopez Freytes, Director	Environmental Quality Board (EQB)
<i>Industry</i>	
Ms. Eileen Pagan, Consultant	McNeil / Johnson & Johnson, Inc.
Mr. Nelson Cruz	McNeil / Johnson & Johnson, Inc.
Mr. Jorge Al-Khoury	(Independent Industry Consultant)
<i>Academia</i>	
Mr. Luis E. Rodriguez Rivera, Professor	School of Law, University of Puerto Rico (UPR), Rio Piedras; former Director of ADS and the Department of Natural Resources



Figure 2 Interview Sites

2. Government Agencies and Waste Management

Solid waste management is overseen by several government entities in Puerto Rico that span federal, commonwealth, and municipal levels (Figure 3). The Environmental Quality Board (EQB) reports directly to the United States Environmental Protection Agency (USEPA) and to the Governor of Puerto Rico. The EQB is responsible for executing Puerto Rican regulations to implement U.S. laws such as the Resource Conservation and Recovery Act (RCRA) which regulates the disposal of both hazardous and non-hazardous waste. Similar to state environmental protection agencies, the regulations adopted by the Puerto Rican legislature and overseen by EQB must be at least as stringent as those regulations created by the USEPA. EQB's regulatory responsibilities also include monitoring and permitting landfill and recycling entities, inspection of waste management sites, and fining those persons who dispose of waste illegally (Rios, 2006; Freytes, 2006). The Autoridad de Desperdicios Solidos (ADS, referred to in English as the Solid Waste Management Authority, or SWMA) resides under the umbrella of the Department of Natural Resources; the Secretary of the Department of Natural Resources serves as the Board of Directors of ADS. However, the role of ADS is to serve as the liaison between EQB and the municipalities. ADS prepares the plans that must be carried out by the municipalities to meet the mandates required by EQB.

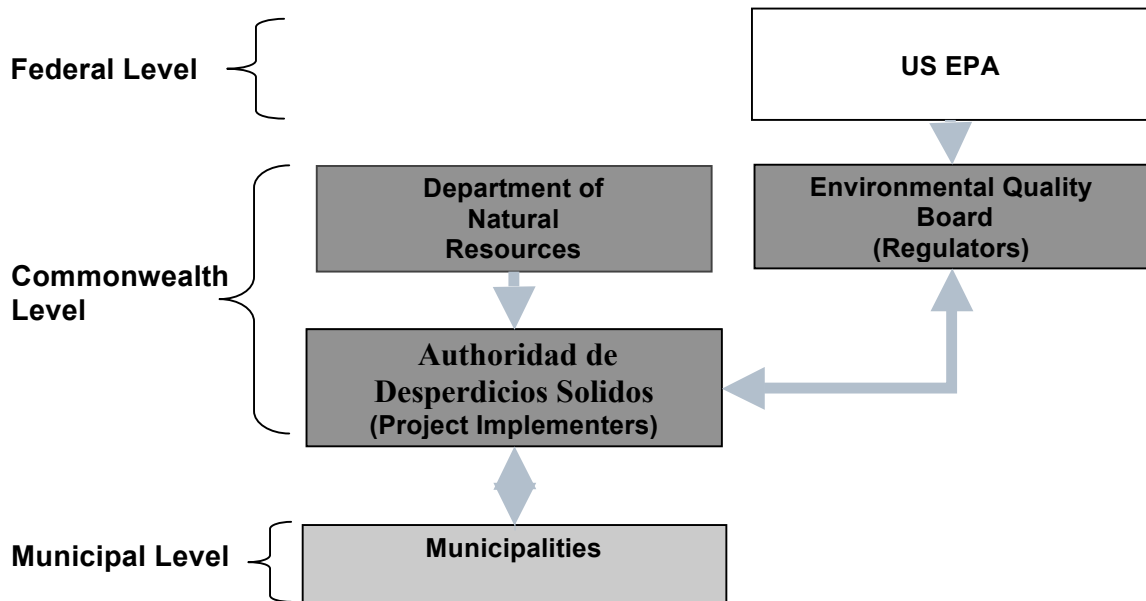


Figure 3 The hierarchy of the federal, commonwealth, and municipal government entities controlling solid waste management in Puerto Rico.

Furthermore, ADS is responsible for providing funding for the projects set forth in the implementation plans. For example, private recycling companies may apply to ADS for guaranteed loans to finance the purchase of new recycling equipment (Rios, 2006; Freytes, 2006). ADS tracks recycling rates on the island by collecting market statistics from recycling companies and by reviewing formal recycling plans that are required of companies with more than 10 employees (Cruz, 2006; Vasquez, 2006) .

3. History of Solid Waste Management Regulation in Puerto Rico

The progression of regulations and policies governing solid waste management in Puerto Rico has not been a straightforward one. There have been several policy reversals and instances of high-level corruption. Mapping out the political history of recycling is crucial for understanding the current state of recycling on the island.

In the past, each of Puerto Rico's municipalities had its own landfill. These were mostly informal dumping sites, with several sited close to aquifers or on "sinkholes", allowing leachate to flow quickly into groundwater (Miranda & Hale, 2005). Some sites simply burned the trash, giving rise to serious local air pollution problems. Over the years, several of the sites exceeded capacity and had to be discontinued, so that by the late 1980s, more than 15 municipalities lacked landfills (Hunter & Arbona, 1995). The historically informal nature of these disposal sites has continued to the present day.

Prior to 2000, SWM plans were generally focused on the development of public infrastructure. After the elections of that year, policy shifted toward economic development within the waste management industry. New interest emerged in attracting corporations that utilize recyclable materials. For instance, entrepreneurs who reused tires for making parking stoppers and buckets were identified and permitted. Similarly, industrial parks were planned with recycling and storage facilities to encourage industries to use waste. These initiatives, however, were largely unsuccessful (Rivera, 2006).

A detailed history of policies and regulations related to SWM is provided below (Rivera, 2006).

