Intelligent Global Pooling Systems (iGPS)
Company LLC

Briefing Paper

Streamlined Life Cycle Assessment of the iGPS Pallet, the Typical Pooled Wooden Pallet, and the Single-Use Wooden Pallets

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EXECUTIVE SUMMARY

Environmental Resources Management (ERM) was retained by Intelligent Global Pooling Systems (iGPS) Company LLC for two purposes:

- To evaluate a life cycle study publicly cited by Virginia Tech academics regarding the comparative environmental performance of wooden and plastic pallets

- To conduct a comparative life cycle assessment (LCA) of three types of 40-inch by 48-inch GMA-compliant pallets common to the North American market: the single-use wooden pallet, the typical pooled multi-use wooden pallet, and the iGPS plastic pallet. Each of the three types of pallets are utilized in the transport of a wide range of non-bulk items (e.g., food, consumer goods, electronic goods) such as those found in retail and wholesale stores.

In the first quarter of 2008, ERM conducted research to determine the origin and age of the study ("the TNO study") cited by the Virginia Tech academics. In the first half of 2008, we also performed a streamlined LCA, which was described in a comprehensive report prepared for iGPS. This briefing paper provides a summary of the content of that report.

With respect to the first objective, ERM found that the TNO study, *A.G. Kloppenburg, P.M. Esser: Miliegerichte levens-Cyclus-Analyse van memalige houten pallets en meemalige kunststof pallets*, was dated 28 March, 1994. This was prior to the 1997 ISO standardization of the LCA process, and due to its age unsuitable for drawing conclusions with respect to today's environmental impacts of plastic and wooden pooled pallet systems.

With respect to the second objective, ERM's streamlined LCA study examined the following types of environmental impacts for each of the three pallet systems:

- Global warming
- Ozone depletion
- Summer smog formation (photochemical oxidation)
- Depletion of non-renewable resources (abiotic depletion)
- Eutrophication
- Acidification
- Aquatic toxicity
- Terrestrial toxicity

For the baseline scenarios, the results of this study showed that the iGPS plastic pallet had lower environmental impacts in all impact categories compared to the typical pooled wooden pallet, and a substantially smaller environmental footprint than the single-use pallet. Incorporating a relatively small proportion (15% by weight) of recycled HDPE into the iGPS pallet further improved the environmental performance, while the 100% recycled HDPE pallet had a markedly smaller environmental footprint.

Since current typical pooled wooden pallet data were not readily available except through secondary sources, sensitivity analyses were performed to determine how varying certain data inputs would change the LCA results. Analyses of these "what-if" scenarios indicated that the most significant input variable was the trips per pallet lifetime (a function of pallet durability and useful life), followed by the distance each pallet travels, and then pallet weight.

A review of the environmental impacts for each life-cycle stage showed that the majority of environmental impacts from the iGPS pallet accrue from the production of virgin high density polyethylene (HDPE), the key raw material in the plastic pallet. This is a life cycle stage over which iGPS has no control. However, incorporating recycled HDPE content into the iGPS pallet mitigated environmental impacts associated with HDPE production.

1.0 OBJECTIVE 1 – EVALUATE A PALLET LIFE CYCLE STUDY PUBLICLY CITED BY VIRGINIA TECH ACADEMICS

ERM conducted a third-party review to determine the source and reliability of a study, cited by a November 1, 2007 article (www.palletenterprise.com) as the basis for the conclusion that wooden pallets were environmentally preferable to plastic pallets.

The article, *Virginia Tech:: Convergence of Two Shades of Green — Environmental Impacts from the Manufacture, Use, and Disposal of Pallets*, was co-authored by Peter Hamner and Marshall White of the Center for Unit Load Design, Department of Wood Science and Forest products at Virginia Tech. It referred to a life cycle assessment (LCA) case study, attributed to the Netherlands Packaging and Pallet Industry Association (EPV), comparing plastic and wooden pallets. The authors' conclusions were based on their review of a four-page synopsis, *The Environmental-oriented Life-Cycle Analysis of multiple wood pallets and multiple use synthetic pallets*, published by TNO (Netherlands Organization for Applied Scientific Research —Centre for Wood Technology) and EPV.

The LCA synopsis, which was undated, did not include the type of information necessary for a LCA professional practitioner to properly evaluate the case study and its conclusion. In a summary of a life cycle assessment study, whether a streamlined LCA or of a full LCA to an international standard such as ISO 14040, the following would be expected to be stated:

- the goal of the LCA study;
- the functions of the product systems;
- the functional unit;
- systems boundaries;
- excluded life cycle stages;
- the year and representativeness of the data used; and
- the limitations of the study.

ERM found that the TNO study upon which the synopsis was based, *A.G. Kloppenburg, P.M. Esser: Miliegerichte levens-Cyclus-Analyse van memalige houten pallets en meemalige kunststof pallets*, was dated 28 March, 1994. This was prior to the 1997 ISO standardization of the LCA process, and due to its age unsuitable for drawing conclusions with respect to today's environmental impacts of plastic and wooden multi-use pallet systems.

