Comparing the Ecological Footprints of the U.S. and the E.U.

Dr. Jim Bowyer

Kathryn Fernholz
Dr. Jeff Howe
Dr. Steve Bratkovich

April 22, 2009
Revised June 9, 2009

Dovetail Partners, Inc.

Comparing the Ecological Footprints of the U.S. and the E.U.

Background

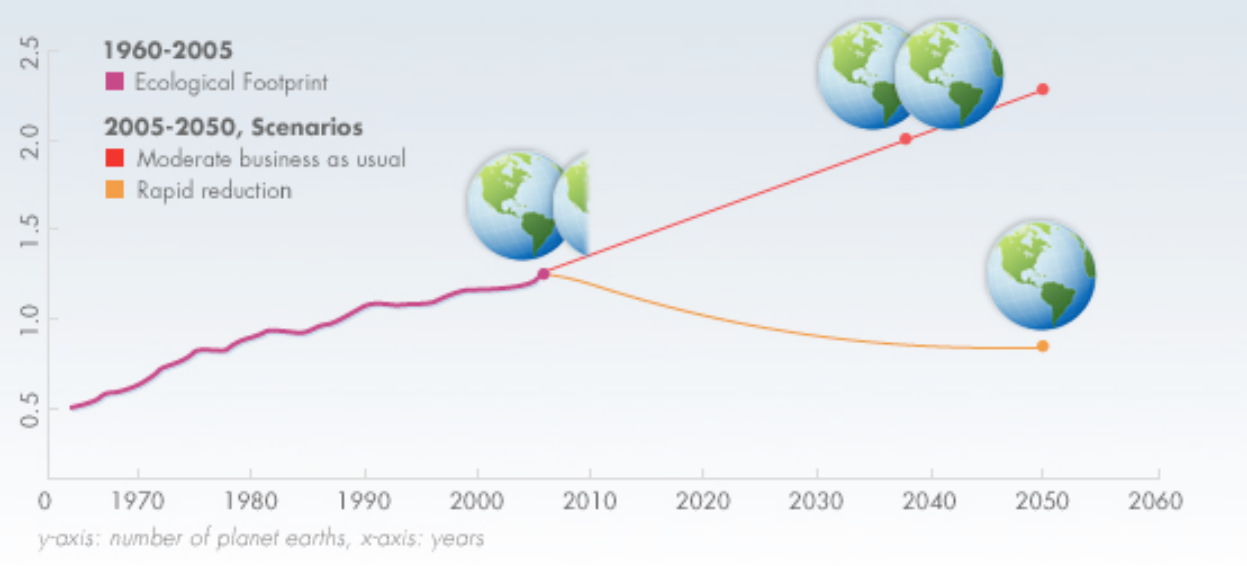
The Ecological Footprint concept, first introduced 15 years ago, provides an interesting way of looking at consumption. Consumption of the full range of bioresources[1] - from grain, beef cattle, and fish, to peat and timber - is converted to a measure of the land and water surface area required to support that consumption, as well as disposal of wastes.

Not surprisingly, the Ecological Footprint of the United States, the highest consuming nation in the world, is larger than for any other nation. What *is* surprising is that the U.S. footprint is *double* that of the E.U. and far higher than a number of nations that consistently rank higher or comparable to the U.S. in quality of life indices.

Examination of biocapacity[2] on a national basis shows that many of the most affluent countries, such as the United States, are consuming bioresources at levels beyond long-term replenishment capacity, and impacting far greater geographic areas than defined by national borders and coastal seas. Largely as a result of the practices of these relatively few countries, the global Ecological Footprint is estimated to now exceed the long-term carrying capacity of the earth (Figure 1).

Such estimates raise a question as to what responsibility high-consuming nations have to reduce the impacts of their consumption. Critical thinking about this issue inevitably leads to consideration of not only bioresource consumption, but consumption of non-renewable resources as well, and paints a sobering picture of our national profile.