1970- The Puerto Rico Environmental Public Policy Act is passed, establishing the Environmental Quality Board as the local equivalent to the USEPA. Although the newly-

- created EPA has some oversight and enforcement responsibilities, the EQB is set up as an independent agency.
- 1976-** RCRA is signed at a federal level.
- 1980s-** ADS is created by the Legislature of the Commonwealth specifically to manage solid waste management on the island.
- 1988-** EQB does a survey of landfills on the island and finds that only 2 out of 62 are “well-operated”, while 57-60 of them are referred to as “a disaster.” (Hunter & Arbona, 1995). As a result of this survey, ADS undertakes a comprehensive review of solid waste management options on the island.
- 1990-** Law of Municipalities is passed, updating the legal mandate of municipal governments. In it, ADS is listed as an advisor on solid waste management issues.
- 1991-** ADS develops its first recycling plan to be undertaken as a pilot.
- 1992-** The Puerto Rico Legislature formally passes a Commonwealth analog to RCRA; ADS is given authority to implement the law (Hunter & Arbona, 2004) ADS immediately decides to close 32 landfills, based on lack of RCRA Subtitle D compliance and shortage of additional space. This leaves 29 landfills in operation. The Legislature adopts a recycling target of **35 percent** (Law No. 70; 1992), giving ADS four years to meet it. Curbside recycling begins in some sections of San Juan municipality.
- 1993-** Public drop-off points are built in most municipalities, allowing people without curbside recycling services to bring their recyclables to a central location for collection.
- 1995-** The “Regional Plan for the Infrastructure for Recycling and the Disposal of Solid Waste in Puerto Rico” is adopted as a means to meet the 35 percent recycling rate requirement established in 1992. In an attempt to achieve economies of scale, the plan divides the island into 11 regions so that the municipalities can share facilities (Figure 4). Each region is assigned landfills meeting the RCRA Subtitle D standards. Transfer stations are to be set up as regional collection points for MSW en route to landfills (Miranda & Hale, 2005). The plan includes seven “clean” Material Recovery Facilities (MRFs) where already-separated recyclable materials are taken, seven “dirty” MRFs where recyclable materials are to be separated from municipal solid waste, five yard trimmings and mulch facilities, and seven compost facilities (Alpert & Lopez, 1997). The plan also considers building waste-to-energy (W2E) facilities in Guaynabo and Arecibo, the two regions with the highest levels of waste production (Miranda & Hale, 2005).

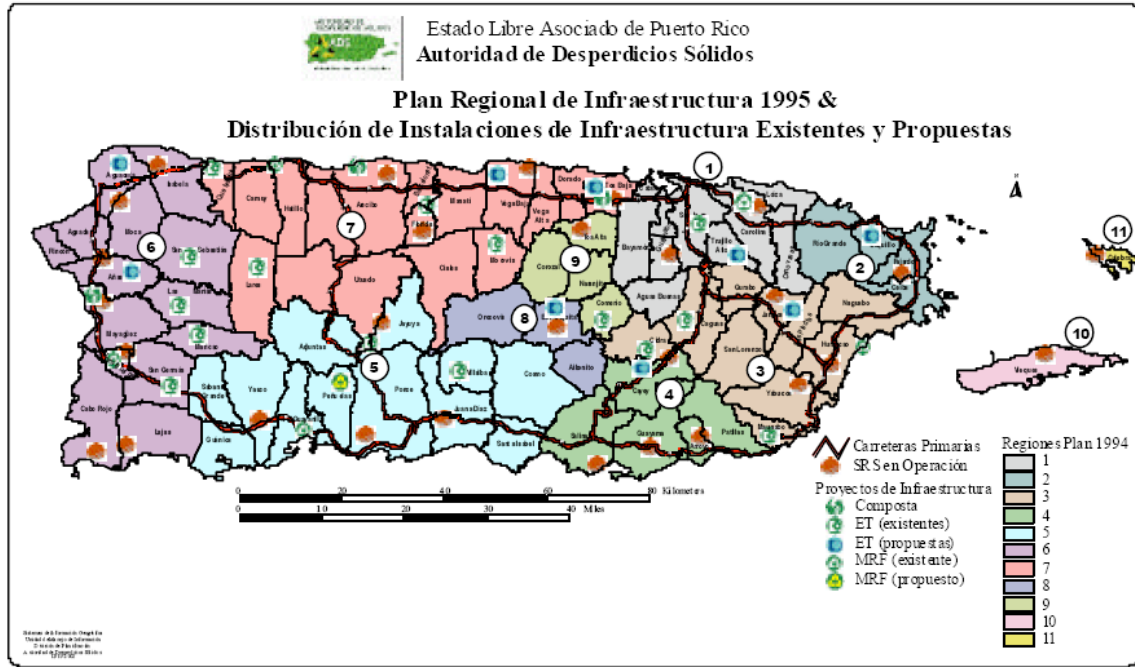


Figure 4 The 1995 Regional Waste Management Plan Map, from ADS (2006)

- 1996-** ADS is provided with a US\$200 million credit line from the Legislature. During Governor Pedro Gonzales' second term, ADS begins implementation of the 1995 plan with construction of numerous transfer stations and begins a bidding process for Waste-to-Energy (W2E) plants. Opposition from academics and environmental groups against waste incineration begins in earnest, headed by the local NGO Misión Industrial. The 35 percent recycling target goes unmet, and is extended until 2000.
- 2000-** The international corporation Ogden wins a bid to construct a W2E plant in the Arecibo region. In November, the opposition wins the election and Governor Sila Calderón is installed. The campaign makes election promises of discontinuing plans for waste incineration. The island falls far short of 35 percent recycling goal, which is extended again until 2006.
- 2001-** The new Legislature passes a law prohibiting incineration as a means of solid waste disposal. As a result, Ogden retracts its bid. Illegal landfilling is also formally recognized as a high-priority issue for the government. Major instances of corruption are uncovered within ADS and operations are shut down for the remainder of the year.
- 2002-** In December, EQB sues the municipality of Patillas for lack of compliance of its SWM system. This is the first court case of its kind in Puerto Rico.

- 2004-** The ‘Prevention of Contamination’ Law is passed (Provision No. 416; Sept 22, 2004), encouraging recycling and the exchange of waste materials.
- 2005-** The mayor of Caguas, a powerful political figure, institutes a one percent sales tax in the municipality to cover the costs of solid waste management. This is, in effect, a consumption tax, and the first sales tax on the island.
- 2006-** A new integrated solid waste management plan for the island titled “Strategic Plan for the Management of Solid Residues in Puerto Rico” is submitted by ADS to EQB and the USEPA. This plan is still being reviewed by EPA. If this plan is not approved, then the authority over solid waste management may be reclaimed by the EPA. In conjunction with the new plan, EQB and the USEPA anticipate the next round of landfill closings to affect two landfills (Freytes, 2006). In the new plan, the focus is shifted away from regional infrastructure and the recycling responsibilities will be returned to municipalities (McPhaul, 2004). This will be accomplished by amending the Law of Autonomous Municipalities to establish municipal responsibility for the handling of recovered recyclable materials and solid residues in general. ADS will support the municipal recycling programs by fund pairing or granting funds. The amendments will also make mandatory the separation of recyclable materials at the source (ADS, 2006). Furthermore, the new strategic plan details the following new initiatives for improving the recycling rate:
- *Education and Public Awareness-* ADS will work with the Department of Education to ensure that there is environmental curriculum related to the handling of recyclable materials and solid waste. Pilot programs in 10 percent of the island’s public schools will shift environmental science from an elective to a core subject in public schools. ADS has budgeted more than \$100 million for this initiative over 20 years (ADS, 2006). ADS plans to develop citizen consciousness campaigns through newspapers, radio, and television, so as to increase the public’s attention to recycling. ADS will also provide recycling program information through internet and periodic publications (ADS, 2006).
 - *Green Purchasing-* ADS will design an advertising campaign in the media to promote purchasing products made up of recycled materials. ADS will also establish regulations that require all central government agencies to give preference in their purchases to products manufactured with recyclable materials (ADS, 2006).
 - *E-waste Management-* ADS plans to separate electronic waste from the waste stream to landfills. ADS will design educational materials on handling electronic waste and