2.0 OBJECTIVE 2 -- CONDUCT A COMPARATIVE LIFE CYCLE ASSESSMENT OF THREE PALLET SYSTEMS

2.1 INTRODUCTION

ERM was requested to conduct a comparative life cycle assessment (LCA) of the iGPS plastic pallet, which is made from high density polyethylene (HDPE), with two types of wooden pallets: the single-use wooden pallet and the pooled wooden pallet. Each of the three types of pallets reviewed in this study are utilized in the transport of a wide range of non-bulk items (e.g., food, consumer goods, electronic goods) such as those found in retail and wholesale stores. They are representative of those available in the current North America market, specifically the 40-inch by 48-inch GMA standard pallet

The study was conducted in conformance with the international standard for Life Cycle Assessment, ISO14040:2006, which states that: *"LCA is a technique for assessing the environmental aspects and potential impacts associated with a product by:*

- *Compiling an inventory of relevant inputs and outputs of a product system;*
- *Evaluating the potential environmental impacts associated with those inputs and outputs; and*
- *Interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study."*

An LCA evaluates the potential environmental impacts throughout a product's life, from raw material acquisition through production, use and disposal (i.e., from cradle to grave). The general impacts considered included:

- Global warming
- Ozone depletion
- Summer smog formation (photochemical oxidation)
- Depletion of non-renewable resources (abiotic depletion)
- Eutrophication
- Acidification
- Aquatic ecotoxicity
- Terrestrial ecotoxicity

2.2 GOAL, SCOPE, AND SYSTEMS STUDIED

The goal of this study was to determine the relative environmental impacts of three types of pallets: the iGPS plastic multi-use pallet, the pooled wooden pallet, and the single-use wooden pallet.

In addition, the environmental impacts of potential future iGPS pallets, incorporating 15% and 100% recycled HDPE, were also evaluated. Based on information from the pallet producer, the 100% recycled HDPE iGPS pallet was modeled as 97.5% recycled HDPE and 2.5% virgin HDPE to make up for production losses.

The functional unit chosen for effective comparison purposes in this study was 100,000 trips. The 100,000 trip functional unit was converted to a total number of pallets based on reasonable assumptions of pallet lifetime (e.g., information published by the USEPA[i] for generic plastic pallets; studies of single-use and multi-use wooden pallets containing both hardwood and softwood; and data from iGPS management experienced in the use of plastic and wooden pallets). A recent study[ii] of wooden pallets also used this functional unit.

Single-use wooden pallets typically transport these goods for one to two trips between a product manufacturer and a warehouse/distribution (W/D) facility. The pooled wooden pallet system and iGPS pallet system are closed-loop: pallets are closely tracked and controlled to make multiple trips between a product manufacturer and a W/D facility. A pooled wooden pallet typically lasts two to three years and makes five to seven trips per year. The iGPS pallet was predicted to make 5 to 7 trips per year and to last 20 years.

The baseline scenarios for each of the three pallet systems studied, including trips per pallet lifetime, pallet weight, loss rate, and primary material composition, are shown in Table 2.1. Other scenarios were also modeled to evaluate the impact of varying trip rate, pallet weight, and travel distances; the results of these sensitivity analyses are described later in this report.

Table 2.1 Pallet Systems in this Study

	iGPS Pallet			**Pooled Wooden Pallet**	**Single-use Wooden Pallet**
	100% virgin HDPE	**15% recycled HDPE**	**100% recycled HDPE***		
Trips/Pallet Lifetime	100	100	100	15	2
System Loss Rate – %	1.0	1.0	1.0	4.0	11.0
Pallets per Functional Unit	1,000	1,000	1,000	6,667	50,000
Pallet Weight – lbs (kg)	47.5 (21.6)	47.5 (21.6)	47.5 (21.6)	70 (32)	50 (23)
Input Materials					
Hardwood – lbs (kg)	---	---	---	15.8 (7.2)	9.7 (4.4)
Softwood – lbs (kg)	---	---	---	52.3 (23.8)	39 (18)
Paint – lbs (kg)	---	---	---	0.53 (0.24)	---
Steel – lbs (kg)	10 (4.5)	10 (4.5)	10 (4.5)	1.8 (0.82)	1.3 (0.59)
Virgin HDPE – lbs (kg)	33.3 (15.2)	28.3 (12.9)	0.39 (0.17)	---	---
Recycled HDPE – lbs (kg)	---	5.0 (2.3)	32.9 (15.2)	---	---
Fire Retardant – lbs (kg)	3.4 (1.5)	2.9 (1.3)	.094 (.043)	---	---

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[i] U.S. EPA GreenScapes Program, Pallet Alternatives Cost Calculator, available online at http://www.epa.gov/GreenScapes/tools/pallets.pdf, 2006.

[ii] Franklin Associates. *Life Cycle Inventory of Wood Pallet Systems: Final Summary Report.* Prepared for CHEP Americas, March 15, 2007

2.3 SYSTEM BOUNDARIES

The pallet systems investigated in this study included all life cycle stages, from production of raw materials through end-of-life. All energy and materials used were traced back to the extraction of resources. Emissions from each life cycle stage were quantified and used to calculate the environmental impacts.

To ensure representative product system data, detailed questionnaires were sent to iGPS. An extensive data collection procedure was then undertaken by iGPS and its suppliers to collate specific details on the production, use, and recycling of iGPS plastic pallets. The primary data collected from iGPS and its pallet suppliers regarding pallet production, pallet weight, loss rate, and transportation distances represented the situation in the 2007 financial year and 2008 year-to-date, as well as conservative future assumptions. For example, iGPS reported the loss rate to date as less than 0.5%; however, this study utilized 1% to be conservative.