Figure 1
The World's Ecological Footprint



Source: http://www.footprintnetwork.org/en/index.php/GFN/page/world_footprint/

[1] Bioresources are defined as any resource of biological origin and encompassing renewable resources.
[2] Biocapacity is defined as the capacity of ecosystems to produce biological materials useful to humans and to absorb waste materials generated by humans, using current management schemes and extraction technologies.

The Ecological Footprint

In the early 1990s a University of British Columbia graduate student, Mathis Wackernagel, became interested in the possibility of developing an easily understood measure of consumption vs. ecological carrying capacity. What he came up with was a method for describing consumption of bioresources in terms of the area of earth's surface required to support that consumption. Initially dubbed "appropriated carrying capacity," the concept was later described by the term "Ecological Footprint" (Wackernagel 1994; Wackernagel and Rees 1996).

Wackernagel's approach provides an indication of human use of biological materials in comparison to the earth's capacity for biomaterials production. What is involved is conversion of all of the biological materials consumed and all of the biological wastes generated annually per capita into an equivalent number of *global hectares* (see following paragraph). For example, per capita consumption of a physical resource (such as fish, beef, wheat, or timber) is converted to an equivalent surface area (hectares or acres) by dividing by the yield of the specific land or sea area from which that physical resource is harvested. This number is then converted to global hectares using yield and equivalence factors. A summation of the number of global hectares associated with the full suite of bioresources yields the Ecological Footprint. The Ecological Footprint of a city, province, or nation is determined by multiplying the per capita footprint for residents of that geographic area by population. There is a carbon component to the Ecological Footprint. This is a measure of the biological capacity, expressed in terms of global hectares, required to process human emissions of fossil carbon dioxide.

As noted in the Global Footprint Network website,[3] a global hectare is "a common unit that encompasses the average productivity of all the biologically productive land and sea area in the world in a given year. Biologically productive areas include cropland, forest and fishing grounds, and do not include deserts, glaciers, and the open ocean."

The exclusion of open oceans and less productive lands from biocapacity accounts, the way in which the global carbon budget is allocated, the failure to allocate space for other species, and other issues are the basis for considerable criticism of the ecological footprint, and such issues are said to limit wider use of the ecological footprint concept in environmental policy-making. In one recent study (Venetoulis and Talberth, 2007) the ecological footprint was recalculated using a new approach that included the entire Earth's surface in biocapacity measures, reallocated the carbon budget and reported carbon sequestration biocapacity, and considered space needs for species other than humans. The study concluded that traditional measures of the ecological footprint are too conservative; using a more comprehensive accounting showed humanity's global footprint and ecological overshoot to be substantially greater than commonly reported.

The U.S. Compared to Other Nations

It is not surprising that the nations with the highest consumption have the highest ecological footprints. The current economic disaster notwithstanding, the United States leads the world in consumption of almost everything in both per capita and absolute terms. As a result, our ecological footprint also ranks as the world's largest – at 9.4 hectares (23.2 acres) per person or

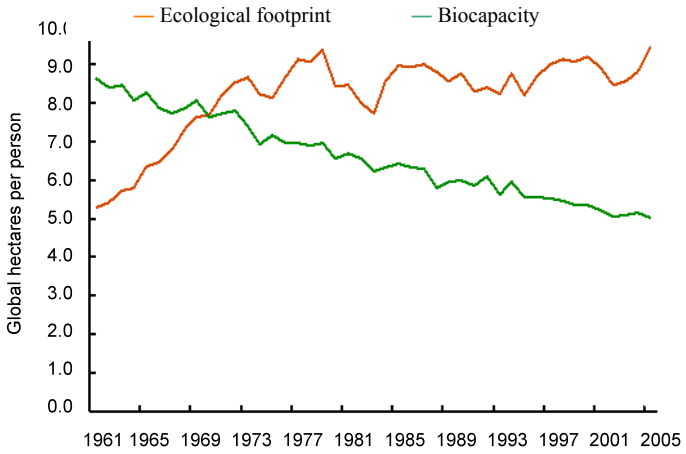
[3] http://www.footprintnetwork.org

(306 million x 9.4 ha/23.2 ac) for the nation. Other nations with large footprints are also affluent nations, including many of the western and northern European nations, Canada, Japan, Australia, and New Zealand.