will distribute them to academic institutions, libraries, community groups, government agencies and private enterprise. ADS will also develop a campaign twice a year for the collection of electronic waste in municipalities (ADS, 2006).

Present- In May, the Commonwealth government shuts down for want of funds. The island is largely incapacitated as schools and government offices close, leaving more than 200,000 people without work. One solution being debated is the institution of an island-wide sales tax of seven percent, of which a part could be allocated for solid waste management (BBC, 2006). The 35 percent recycling rate target deadline looms; another extension is probable.

4. Solid Waste Flows in Puerto Rico

According to data collected by ADS, municipalities and private industries landfill approximately 9,860 tons/day and recycle 1,540 tons/day (ADS, 2001; ADS, 2003). Therefore, municipalities and private industries generate an estimated 11,400 tons/day. The process by which these materials flow to landfills and recycling facilities is described in this section. Municipal collection is not uniform; a few municipalities provide curbside collection services for recyclable materials, others simply collect material from public drop-off points. These materials are sent to public and private MRFs, sometimes via regional transfer stations. There are 7 public MRFs on the island; these are operated by municipalities themselves (Rios, 2006). Public MRFs do not export recyclables. Rather, they sell their sorted materials to the private MRFs.

There are dozens of private MRFs in Puerto Rico; IFCO and Pronatura being the two largest. A complete list is given in Appendix 1. In addition to receiving material from municipalities, private MRFs also sign contracts with industrial and commercial facilities to provide collection services for recyclable materials, as required by law. The percentages of recyclable material originating from municipalities and private businesses are estimated to be 20 percent and 80 percent, respectively (IFCO, 2006). The remainder is provided by scavengers who collect recyclable materials from places such as beaches, roads, and local enterprises. However, both public and private MRFs are purely collectors and there are no significant recycling facilities for traditional recyclables on the islands. * JAEL, a small plastics recycler in the northeast of Puerto Rico, used to produce plastic pots; it is not known whether they still do so. Owens Illinois, a large multi-national company, uses recycled glass as a portion of its feedstock. There used to be a small

* For the purposes of this report, traditional recyclables have been defined as paper, cardboard, glass, aluminum, and plastic.

industry of plastic lumber and plastic-wood composite producers, but those businesses have since closed (Rios, 2006). However, the high purity requirement means that very little of the available material is suitable. With no significant domestic market for recyclables, private MRFs export most of their material. For example, IFCO generally exports 50 percent of its recyclable materials to China. Pronatura exports recyclable materials to Georgia, Central and South America, and Asia. If market prices for recyclable goods are low, private MRFs will store their material until prices become more favorable. The MRFs also generate waste (usually contaminated materials), which is sent to the landfills.

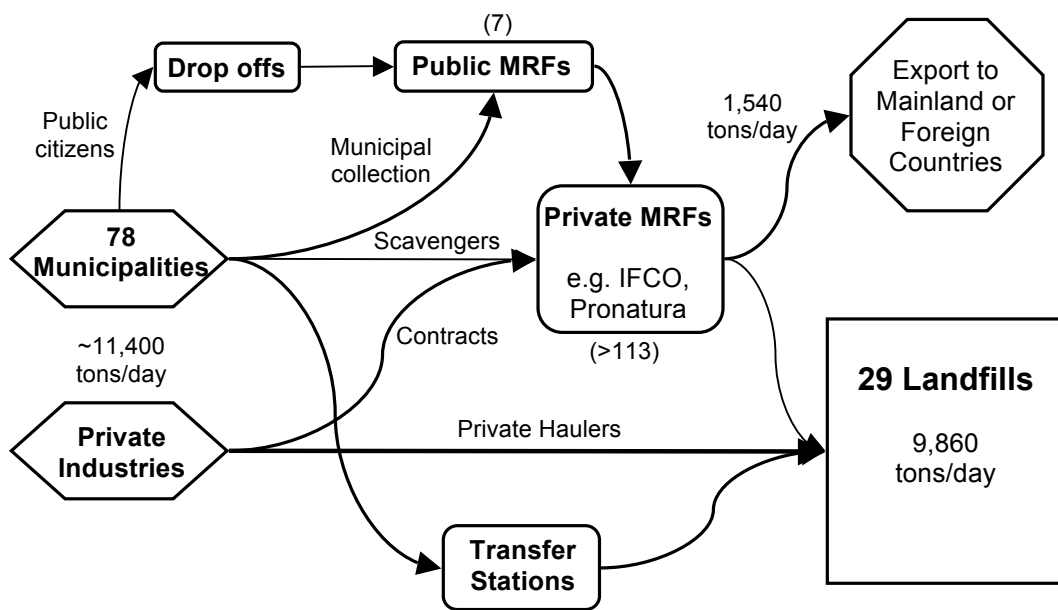


Figure 5 Material flow diagram of solid waste and recyclables in Puerto Rico

Due to a lack of sufficient data, it was not possible to quantify all of the material flows on the island, so a qualitative diagram was undertaken (Figure 5).

5. Estimated Recycling Rates for Puerto Rico

Previous sections of this report have outlined Puerto Rico's waste management infrastructure and past initiatives for meeting the goal of a 35 percent recycling rate; this section reviews their success. Unfortunately, the initiatives and infrastructure established in Puerto Rico have not proven particularly effective. The recycling rate target of 35 percent seems to be a reasonable goal, given that approximately 55 percent of the ~3.6 million tons of waste landfilled in Puerto

Rico in 2003 was composed of recyclables and an additional 35 percent consists of compostable material (ADS, 2003). Figure 6 shows the average composition of waste, as received by landfills.