Secondary sources of data were used for the pooled wooden pallet and single-use wooden pallet. The data were sourced from publicly available databases and literature as well as from management within iGPS who were experienced in the use of pooled, exchange, and single-use wooden pallets. Where specific production, processing and disposal data were not available, generic data and estimates were used based on forestry and wood products information sources. Where data from public databases were not as current, data use was justified according to data quality indicators such as reliability, temporal correlation, technological correlation, geographical correlation, and completeness.

2.3.1 EXCLUSIONS

The manufacture, maintenance and decommissioning of capital equipment and the improper disposal or littering of wooden pallets outside of the systems studied were not included in ERM's LCA. Biogenic sources of carbon were not included in calculating global warming potential, consistent with the Intergovernmental Panel on Climate Change (IPCC) guidelines. The weight of products transported using the pallet systems in the study and the use of pallets between the W/D and the retail location were not included.

Also not taken into account in evaluating the performance of the pallet systems were competitive attributes of the iGPS pallet that are important to the cost/benefit analysis in choosing a pallet system such as:

- Fuel costs associated with transportation of palletized products
- Minimization of product damage and rejected shipments
- The safety of workers who handle pallets
- Dimensional uniformity to facilitate automation and speed in handling
- Hidden labor costs for pallet tracking

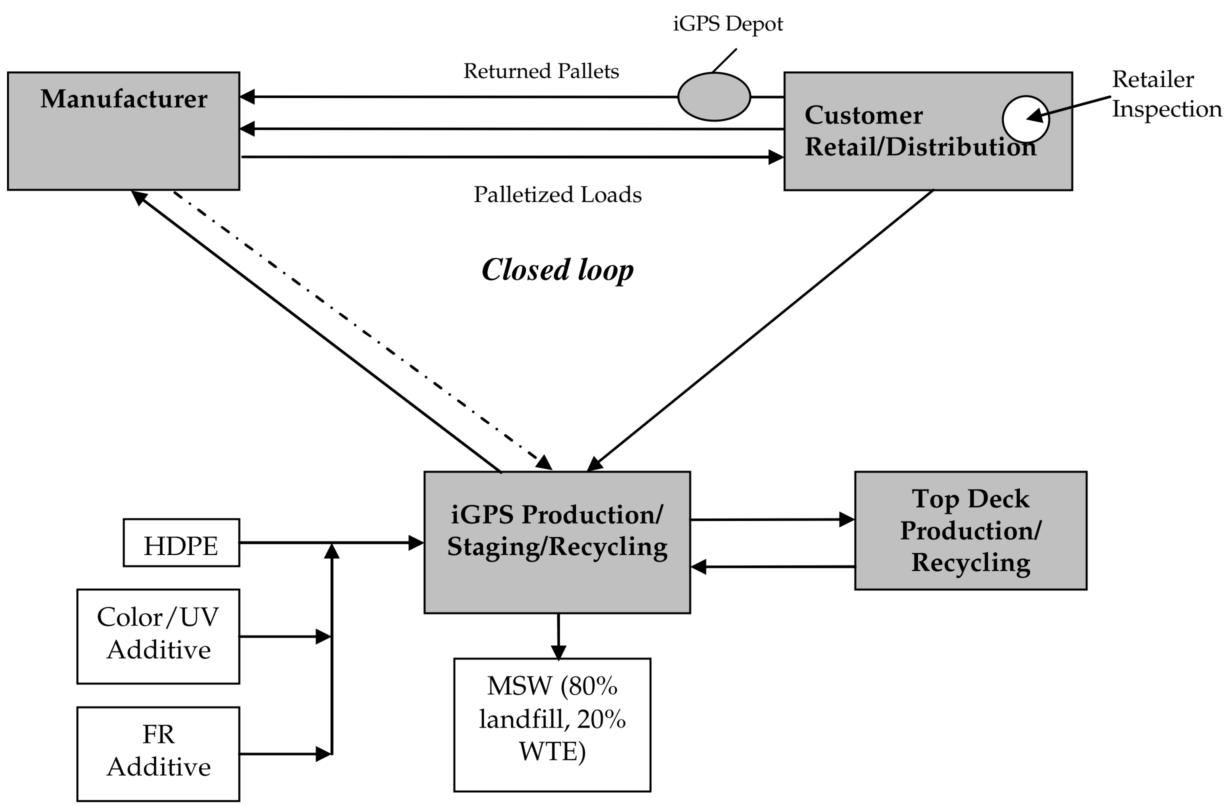
- Fire retardation characteristics and conformance with National Fire Protection Agency (NFPA) standards

- Pallet handling equipment damage at product manufacturers and W/Ds.

2.3.2 SYSTEM BOUNDARIES

Figures 2.1 to 2.3 detail the main life cycle stages that were included in the streamlined life cycle analysis of the three types of pallet systems.