Because the Ecological Footprint concept was developed for the purpose of gauging development against ecological carrying capacity, the footprint measure is reported against estimates of biocapacity of the region involved. Biocapacity is a dynamic measure, varying year by year with changes in management of agricultural land, forests, water bodies, and other areas. Development of new technologies for resource conversion and use, ecosystem degradation, and weather also affect biocapacity. As with the footprint, biocapacity is expressed in terms of the number of productive hectares (or acres) from which bioresources can be drawn.

Comparisons of Ecological Footprint values with biocapacity measures tend to show that high consuming nations are living beyond their ability to support that consumption. The United States, for example, is a large nation with abundant natural assets, yet per capita biocapacity is declining due largely to expanding population and a high and growing level of consumption (Figure 2). The Ecological Footprint, on the other hand, is large and is tending to grow over time.

Figure 2
The Ecological Footprint vs. Biocapacity of the United States



Source: www.footprintnetwork.org/en/index.php/GFN/page/trends/U.S./

The calculated Ecological Footprints of a number of other nations are also higher than estimates of biocapacity. In a number of cases, such as for European nations, the cause is the same as in the U.S.: high levels of consumption and lower and declining per capita Biocapacity linked to environmental degradation and large populations. Footprint and biocapacity measures for several of the largest European nations are shown in Figure 3.

Figure 3
Ecological Footprint vs. Biocapacity of Several European Countries

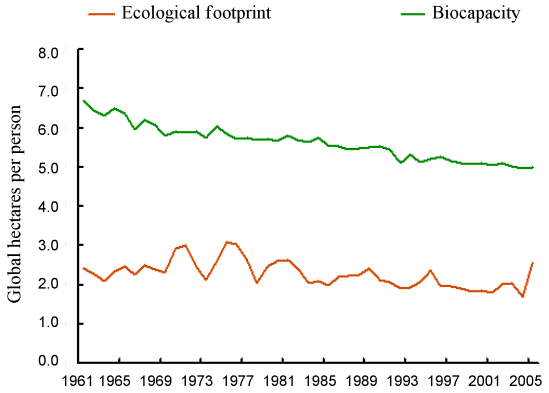
Source: www.footprintnetwork.org/en/index.php/GFN/page/trends/U.S./

Not all affluent nations are living beyond their ability to provide for biological consumption. Sweden, for instance, has abundant bioresources, a well established environmental ethic, and a relatively small population; the result is a lifestyle that is well within biological carrying capacity (Figure 4). Australia, New Zealand, and Canada also have advanced economies, but a relative abundance of bioresources (Table 1); these nations are a major source of raw materials for other countries.

The Ecological Footprint of a country may also exceed its biocapacity if its stock of biological resources is low, and its population and/or consumption quite high. Countries in this category include China, India, Germany, Italy, the UK, South Korea, Egypt, Jordan, Israel, Singapore, Vietnam, and the Philippines.

On the other side of the ledger are the economically developing nations that for the most part have vastly smaller Ecological Footprints (bottom half of Table 1) and that provide significant quantities of natural resources to the more economically developed. An obvious problem is that each new addition to the developed nation list results in subtraction from the list of developing (or resource supply) nations. Accentuating this dynamic is the reality of growing populations, especially within the developing nations, commonly accompanied by environmental degradation (or erosion of envionmental capital) within these nations.