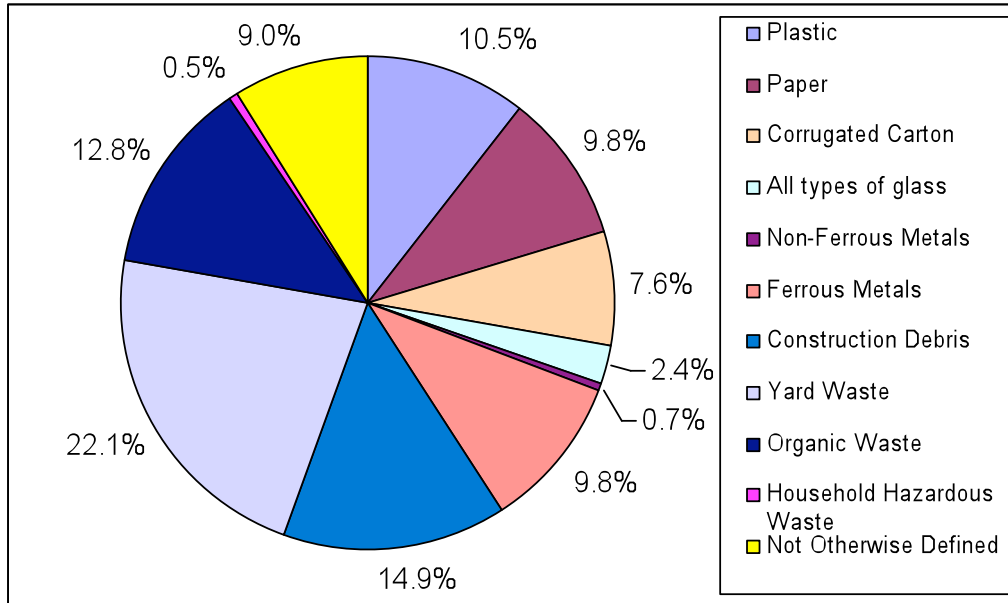


Figure 6 Average Composition of Sold Waste Discards in Puerto Rico in September, 2003

Despite the high fraction of recoverable waste, ADS estimates that the average recycling rate in Puerto Rico is about 7-10 percent. The lower estimate excludes scrap metal from cars whereas this metal is included in the upper estimate (Rios, 2006). As can be seen in Table 2, ferrous metals and construction and demolition debris make up the majority of recycled material, by weight.

Table 2 Tons of Materials Recycled in Puerto Rico in 2000

Material	Mass (in tons)
Plastic	5,870
Paper	41,981
Aluminum	33,938
Other Metals	101,252
Glass	3,799
Cardboard	83,670
Garden trimming	16,528
Tires	15,729
Asphalt waste	31,820
Concrete waste	226,105
Total	560,692

Source: ADS, 2001

Dividing the amount of material recycled by the amount generated gives an overall recycling rate of 13 percent, somewhat higher than official estimates. Again due to data restrictions, however,

we used data from 2000 and 2003 and assumed that flows did not change much within this time period. This may account for the discrepancy in rates.

This analysis was restricted to the recycling of traditional recyclables, characterized here as paper, cardboard, glass, aluminum, and plastic. In 2000, about 169,000 tons of traditional recyclables were recovered. Figure 7 shows an estimated recycling rate for each material (see Appendix 2 for calculations).

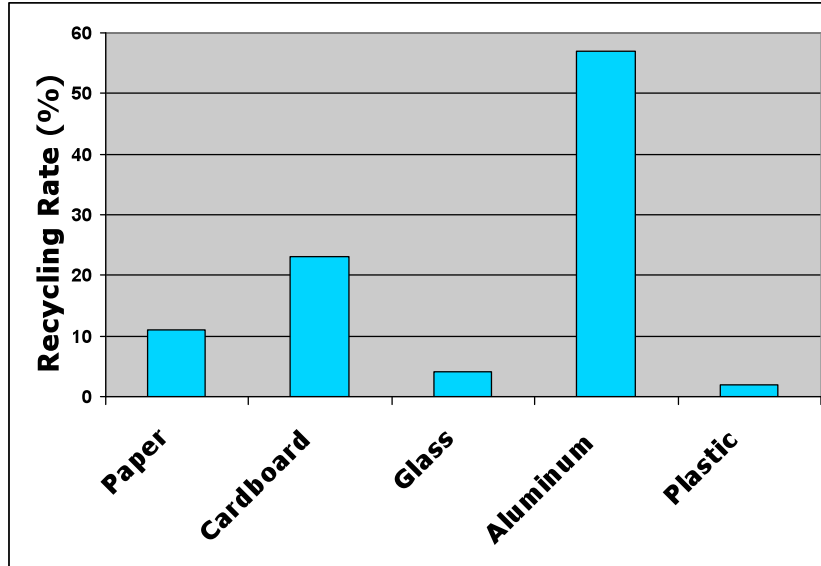


Figure 7 Estimated recycling rates for traditional recyclables in Puerto Rico, 2000

This methodology assumes that all of material is either landfilled or recycled so that the sum is equal to the amount generated. Furthermore, this methodology assumes that all non-ferrous metals are aluminum. In reality, a large fraction of non-ferrous metals is copper. Therefore, the recycling rate presented for aluminum is probably underestimated.

6. Recycling Business in Puerto Rico

The two largest recycling companies in Puerto Rico were interviewed to estimate their share in the Puerto Rican traditional recyclable market, the source and eventual fate of their recyclables, and the most voluminous or profitable recyclable materials. Both of these companies specialize in paper and cardboard collection; however, each company also recovers limited amounts of plastics, aluminum, and glass. IFCO recovers approximately 120,000 tons of recyclable materials per year and Pronatura recovers approximately 29,000 tons per year. Of the total, this represents 71 percent and 17 percent, respectively. The remaining 12 percent is recovered by a number of smaller companies. The approximate quantities of materials recovered by IFCO and Pronatura

are presented in Table 3 and Table , below. These estimates presented in this section are based upon information provided by IFCO and Pronatura; calculations are shown in Appendix 2, Tables 4-9

Table 3 Estimated Recovery of Recyclables by IFCO, 2005

Material	Mass (in Tons)
Cardboard	78,000
Newspaper	12,000
High glossy boxes	9,000
Chipboard	3,600
Other	17,400
Total	120,000

Source: Based upon estimates provided by Tous, 2006
 Note: The majority of “other” consists of cotton swabs, plastics, cans, and glass

Table 4 Estimated Recovery of Recyclables by Pronatura, 2005

Material	Mass (in tons)
Cardboard	6,000
Newspaper	10,000
Other	13,000
Total	29,000

Source: Based upon 2005 estimates provided by Vasquez, 2006
 Note: The majority of “other” consists of glossy paper, office paper, and plastic bottles

Based upon these estimates and those provided by ADS, this study concludes that IFCO and Pronatura recycle (of the total recycled in Puerto Rico):

- Nearly 100 percent of cardboard
- More than 74 percent of paper
- Less than 70 percent of aluminum, plastic, and glass

Discussions with industry experts indicated that leading companies in the recovery of aluminum, plastic, and glass are GC Recycling, JAEL, and Owens Illinois.