Figure 2.1 System Boundaries for iGPS Pallets



Note: ***Scenarios for HDPE input into the iGPS pallet included in the report are:***

- ***Baseline scenario: virgin HDPE***
- ***Alternate scenarios: 85% virgin/15% recycled HDPE and 100% recycled HDPE (2.5% virgin/97.5% recycled HDPE)***

Figure 2.2 System Boundaries for Pooled Wooden Pallets

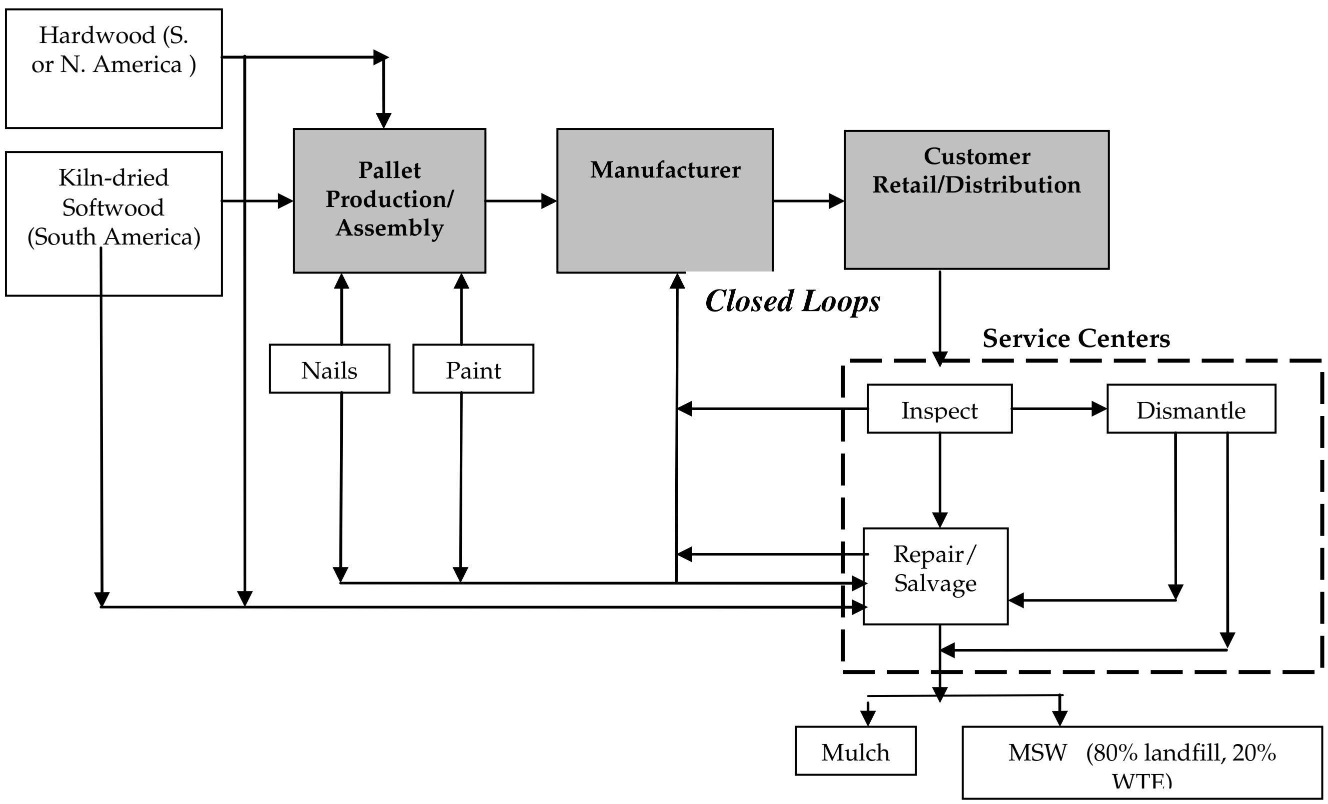
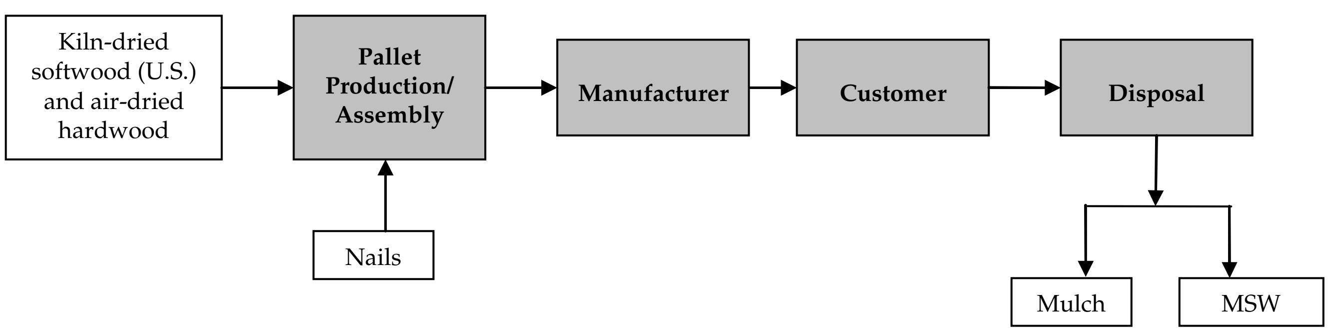


Figure 2.3 System Boundaries for Single-use Pallets



2.4 IMPACT ASSESSMENT

The method for quantifying environmental impacts was that developed and advocated by CML (Centre for Environmental Science, Leiden University) and incorporated into the SimaPro LCA software tool which was the principal modeling tool used in this study.

The version contained in the software is based on the CML spreadsheet version 2.02 (September 2001) as published on the CML web site. For aquatic and terrestrial eco-toxicity, the Representative Toxicity Model (Impact 2002+) was used.

The results of the LCA comparative analyses are described and depicted in tabular and graphical formats in this section. Table 2.2 details the results for each pallet type for each impact category. Because the single-use wooden pallet's impacts were predictably so much greater than those of the multi-use pallets, the single-use wooden pallet was not included in graphical depictions of the comparative environmental impacts. Similarly, the comparative impact of the 100% recycled HDPE iGPS pallet was, as expected, significantly lower than for the iGPS pallet with 100% virgin HDPE content. Thus, this also is not shown in graphical form in this summary.