Figure 4
Ecological Footprint vs. Biocapacity of Sweden



Source:
www.footprintnetwork.org/en/index.php/GFN/page/trends/U.S./

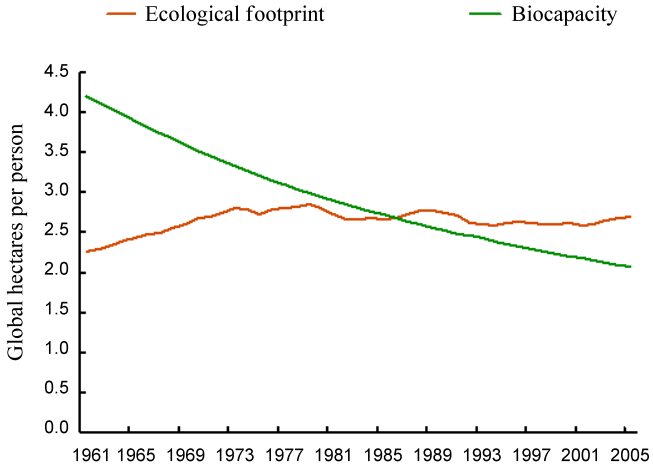
Table 1
Ecological Footprints of Selected Countries, 2005.

	Country	Ecological Footprint (hectares/capita)	Biocapacity (hectares/capita)
Biocapacity is less than Ecological Footprint	United States	9.42	5.02
	Japan	4.89	0.60
	Germany	4.23	1.94
	China	2.11	0.86
	Vietnam	1.26	0.80
	India	0.89	0.41
Biocapacity is greater than Ecological Footprint (resource supply nations)	Australia	7.81	15.42
	New Zealand	7.70	56.64
	Canada	7.07	20.05
	Sweden	5.10	9.97
	Russian Federation	3.75	8.11
	Chile	3.00	4.14
	Venezuela	2.81	3.15
	Brazil	2.36	7.26
	South Africa	2.08	2.21
	Peru	1.57	4.02
	Gabon	1.30	24.97
	Indonesia	0.95	1.39
	Dem. Rep. of Congo	0.61	4.17

Source: Ewing et al. 2008. The Ecological Footprint Atlas 2008.

Wackernagel and Rees concluded (as have subsequent researchers) that given current levels of productivity and materials use efficiency global consumption of biological resources exceeds the ability of the world to support that consumption over the long term (Figure 5).

Figure 5
Global Ecological Footprint vs. Biocapacity



The U.S. vs. the E.U.

Interesting Comparisons

Every now and then, rankings are made of quality of life in various countries. Reader's Digest recently (2008) published a green and livable index using the United Nations 2006 Human Development Indicators (HDI) data and the 2005 Environmental Sustainability Index (ESI). In this ranking the United States was 23rd, with 13 nations of the E.U. ranking higher. In the most recent list of Human Development Indicators (UNDP 2008) the U.S. is ranked 15th, with 10 European nations higher on the list. In view of such rankings, it is interesting that the Ecological Footprint of the U.S. is substantially higher than all 27 countries of the E.U., and than all E.U. countries often listed as offering a higher or comparable quality of life than the U.S. (Table 2). In fact, many of the countries often listed as offering higher or comparable quality of life as the U.S. have Ecological Footprints that are 55% or less that of the United States. Why is this?

Unraveling Our Large Footprint

An Examination of Various Footprint Components

To understand why the Ecological Footprint of the United States is so large and the footprint of E.U. nations is so much smaller requires thinking about the functions of bioresources. The biosphere is a carbon sink. It is also a source of food (grains, fruits and vegetables, meat, fish) and alcoholic beverages, bio-based materials (primarily wood) for use in residential and non-residential construction and a host of other uses, raw materials for the manufacture of paper and paperboard, and heat. Biofiber is also commonly used in producing a wide range of products including clothing, auto parts, and reinforced composite materials of all kinds. In recent years increasing volumes of biomaterials (biomass) have been used in producing liquid fuels such as ethanol and biodiesel.

The primary explanation for the very large Ecological Footprint of the United States relative to Europe is higher energy and fossil fuel consumption (see next section), and the related function of biological resources in carbon cycling. In addition, wood is more commonly used in home construction in the U.S.[4], and average per capita living space in those homes is far higher than in even other affluent countries, resulting in not only greater quantities of raw materials needed for construction, but for furnishings, cleaning, maintenance, and heating/cooling as well. Moreover, U.S. per capita consumption of paper and paperboard is more than double that of the E.U. overall, and higher than any individual E.U. country except Finland.