Eighty to eighty-five percent of the waste collected by Pronatura is industrial waste with their biggest industrial clients being supermarkets and newspapers companies. Likewise, 80% of recyclables collected by IFCO come from industrial and commercial sources. Of these recyclables, 10% is sold to IFCO by scavengers. These scavengers primarily collect aluminum cans for which they can get \$15/ton. IFCO has contracts with only three major resorts. Resorts

have not been designed to include space for recycling bins or other recycling equipment, and thus the resorts are doing little recycling. Similarly Pronatura does not collect recyclables from hotels because they would require 24 hour service and the recycling companies presently do not have the capacity to handle these loads. These facts suggest that Puerto Rico's low recycling rate is an artifact of the lack of participation by the tourism and municipal sectors.

IFCO collects municipal recyclables from approximately 50 of 78 municipalities. However, this recyclable stream still only accounts for 20% of their business. To promote recycling, IFCO sponsors a municipal recycling days and sponsors school recycling. IFCO believes residential recycling rates could be improved by instituting single stream sorting in which a single truck picks up all types of recyclables for a neighborhood and sorts them at IFCO. Such a system would optimize the use of collection trucks.

Most companies and individuals who provide recyclable materials to IFCO are paid 50% of the price IFCO receives from the brokers. IFCO also provides municipalities recycling equipment such as recycling receptacles and balers for free. Sometimes a price is deducted from industrial clients in exchange for the rent or servicing of recycling equipment. Those companies and municipalities that bring recyclables to Pronatura are also paid for the materials. Pronatura will lend dumpsters, bailers, and compactors to those who regularly supply them with materials at no charge.

To cut down on costs, Pronatura is now aiming to attract larger industrial clients who do their own bailing. Smaller firms who require training in use of the equipment are becoming too costly. As a way to attract business, recycling companies are beginning to consider expanding their services to recycling, waste management, OSHA training, and environmental consulting. As such, Pronatura has begun to offer OSHA training.

Given that the bulk of material collected by IFCO and Pronatura come from the industrial sector and the importance of the pharmaceutical industry to the island of Puerto Rico, it was important to learn whether recycling was considered in the daily business practices of pharmaceutical businesses. Therefore, Nelson Cruz, Environmental Manager of Johnson & Johnson's McNeil plant (where Tylenol PM is produced) and Eileen Pagan, Project Manager at ERM-Puerto Rico on assignment at the McNeil plant, were interviewed (Cruz, 2006; Pagan 2006). Despite the fact that less than 1% of the McNeil's budget is spent on waste management, McNeil has assisted

schools in the surrounding area to build recycling collection centers and collect and arrange for the pick up of municipal recyclables brought in by its own employees. Furthermore, in accordance with Puerto Rico's Law 411, stipulating that all organizations employing more than ten people must submit a recycling plan to ADS, the company has established a plan for reducing, recycling, landfilling, and even incinerating waste. Though the company reuses select items such as cardboard boxes and recycles cardboard, plastic, glass, paper, newspaper, wooden palettes, and metal scraps through GC recycling and JAEL, the company makes a conscious effort to further reduce the tons of material landfilled materials by shipping some of their waste to an incinerator in New Jersey through a company named Covante. Several pharmaceutical companies also send their electronics to Caribbean Hi-Tech Recycler, Inc, in Guanica (Fernandez, 2006). Some electronics are disassembled there, while the rest is shipped in their assembled forms to Japan, China, the Dominican Republic, and elsewhere. There is concern that large amounts of electronics are being illegally dumped, given that there are no other electronics recycling companies contracted with the municipalities and that electronics containing hazardous substances are prohibited in landfills (Fernandez, 2006).

7. Discussion

In the course of this study, a number of factors were identified that influence recycling and waste management on the island, some of which were mentioned in the preceding sections. These can be broadly categorized into infrastructure issues, political factors, economic factors, and cultural factors.

Infrastructure

The analysis of IFCO and Pronatura's sources of material indicate that while the industrial sector contributes strongly to Puerto Rico's recycling rate, the municipal and tourist sectors are recycling very little. Interview subjects indicated that both sectors have low recycling rates due to a lack of infrastructure. Few municipalities offer curbside pick-up service, and there is not a sufficient number of public drop-off centers to make this voluntary recycling system viable. Citizens have little incentive to drive their recyclables for miles to the nearest drop-off center when they can throw their garbage conveniently in their household trash bins for free.

Furthermore, very few hotels contract with recycling firms because they are not designed with space for recycling bins and equipment and most recycling firms do not have the capacity to handle the large volume of goods generated by this sector. Given that tourism makes up such a

large portion of Puerto Rico's economy (and hence consumption), it can be assumed that instituting mandatory recycling for this sector would greatly increase the island's recycling rate.

Political

At the political decision-making level, many obstacles have been created – intentionally or unintentionally – that negatively influence the recycling systems in Puerto Rico. Firstly, it is the nature of democratic politics that administrations come and go, and decisions made by predecessors are often struck down by the successor. In the Puerto Rican context, for example, a budget that was approved in the late 1990s to fund new infrastructure for the solid waste management system and meet the recycling rate target. Large projects were started across the island to implement the proposed plan, particularly the construction of transfer stations. In 2001 when the Governor Calderón came to power, this budget was simply suspended, and many of the infrastructure projects were halted in the middle of their construction period. Today, those transfer stations are serving as waste depots around the island.

Secondly, corruption has been a political factor stunting the development of recycling in Puerto Rico. PRIME, the consultancy hired by ADS to manage the development of recycling infrastructure during the late 1990s, was in fact staffed by many people who had previously been part of the agency. In 2001, it was discovered that PRIME had been embezzling large sums during the course of the project construction. Budgets for the transfer stations were found to be egregiously overstated. PRIME's focus on transfer stations was thought to be one of the main reasons why other types of infrastructure were not developed. After the discovery, ADS was effectively shut down for the year as appropriate measures were taken. This calamity halted any progress in implementing the 1995 plan.

Finally, political issues are not limited to the government. Plans to build waste-to-energy facilities were met by fierce opposition from environmental and public interest groups. Misión Industrial has been the most vocal of any NGO in its opposition and has used the media effectively to sway public opinion. Their logic is that W2E technology is overly polluting and that lifting the pressure on landfills will absolve municipalities of their recycling responsibilities. It is a valid point, but given the sheer magnitude of the waste disposal issue, it is clear that even if Puerto Rico achieves its recycling goal of 35 percent, it will still have to deal with an overburdened landfill system. The Legislature's moratorium on planning W2E facilities was in response to the public outcry stoked by Misión Industrial and others (Rivera, 2006).