Table 2.2 Impact Profile for iGPS Pallet, Pooled Wooden Pallet (PWP), and Single-use Wooden Pallet

Impact Category	Unit	iGPS Pallet			Pooled Wooden Pallet	Single-use Wooden Pallet
		Virgin	85/15	Recycled*		
abiotic depletion	kg Sb eq	666	507	59	997	2,111
global warming	kg CO_2 eq	44,901	35,536	8,730	148,224	299,602
ozone layer depletion	kg CFC-11 eq	0.0015	0.0015	.001	0.019	0.028
photochemical oxidation	kg C_2H_4	17.1	11.5	1.6	46.2	147.2
acidification	kg SO_2 eq	417	352.6	58.8	1,176	2,162
eutrophication	kg PO_4 eq	36.3	28.65	8.47	175.5	394
aquatic ecotox	kg TEG water	4,690,450	497,520	239,842	10,285,971	--
terrestrial ecotox	Kg TEG soil	494,802	361,790	330,420	5,484,856	--

** 97.5% recycled/2.5% virgin HDPE*

Figures 2.4 and 2.5 compare the life cycle impacts of the pooled wooden pallet, the virgin iGPS pallet, and the 85/15 iGPS pallet (15% recycled HDPE).

Figure 2.4 ***Comparison of the Pooled Wooden Pallet (PWP), Virgin iGPS Pallet, and 15% Recycled iGPS Pallet Life Cycle Impacts***

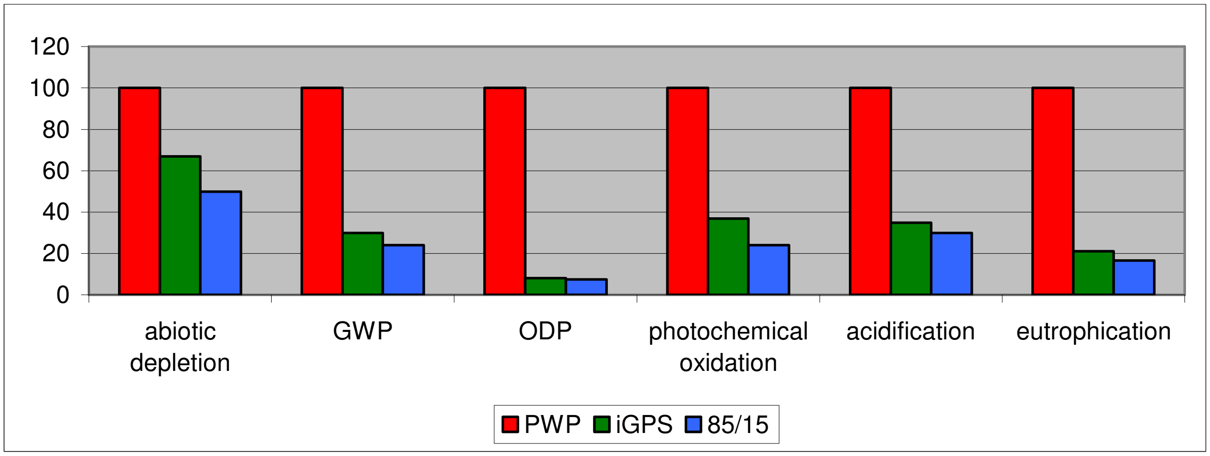
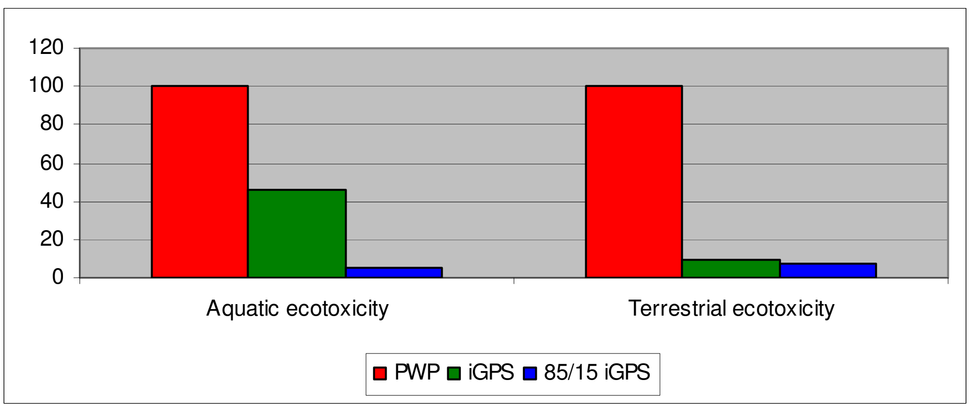


Figure 2.5 ***Comparison of the Pooled Wooden Pallet, Virgin iGPS Pallet, and 15% Recycled iGPS Pallet LC Impacts (Representative Toxicity Model)***



A rule of thumb in LCA is that differences in impacts of 25% or less are not considered to be significant due to uncertainties in inputs. The iGPS HDPE pallet (both with and without recycled HDPE content) had substantially lower environmental impacts in all impact categories.