Table 2
Ecological Footprints of the U.S. and E.U. Countries* **

Country	Ecological Footprint (hectares/capita)
United States	**9.42**
Denmark	8.04
Estonia	6.39
Ireland	6.26
Greece	5.86
Spain	5.74
Czech Republic	5.36
UK	5.33
Finland	5.25
Belgium	5.13
Sweden	5.10
Austria	4.98
France	4.93
Italy	4.76
Slovenia	4.46
Portugal	4.44
Netherlands	4.39
Germany	4.23
Poland	3.96
Hungary	3.55
Latvia	3.49
Slovakia	3.29
Lithuania	3.20
Romania	2.87
Bulgaria	2.71
Weighted E.U. Average	**4.70**

* Values are not provided for Cypress, Malta, or Luxembourg as these countries are not included within the Ecological Footprint Atlas.

** Countries highlighted in yellow are those often listed as offering a higher or comparable quality of life as the United States.

Source: Ewing et al. 2008. The Ecological Footprint Atlas 2008.

[4] Use of wood in construction is included in the footprint as a calculation of the land area required to support production of wood removed in periodic harvests. Brick, concrete, and steel use in construction is not included in the footprint calculation (even though production of these materials has substantial environmental impact), since the footprint is focused on biomaterials only.

An added contributor to the large U.S. Ecological Footprint is high meat and grain consumption relative to Europe. In 2007, per capita consumption of meat (beef, pork, poultry, and mutton/goat meat) was more than 17 percent higher in the U.S. than in the E.U., and 11 percent higher than in the 15 nations of western Europe; per capita consumption of beef was 70 percent higher in the U.S. Largely attributable to high beef consumption, U.S. per capita consumption of grains was about double that of the E.U. in 2007. And, U.S. consumption of ice, the making of which consumes about 13 billion kilowatt hours of electricity and results in the liberation of about 29 billion tons of CO_2, is vastly greater than in Europe where ice use is rare.

European diets, in contrast to the U.S., are more heavily oriented toward pork rather than beef, and toward fish. E.U. per capita consumption of fish was nearly four times that of the U.S. in 2007.

In summary, the U.S. Ecological Footprint is larger than that of other countries because per capita consumption of energy and a wide range of goods of all kinds is greater. Wastes, including carbon dioxide, are greater as well, adding to the relative size of the footprint.

The Energy/Ecological Footprint Connection

The Ecological Footprint of the U.S. is exactly double that of the E.U. Coincidentally, U.S. per capita energy consumption is also almost exactly double (2.08x) that of the E.U. (Table 3).

An interesting question is *why* U.S. energy consumption is so high relative to other countries. To understand high energy consumption is to understand why the U.S. Ecological Footprint is so large, and perhaps how it might be reduced.

Consideration of the following questions perhaps provides a basis for understanding:

1) Why are U.S. homes in comparison to those of the E.U.:
   - so much larger?
   - so seldom designed so that zone heating could be effectively employed?
   - so much more dispersed?
   - so much less likely to be served by rapid transit?

2) Why are U.S. automobiles:
   - so large and so fuel inefficient in comparison on average to those in the E.U.?

3) Why do U.S. residents travel, on average, 2.5 times the number of auto miles annually per capita and 3 times the number of air miles, but only one-half the distance per capita by rail and bus transit systems?

In a word, the answer to all of these questions is **energy**, and more specifically **cheap energy**. A long history of abundant, low cost energy has allowed U.S. residents to make everyday decisions, large and small, with little or no thought to either the price or availability of energy. Faced with a decision whether to live close to work or in the distant suburbs with a long commute long distance, the first and often only thought has been about the driving *time*. Energy efficiency or a hot tub? - Who cares that the hot tub will likely require more power than any applicance? Compact or full size? - Until recently, this kind of decision pretty much hinged on the intitial price of the vehicle.