Economic

At present, the only economic incentive to recycle is in the form of tipping fees at landfills. Several interview subjects commented that these fees are too low at present and do not reflect the true cost of disposal into landfills, including rehabilitation and closing costs. Tipping fees are approximately \$30 per ton of material. This is far less than the average of \$70.53 per ton for the Northeast region of the United States, which has a comparable population density (NSWMA, 2005). There are no direct economic incentives for households to separate out their recyclables or take them to public drop-off points, such as a pay-as-you-throw scheme. Puerto Rico does not have a bottle bill or a deposit system for beverage containers.

Considering that recyclable materials are so highly valued in many foreign countries, economics may impede the establishment of companies on the island that utilize recycled materials. However, the location of the buyer of recyclable materials does not influence the recycling rate. China's appetite for secondary materials has driven up market prices for recyclables everywhere. Mr. Tous of IFCO explained that profits have increased sharply in recent years, particularly for plastics. While it seems intuitive that selling material to a recycler in Puerto Rico would be more profitable than selling abroad because of reduced transport costs, this may not be the case. This suggests that collection companies may not have much incentive to encourage local recycling, at least for materials that are seeing an increase in price.

Many municipalities do not have the money to experiment with different recycling schemes. It is reported that the budget for most municipalities allots only 30% for infrastructure and services; the remaining 70% is used for payrolls (Rios, 2006). The director of EQB reports that even if the agency sued municipalities in court for non-compliant landfills, many municipalities would not be able to pay. As a result, EQB has begun a process of "consultative enforcement", similar to the environmental contracts negotiated by industry and government in countries such as the Netherlands (Freytes, 2006). Instead of levying a fine on a municipality, EQB now prefers to use non-compliance as an opportunity to cooperate on writing a municipal integrated SWM plan that can actually be implemented by cash-strapped local governments. If municipalities renege on these negotiated plans, however, EQB can increase the fines significantly (Rivera, 2006).

Cultural

Puerto Rico has never had a successful municipal recycling program, and so there is no behavioral precedent for household separation of recyclable material. There appears to be a lack of public awareness of the importance of recycling. Anecdotal evidence suggests that there is no public consciousness about waste or societal guilt about being wasteful (Al-Khoury, 2006). As a result, the public tends to discard all materials out of hand. Schools lack any defined environmental education programs and the government has engaged in only small-scale campaigns to encourage recycling.

There also appears to be a cultural bias against the reuse of waste. For example, plans to incorporate fly ash from power plants were vigorously opposed because of the perception that the ash was somehow dangerous, contrary to scientific evidence (Al-Khoury, 2006).

8. Recommendations

Given the complex socio-political context of recycling in Puerto Rico, recommendations based purely on economics or infrastructure are insufficient. Therefore this study presents a mix of suggestions that address different aspects of the issue. Some of these suggestions may result in higher fees for doing business and hence slow down the pace of economic growth. This may be necessary in the short-term in order to institute an effective waste management and recycling system. It is believed that these short-term costs will be outweighed by the long-term financial benefits of instituting reforms such as those listed below:

1. Institute a pay-as-you-throw system for household waste in as many municipalities as possible. This would be accompanied by a free recycling service, funded through the former. Given the appropriate incentive levels, it has been shown that this system can greatly reduce the amount of household waste that must be landfilled (Callan & Thomas, 2004). This system preferable to a consumption tax, such as the one instituted in Caguas, because it more directly affects consumptive behavior and awareness of disposal issues. ADS has been considering a collection program modeled on Seattle's bag-and-tag program, but it was not included as part of the 2006 plan (Callan & Thomas, 2004; Rios, 2006).
2. Hold the municipalities accountable for implementing recycling programs. As was done with the municipality of Patillas (Section 3), it is important to enforce solid waste management laws. Lax oversight on the part of EQB and ADS is partly to blame for the

- current dearth of effective municipal recycling programs. EQB's new program of "consultative enforcement" is encouraging. The pessimistic financial outlook of many municipalities makes it impossible simply to sue.
3. Extend the mandatory recycling requirement for businesses with more than ten employees to include resorts and other tourism-related facilities.
 4. A few recommendations deal with the direct regulation of landfills.
 - a. Close some, if not all, non-compliant landfills. Puerto Rico will continue to rely on landfills as a buffer as it builds up its recycling infrastructure. But these landfills also serve as a disincentive to serious reform. As the historical *modus operandi*, disposal in landfills will continue to be abused as long as there is easy and cheap access.
 - b. An equivalent recommendation is for the government to intervene in the market and to raise tipping fees across the island. This would provide municipalities, especially, more of an economic incentive to minimize their waste streams.
 - c. Do not approve new landfill sites, such as the tentative site in Guaynabo (Rizzo, 2006).
 5. Bring recyclers to the island. As long as there are few industries interested in using recycled materials locally, there can be no local market for collection companies such as IFCO and Pronatura. Material will continue to be shipped off the island, only to be re-imported as remade goods. Since large-scale operations have avoided the island because the potential waste stream is too small, medium-size enterprises would be appropriate (Rios, 2006).
 6. Increase fines for illegal dumping. Though no amount of fines will ever stop dumping completely, it should be made clear that illegal dumping will not be tolerated and will carry a significant penalty. The current EQB policy of fining the owner of the land where the dumping occurs, while it is seen to be somewhat unfair, seems to be a balanced approach to this difficult aspect of the issue.
 7. Institute an educational campaign centered on recycling. The new 2006 plan of ADS specifies a budget for initial environmental education classes in 10 percent of all schools in Puerto Rico in the next five years. We strongly encourage this action. By all accounts, public apathy is a significant barrier to municipal recycling programs. Targeting young people is an effective way to disseminate knowledge through families, as well as to foster a generation of waste-responsible adults. Inasmuch as they are financially feasible, municipal mailings, radio programs, and the use of city billboards are all encouraged.

9. Conclusion

Based on data collected from ADS, the overall recycling rate of traditional recyclables in Puerto Rico was found to be 7-10 percent. The rate for aluminum was found to be above 50 percent, implying that scrap aluminum is valuable enough to municipalities and industries to collect used containers to sell to private MRFs. The rates for other materials are far below national averages and require improvement. Reasons for the low levels of recycling include the lack of a local market for secondary materials and nonexistent collection programs in many municipalities. This is generally well-known to the various government agencies and it will be interesting to see if and how the new solid waste management plan is implemented. Short-term measures such as instituting taxes or household disposal fees will help to reduce the budget shortfall for waste management programs. Mandating municipal collection of recyclables is a crucial step in improving the recycling rate, as all efforts at public awareness and environmental education will come to nothing if citizens have little access to recycling services.