It can be useful to take a detailed look at the environmental impact contributions for the major life cycle stages of each pallet system. This can be tool to evaluate "hot spots" in a product's life cycle and to highlight opportunities to make product improvements for those life cycle stages within the product owner's control. It can also flag those life cycle stages that demonstrate competitive advantage.

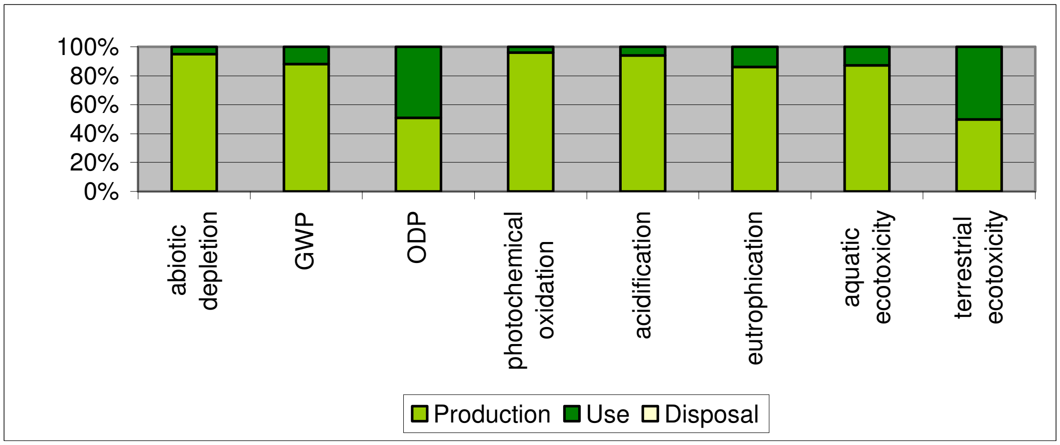
Figure 2.6 shows a breakdown of the environmental impact contributions for the major life cycle stages of the iGPS pallet, which consist of:

- Production – raw material production and transport; pallet manufacture
- Use – transport during use;

- Disposal – end of life

For most of the impact categories, the production phase was responsible for approximately 90 to 95% of the impact. The exceptions were ODP and terrestrial toxicity, where the production phase contributed about half of the impact.

Figure 2.6 iGPS Life Cycle Impacts by Life Cycle Stage



In comparison, for the pooled wooden pallet, the transportation phase was a much more significant contributor to the overall environmental impacts. This is explained by the shorter useful lifetime of the pooled wooden pallet, the additional transport distance to dedicated repair stations, and the heavier weight as compared with the iGPS pallet.

2.5 SENSITIVITY ANALYSES

A sensitivity analysis is a process where key input parameters and method choices about which there may be uncertainties are deliberately varied in the modeling to demonstrate the effect that such variation could have on the results of the assessment. This type of analysis is especially important for studies where model inputs are estimated and assumptions are made for key input parameters.

The following parameters were investigated in the sensitivity analyses and are presented in the order in which varying the inputs resulted in the most significant changes in the outputs:

1. Trips per pallet lifetime
2. Transportation distances
3. Pallet weight

2.5.1 SCENARIO 1 – TRIPS PER PALLET LIFETIME

Varying the number of trips one iGPS pallet and one pooled wooden pallet each make in a lifetime had the most significant impact on the environmental footprint. Increasing the expected lifetime of an iGPS pallet from the base case of 100 trips to the expected case of 120 trips resulted in an approximate 17% to 20% decrease in magnitude for each impact category. In addition, a worst-case scenario of 80 trips per pallet lifetime for an iGPS pallet was modeled. The 80-pallet scenario resulted in an approximate 20% to 25%

increase in the environmental footprint as compared to the 100-pallet scenario. The data are listed in Table 2.3 and depicted in Figure 2.9.

Table 2.3 Change in iGPS Life Cycle by Varying Number of Trips

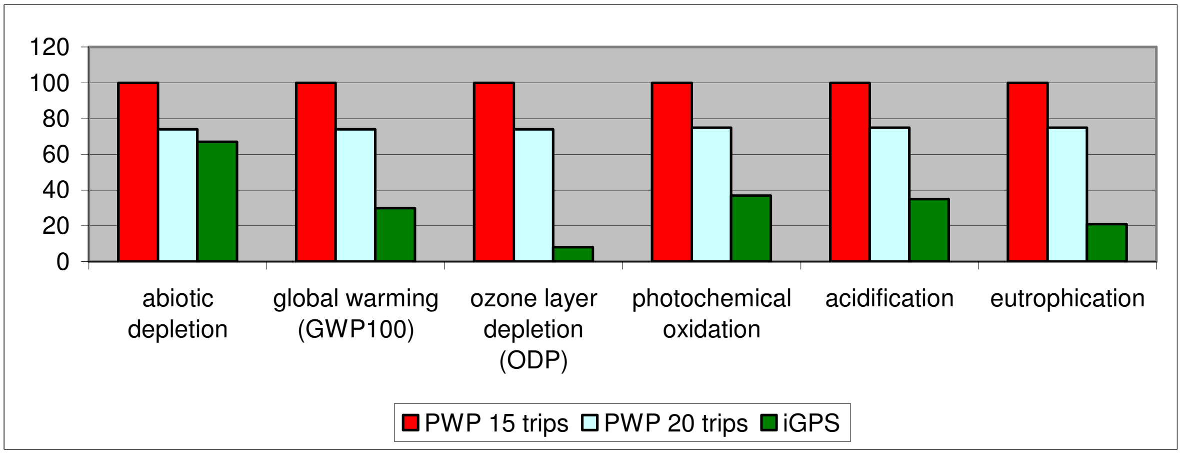
Impact Category	Unit	iGPS 100 trips	iGPS 80 trips	% Change	iGPS 120 trips	% Change
abiotic depletion	kg Sb eq	667	833	+25	555	-17
global warming (GWP100)	kg CO_2 eq	44,900	56,066	+25	37,364	-17
ozone layer depletion (ODP)	kg CFC-11 eq	.0015	.0019	+27	.0012	-20
photochemical oxidation	kg C_2H_4	17.1	21.3	+25	14.2	-17
acidification	kg SO_2 eq	438	526	+20	351	-20
eutrophication	kg PO_4--- eq	39.2	47.1	+20	31.4	-20