When water beds came onto the scene in the 1980s, they found a market that was almost exclusively enclosed within U.S. borders. The fact that these kinds of beds required constant heating, commonly drawing more power than the refrigerator, wasn't even on the radar screens of consumers. Power consumption is also seldom a consideration when considering the purchase of a second home, an ATV, an entertainment center, or a bag of lawn fertilizer.

Table 3
Per Capita Energy Consumption in the U.S. and the E.U. Countries

Country	Per Capita Energy Consumption (kilograms of oil equivalent per person)
United States	**7885.9**
Finland	6555.0
Belgium	5891.7
Sweden	5780.3
Netherlands	5048.8
Czech Republic	4418.6
France	4396.8
Germany	4187.0
Austria	4134.7
UK	3894.6
Estonia	3786.0
Ireland	3656.0
Slovenia	3655.0
Denmark	3634.3
Slovakia	3502.8
Cypress	3367.0
Spain	3339.6
Italy	3169.1
Greece	2794.0
Hungary	2757.4
Bulgaria	2592.0
Portugal	2574.1
Lithuania	2515.0
Poland	2429.0
Malta	2349.0
Latvia	2050.0
Romania	1772.0
Weighted E.U. Average	**3773.4**

* Values are not provided for Cypress, Malta, or Luxembourg as these countries are not included within the Ecological Footprint Atlas.
** Countries highlighted in yellow are those often listed as offering a higher or comparable quality of life as the United States.

Source: Ewing et al. 2008. The Ecological Footprint Atlas 2008.

A clear result of the long history of seldom considering energy implications of purchasing decisions is our large Ecological Footprint. Another is our extremely high energy consumption even in comparison to other affluent nations.

How the U.S. Footprint Might Be Reduced

If we were to attempt to reduce our Ecological Footprint, how might we do it? A simple strategy would be to shift our tax system away from taxation of, say, income and more toward taxation of energy. Though such suggestions have never been popular, such a policy would likely be an effective way of driving change.

With the experiences of the First and Second World Wars and extreme energy scarcity over long periods of time indelibly imprinted in the memories of those who survived those events, policies to moderate energy use have long enjoyed broad public support across the European continent. Thus, a short time ago as Americans were experiencing $4 gasoline for the first time – triggering a sharp decline in large vehicle purchases – Europeans were paying twice that per gallon and more, something they had been doing for decades.

High fuel prices in Europe are the direct result of high taxes on fuel consumption. Those high taxes and high prices have, in turn, resulted in an entirely different mindset (and consumer behaviors) regarding energy consumption and, as noted earlier, vast differences in per capita energy use and environmental impact.

The Non-Renewables Footprint

In view of the fact that the Ecological Footprint takes into account consumption of only bioresources, it is worth considering whether some kind of footprint measure that considers non-renewable resource consumption might show the U.S./E.U. disparity to be smaller than indicated by comparison of just bioresources. For instance, since wood is used to a lesser extent in building houses in most of the E.U. countries, then the use of non-wood resources should be much higher there than here; as shown in Table 4, consumption of cement (and therefore concrete) is, in fact, considerably higher in Europe than in the U.S.

Table 4
Per Capita Consumption of Key Raw Materials - U.S. and the E.U. vs. World, 2007

	Average Per Capita Consumption (kg)			**Consumption Compared to World Average**	
Raw Material	U.S.	E.U.-27	World	U.S.	E.U.-27
Wood*	2.01	1.07	0.54	3.72x	1.98x
Steel	378	395	202	1.87x	1.96x
Aluminum	19.1	15.1	5.8	3.29x	2.60x
Cement	387	624	418	0.93x	1.49x
Plastics	175	106	39	4.49x	2.72x

Source: Data for wood (US) from Howard, USFS (2007) and wood (EU) from Ekström (2008); for cement, steel, and aluminum from the U.S. Geological Survey (2009) and the World Bureau of Metal Statistics (2008); and for plastics from the American Chemistry Council Plastics Industry Producers Group (2009), and from the Association of Plastics Manufacturers in Europe (2009).

* Wood quantities in m^3. Wood consumption data for U.S. 2005, for EU 2007.