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Appendix 1- Recycling Companies in Puerto Rico

Company Name	Type of Materials Collected
Almacen Carabollo	Auto Batteries, Non-ferrous Metals
Alternative Fuels	Used Oil, Used Transportation Oil
Alternative Kartridge	Printer Cartridge
Ambrosiani Hermanos	Used Tires
Ameriplast	Plastics
ARB Recycling	Cardboard, Non-ferrous Metals, Paper, Plastics, Glass
BARFRET Waste Consultants, Inc.	n/a
The Battery Recycling	Auto Batteries, Non-ferrous Metals
Best Recyclers Corp	Printer Cartridge
Betterrecycling Corp	Asphalt
Borinquen Metal Scrap	Auto Batteries, Non-ferrous Metals
Caribbean Composting	Septic Water, Timber Pallets, Compost
Caribbean Hi-Tech Recyclers	Electronic Equipment
Caribbean TopSoil	Timber Pallets, Compost
Caribe Hidroblasting, Corp	Used Transportation Oil
Caribe Palltes & Packaging	Timber Pallets
Cartonera de PR	Cardboard, Paper
Cartridge Outlet P.R.	Printer Cartridge
Chacon Environmental Oil Cleaning	Used Transportation Oil
Chris & John	Tires
Comercial La Pino	Glass
Corporacion Comunitaria Reciclaje del Norte, Inc., P. T.	Material recycling
CN Recycling	Tires
Controlled Demolitions & Recycling	Concrete & Asphalt
Cuqui Craft	Plastics
Edelcar	Cooking Oil
El Gran Tadeo Mill	Auto Batteries, Non-ferrous Metals, Timber Pallets
Embos	Used Tires
EMSCO	Used Oil, Used Transportation Oil
ENSCO Caribe, Inc.	Used Oil
Environics	Auto Batteries, Electronic equipment, Fluorescent Light
ESB PR Corporation	n/a
Estructuras Ambientales	Tires
Facsimil Paper Connection	Printer Cartridge
Fazt Move Transport	Tires
GC Reciclaje, PT	Cardboard, Ferrous Metals, Non-ferrous Metals, Timber Pallets, Paper, Newspaper, Plastics, Glass
Grupo Comunitario de Reciclaje, Inc. P. T.	Material recycling
Harry's Metals Recycling	Non-ferrous Metals
Hector Caro Wooden Pallets	Timber Pallets
Homeca Recycling	Ferrous Metals, Non-ferrous Metals
Hurricane Metals	Non-ferrous Metals
IFCO Recycling	Cardboard, Non-ferrous Metals, Paper, Newspaper, Plastics
Industria y Comercio Pro Reciclaje (ICPRO)	n/a

Industrial Fibers, Corp (IFCO)	Cardboard, Non-ferrous Metals, Paper, Newspaper, Plastics
Induchem Services, Inc	Used Transportation Oil
Integrated Waste Management	Used Tires
Isla Bonita Metals	Auto Batteries, Non-ferrous Metals
J. Torres Wooden Pallets	Timber Pallets
JAEL Plastics	Plastics
JR Recycling	Tires
K & V Tire Collector	Tires
La Casa de las Tintas	Printer Cartridge
Landfill Technologies Corp.	n/a
Las Marias Recycling	Plastics
Laser Copy	Printer Cartridge
Laser Imaging Manufacturing	Printer Cartridge
LB Caribe Service	Used Transportation Oil
Logistic Safety Transport & Environmental Services	n/a
Los Muchachous Metals	Non-ferrous Metals
Marin Oil Collection	Used Transportation Oil
Materials Management	Ferrous Metals
Moncho Metal	Non-ferrous Metals
Multi Recycling Systems	Cardboard, Ferrous Metals, Non-ferrous Metals, Paper, Newspaper, Plastics, Glass
Multiplast Corp	Plastics
N & E Transport	Tires
Nimak Plastic	Plastics
Nova Terra	Electronic Equipment, Ferrous Metals, Non-ferrous Metals
Ochoa Industries Sales	Used Transportation Oil
Oil & Tramp	Used Transportation Oil
Oil Energy System	Used Transportation Oil
ONYX Environmental Services	Fluorescent Light, Used Transportation Oil
Owens Illinois	Glass
Pagan & Pagan Recycling	Non-ferrous Metals
Paletera y Reciclaje del Centro	Timber Pallets
Plastic Home Products	Plastics
Plastex Corp	Plastics
P.R. Imagine Solutions	Printer Cartridge
PR Internaional Salt Corp	Timber Pallets
PR Laser Rechargers	Printer Cartridge
PR Pallet Recycling	Timber Pallets
PR Safety Transport	Used Transportation Oil, Tires
PR Used Oil Collectors	Used Transportation Oil
Pronatura	Cardboard, Non-ferrous Metals, Paper, Newspaper
R4 Enterprises	Septic Water, Printer Cartridge, Ferrous Metals, Tires
RDB Recycle	Tires
Recicla y Gana	Printer Cartridge
Reciclaje del Norte, PT	Cardboard, Non-ferrous Metals, Paper, Newspaper, Plastics, Glass
REMA	Used Tires
Ruben Martinez Oil Collection Service	Used Transportation Oil
Safetech Corporation	

Safety Kleen Environmental Systems	Fluorescent Light, Used Oil, Used Transportation Oil
Salinas Aggregates & Recycling	Concrete & Asphalt
Concrete	
Salinas Resources	Ferrous Metals, Non-ferrous Metals
Sani Plant Co. Inc.	Cooking Oil
Sanchez Tire	Tires
Santurce Metal & Bag	Auto Batteries, Non-ferrous Metals
Scorpio Recycling	Ferrous Metals, Non-ferrous Metals
Servicio Sanitario Perez	Septic Water
Shred It	Paper
Smurfit Fibras Internacionales de PR	Cardboard, Paper
Southwest Metal Recovery	Non-ferrous Metals
Taller de Reciclaje de Metales	Non-ferrous Metals
Toners Plus of PR, Inc	Printer Cartridge
Transportadores de Neumaticos	Tires
Transporte Los Matos	Tires
Triant	Timber Pallets
Tristani Rubber	Used Tires
Tropical City Industries, Inc	Used Transportation Oil
US Recycling	Plastics
Vega Aluminum Recycling	Non-ferrous Metals
Waste Management de PR	Cardboard, Non-ferrous Metals, Paper, Newspaper, Plastics, Glass
Western Medical Waste & Environmental, Inc.	Medical Waste
W.R. Recycling	Auto Batteries, Cardboard, Paper, Newspaper, Plastics, Glass