The trip rate for the pooled wooden pallet was increased from 15 to 20 trips per pallet lifetime, resulting in an approximate 25% decrease in all impact categories as shown in Table 2.5. The results were compared with the 100% virgin HDPE iGPS pallet as shown in Figure 2.7. This sensitivity analysis confirmed the importance of having an accurate estimation of trips per pallet lifetime.

Table 2.4 Change in Pooled Wooden Pallet Life Cycle Impacts by Varying Number of Trips

Impact Category	Unit	PWP 15 trips	PWP 20 trips	% Change
abiotic depletion	kg Sb eq	997	742	-26
global warming (GWP100)	kg CO_2 eq	148,224	110,245	-26
ozone layer depletion (ODP)	kg CFC-11 eq	.019	.0139	-26
photochemical oxidation	kg C_2H_4	46/2	34.6	-25
acidification	kg SO_2 eq	1,176	878	-25
eutrophication	kg PO_4--- eq	176	131	-25

Figure 2.7 Varying Trips per Pallet Lifetime for the Pooled Wooden Pallet

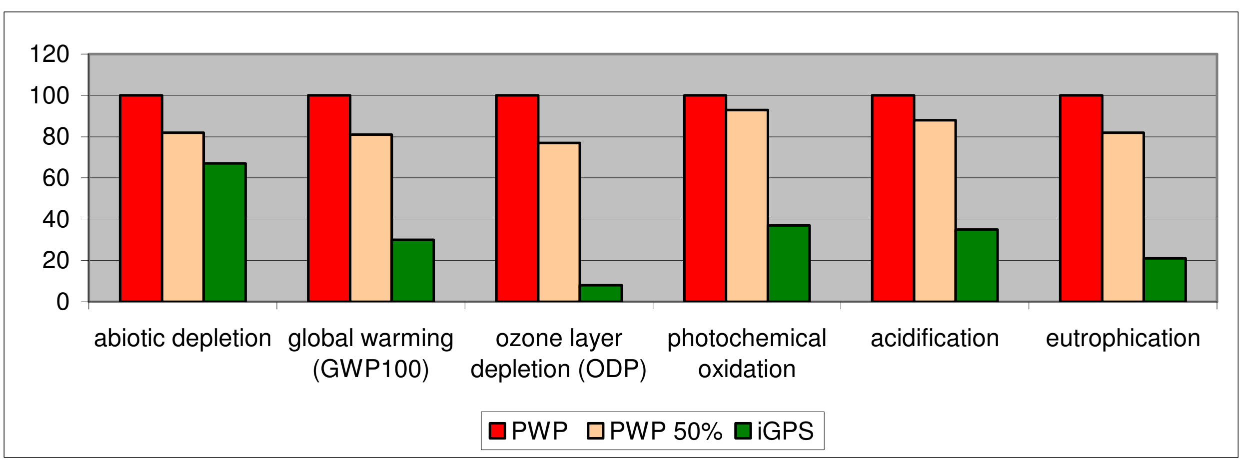


2.5.2 SCENARIO 2 – TRANSPORTATION DISTANCES

As data were not able to be collected directly from pooled wooden pallet suppliers or customers, assumptions were made regarding the location of manufacturing, inspection, and repair facilities based on publicly available information describing the location of pooled pallet facilities in the U.S. and Canada. To gain a better understanding of the importance of mileage assumptions made for the pooled wooden pallet, transportation variations were analyzed in the model to determine the effects on the impact categories. The results from this analysis are shown in Figure 2.8.

Decreasing the overall distance a pooled wooden pallet travels in one trip by approximately 50% decreased the environmental impacts by about 20%. Compared with the iGPS pallet baseline scenario, the pooled wooden pallet still had significantly greater impacts (e.g., above 25%) than the iGPS pallet in all impact categories except for abiotic depletion.