Sources: ADS, 2005; PRMA, 2005; PRIDCO, 2005

Appendix 2 – Recycling Rate Calculations

Calculations for the Recycling Rates of Traditional Materials

Appendix Table 1

Estimated Tons of Waste Landfilled in 2003	3,598,972
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Appendix Table 2

Disaggregated			Aggregated	
Materials	Percent Waste	Landfilled Waste (Tons)	Types of Materials	Landfilled Waste (Tons)
Type 1 Polyethylene	0.8	28,792	Plastic	377,892
Type 2 Polyethylene	3	107,969		
Types 3	6.7	241,131		
High Quality Paper	1	35,990	Paper	352,699
Low Quality Paper	8.8	316,710		
Corrugated Carton	7.6	273,522	Corrugated Carton	273,522
Non-Ferrous Metals	0.7	25,193	Non-Ferrous Metals	25,193
All types of glass	2.4	86,375	Glass	86,375

- Data from non-shaded cells are from ADS, 2003. Shaded cells are calculated.
- Tons of waste were calculated by multiplying the percent of waste times the estimated tons of waste per year for each type of recyclable material.
- The tons of waste were then aggregated over the traditional types of recyclable materials.
- Numbers in the table may not sum due to independent rounding.

Appendix Table 3

Materials	Recycled Tons in 2000	Recycling Rate
Plastic	5,870	2%
Paper	41,981	11%
Cardboard	83,670	23%
Aluminum	33,938	57%
Glass	3,799	4%
Total	169,258	

- Data from non-shaded cells were provided by ADS, 2001. Shaded cells are calculated.
- The recycling rate was calculated by dividing the tons of materials recycled in 2000 (Appendix Table 3) by the tons landfilled (2000) or recycled (2003) (Appendix Table 2 and 3).
- Assumptions include:
 - 1) This methodology assumes that all of material is either landfilled or recycled so that the sum is equal to the amount generated.
 - 2) All non-ferrous metals are aluminum. Therefore, the recycling rate presented for aluminum represents a lower bound.
 - 3) Corrugated carton and cardboard are synonymous.

Calculations Related to Recycling- Pronatura

Appendix Table 4

Source of Materials	Tons Per Month
Churches and Schools	2
Industrial newsprint companies	2000
Supermarket chains	400
Total	2,402

- Data from non-shaded cells were provided by Pronatura. Shaded cells are calculated.
- The total tons recycled per month was calculated by adding the tons of material collected from each establishment.
- An assumption was made that all material collected is recycled.

Appendix Table 5

Type of Material	Tons Recycled Per Year (2005)
Cardboard	5,647
Newspaper	10,000
Other	13,171
Total	28,818

- Data from non-shaded cells were provided by Pronatura. Shaded cells are calculated.
- The total tons of materials recycled per year were estimated by multiplying the tons of materials collected per month (Appendix Table 4) by 12 months.
- The total tons per year of “other” materials recycled were estimated by subtracting the amount of cardboard and newspaper recycled from the total (Appendix Table 5).
- Other materials include glossy paper, office paper, and plastic bottles.
- Numbers in the table may not sum due to independent rounding.

Calculations Related to Recycling- IFCO

Appendix Table 6

Type of Material	Tons Per Month	Tons Per Year
Cardboard	6,500	78,000
Newspaper	1,000	12,000
High glossy boxes	750	9,000
Chipboard	300	3,600
Other	1,450	17,400
Total	10,000	120,000

- Data from non-shaded cells were provided by IFCO. Shaded cells are calculated.
- The total tons per year of “other” materials recycled were estimated by subtracting the amount of cardboard, newspaper high glossy boxes, and chipboard from the total.
- The total tons of materials recycled per year were estimated to be approximately 120,000 by multiplying the tons of each materials collected per month by 12 months.
- Other materials include cotton swabs, plastics, cans, and glass.

Calculations Related to Traditional Recyclables Recovered by IFCO and Pronatura

Appendix Table 7

Recycled Materials	Tons in 2000
Plastic	5,870
Paper	41,981
Cardboard	83,670
Aluminum	33,938
Glass	3,799
Total	169,258

- Data from non-shaded cells were provided by ADS, 2001.
- Given that IFCO recycles approximately 120,000 tons per year of traditional recyclables (Appendix Table 6) and Pronatura recycles approximately 28,818 tons per year (Appendix Table 5) and Puerto Rico recycled approximately 169,258 tons in 2000 (Appendix Table 7), it is estimated that IFCO recycles approximately 71% of traditional recyclables, Pronatura recycles approximately 17% of recyclables, and the remaining 12% of recyclables are recovered by other companies.

Appendix Table 8

Company	Minimum Tons of Paper Recycled Per Year
IFCO Paper	21,000
Pronatura	10,000
Total	31,000

- Data from shaded cells are calculated.
- The minimum paper recycled by IFCO each year was assumed to include newspaper and high glossy boxes. Paper materials included in the “other” category were not included.
- The minimum paper recycled by Pronatura each year was assumed to include newspaper only. Paper materials included in the “other” category were not included.
- Given that Pronatura and IFCO recycle 31,000 tons of paper each year at a minimum and 41,981 tons of paper from Puerto Rico was recycled in 2000, it can be estimated that a minimum of 74% of paper in Puerto Rico is recycled by IFCO and Pronatura.

Appendix Table 9

Company	Maximum Tons of Aluminum, Plastic, and Glass Recycled Per Year
IFCO	17,400
Pronatura	13,171
Total	30,571

- Data from shaded cells are calculated
- It was assumed that all “other” materials recycled for each company consist only of glass, aluminum, and plastic; therefore, these estimates represent maximums.

- Given that Pronatura and IFCO recycled at most 30,571 tons of paper each year and 43,607 tons of aluminum, plastic, and glass from Puerto Rico was recycled in 2000, it can be estimated that a maximum of 70% of these materials were recycled by IFCO and Pronatura.

Company	Tons Cardboard Recycled Per Year
IFCO	5,647
Pronatura	78,000
Total	83,647

- Data from unshaded cells are provided by IFCO. Data from shaded cells are calculated
- Pronatura's tons of cardboard recycled per year are based on Pronatura's monthly estimate multiplied by 12.
- Given that Pronatura and IFCO recycles approximately 83,647 tons of cardboard and approximately 83,670 tons of cardboard from Puerto Rico was recycled in 2000, it can be estimated that nearly 100% of these materials were recycled by IFCO and Pronatura.