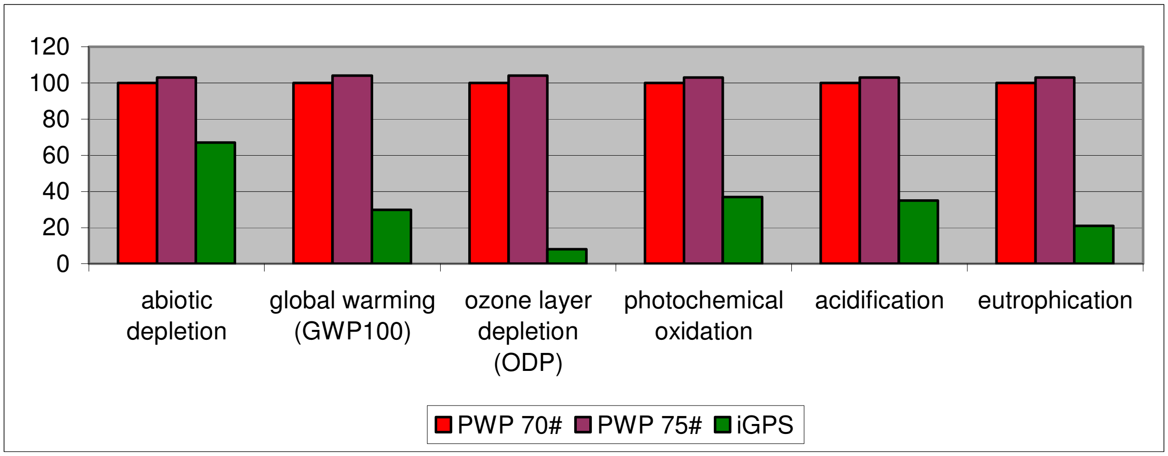
Figure 2.8 Varying Transportation Mileage for the Pooled Wooden Pallet



2.5.3 SCENARIO 3 – PALLET WEIGHT

Due to the discrepancies that exist in publicly available data sources regarding the total weight of a pooled wooden pallet, a sensitivity analysis was performed to examine the effect the chosen weight had on the life cycle impact results. The weight was increased from 70 pounds to 75 pounds based on information from iGPS management experienced with wooden pallets that they are capable of becoming heavier when wet. As shown Figure 2.9, the result was an increase in impacts of approximately 3%.

Figure 2.9 Varying the Weight of the Pooled Wooden Pallet



2.6 CONCLUSIONS

For the baseline scenarios, the results of this study showed that the iGPS plastic pallet had lower environmental impacts in all impact categories compared to the typical pooled wooden pallet, and a substantially smaller environmental footprint than the single-use pallet.

A review of the environmental impacts for each life-cycle stage showed that most of environmental impacts from the iGPS pallet accrue from the production of virgin HDPE. This is a life cycle stage over which iGPS had no control. Incorporating a relatively small proportion (15% by weight) of recycled HDPE into the iGPS pallet lessened the environmental impacts. The 100% recycled HDPE pallet had a markedly smaller environmental footprint.

The transportation phase of the life cycle was where the iGPS pallet demonstrated significant environmental benefits compared to the pooled wooden pallet. This was due primarily to the iGPS pallet's ability to make many more trips per pallet lifetime as well as its lighter weight. Elimination of the repair step common to the typical pooled wooden pallet system resulted in fewer truck miles traveled per pallet trip, hence lower fuel use and transportation-related emissions and impacts.

Because of uncertainties associated with the use of secondary data for evaluating the pooled wooden pallet, sensitivity analyses were performed to determine how varying certain data inputs would change the LCA results. Analyses of these "what-if" scenarios indicated that the most significant input variable was the trips/pallet lifetime, followed by trip distances, then pallet weight. This underscores the importance of having accurate trip rate and distance data to improve the reliability of the LCA results.

Due to the iGPS pallet's comparatively short time in the marketplace (since 2006) compared to the pooled pallet system and single-use pallet, iGPS intends to continue to collect data to validate the assumptions made in this report, particularly with respect to trips per pallet lifetime and transport distances.

3.0 LIMITATIONS

ERM is not engaged in environmental life cycle assessment for the purposes of advertising, sales promotion, or endorsement of any client's interests, including raising investment capital, recommending investment decisions, or other publicity purposes. This report is based upon the application of scientific principles and professional judgment to certain facts with resultant interpretations. The report has been conducted and prepared in accordance with ISO 14040:2006 guidance; however, it has not been peer reviewed. Professional judgments expressed herein are based on the facts currently available within the limits of the existing data, scope of work, budget, and schedule. We make no warranties, expressed or implied, including, without limitation, warranties as to merchantability or fitness for a particular purpose. .

4.0 DEFINITIONS

The life cycle assessment impact categories included in this report are defined herein.

Abiotic depletion is related to the extraction of scarce minerals and fossil fuels.

Acidification is the reaction of acidic gases such as sulphur dioxide that react with water in the atmosphere to form "acid rain" which can cause ecosystem impairment.

Aquatic ecotoxicity is the impact of manmade and natural materials and activities on aquatic organisms, from the subcellular, through individual organisms, to communities and ecosystems.

Eutrophication is the increase in chemical nutrients -- typically compounds containing nitrogen or phosphorus -- in an ecosystem. It may occur on land or in water. The impact may include excessive plant growth and decay, resulting in a lack of oxygen, impaired water quality, and increased stress on fish and other animal populations.

Global warming potential (GWP) is the ratio of heat trapped by one unit mass of the greenhouse gas to that of one unit mass of CO_2 over a specified time period. This trapping of heat has been implicated in climate change.

Ozone depletion potential (ODP) is the relative value that indicates the potential of a substance to destroy ozone gas as compared with the potential of chlorofluorocarbon-11 (CFC-11) and has been connected with the destruction of stratospheric ozone, increasing the amount of harmful UV light hitting the earth's surface.

Photochemical ozone creation (summer smog) is due to nitrogen oxides and volatile organic compounds combining in the presence of sunlight to form low-level ozone. At low level, it is implicated in impacts such s crop damage and increased incidence of asthma.

Terrestrial ecotoxicity is the impact of manmade and natural materials and activities on terrestrial organisms, from the subcellular, through individual organisms, to communities and ecosystems.