It might be tempting to conclude that reducing wood use in construction would reduce the Ecological Footprint. It probably would if nothing else were used in the place of wood. However, as pointed out in several previous Dovetail reports, substituting steel or concrete for wood in construction translates to large increases in energy and fossil fuel consumption and significantly greater emissons of carbon dioxide. On balance, using more wood in construction, rather than less (of course within sustainable limits), would serve to reduce the size of the footprint.

The Bottom Line

The Ecological Footprint is an expression of bioresource consumption in terms of surface area. The per capita Ecological Footprint for U.S. citizens is quite large, and larger even than that of nations often identified as offering a higher quality of life. The same is true of energy consumption. Fundamentally, the large U.S. Ecological Footprint is due to high consumption. High consumption, in turn, is closely linked to abundant low cost energy.

The key to reducing the size of our Ecological Footprint (and probably our carbon emissions) is the cost of energy. A consistently higher price for all forms of energy would serve to bring consideration of energy efficiency to the forefront of engineering and everyday life, likely bringing dramatic change over time.

References

European Commission. 2007. Panorama of Transport – 2007. Eurostat Statistical Books. (http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-DA-07-001/EN/KS-DA-07-001-EN.PDF)

Ewing, B., Goldfinger, S., Wackernagel, M., Stechbart, M., Rizk, S., Reed, A., and Kitzes, J. 2008. The Ecological Footprint Atlas 2008. Oakland, California: Global Footprint Network, October 28. (http://www.footprintnetwork.org/en/index.php/GFN/page/methodology/)

Howard, James L. 2007. U.S. timber production, trade, consumption, and price statistics 1965 to 2005**.** USDA-Forest Service, Res. Pap. FPL-RP-637. (http://www.treesearch.fs.fed.us/pubs/28972)

Makower, J. 2005. Europe's Ecological Footprint. Futurelab. (http://blog.futurelab.net/2005/06/europes_ecological_footprint.html)

Meima, R. 2008. Not Invented Here: What New England Can Learn from Northern E.U.rope About Energy (And how many small bU.S.inesses could benefit). Marlboro College Graduate Center MBA Blogs, July 24. (http://gradcenter.marlboro.edu/blogs/node/17)

O'toole, R. 2009. E.U.rope vs. the U.S. The Antiplanner. (http://ti.org/antiplanner/?p=949)

Reader's Digest. 2008. Most Livable Places – 2008.

(http://www.photiU.S..com/rankings/greenest_countries_2008.html)

Reed Business Information. 2007. Putting the Chill on Ice Maker Energy Consumption, Foodservice Equipment and Supplies, December 1. (http://www.fesmag.com/energy-aware/article/CA6549981.html)

Schewe, P. 2008. High Living Standards But With Less Energy. Inside Science News Service, November 12. (http://www.aip.org/isns/reports/2008/064.html)

Swivel. 2009. Per Capita Consumption Data for Various Countries and Regions. (http://www.swivel.com/data_sets?sort_direction=DESC&filter=none&tag_name=consumption&sort=view_count&view=list&when=all_time&official=false)

United Nations Development Program. 2008. Human Development Rankings – 2008. (http://hdr.undp.org/en/statistics/)

Venetoulis, J., and Talberth, J. 2007. Refining the Ecological Footprint. Environment, Development and Sustainability 10(4): 441-469.

Wackernagel, M. 1994. Ecological Footprint and Appropriated Carrying Capacity: A Tool for Planning Toward Sustainability. Ph.D. Thesis, School of Community and Regional Planning, University of British Columbia. Vancouver, Canada.

Wackernagel, M. and W. Rees. 1996. Our Ecological Footprint: Reducing Human Impact on the Earth. Gabriola Island, BC: New Society Publishers.

World Resources Institute. 2007. Total Energy Consumption Per Capita by Country and Region. Earthtrends. (http://earthtrends.wri.org/text/energy-resources/variable-351.html)

World Wide Fund for Nature. 2007. Europe 2007 – Gross Domestic Product and Ecological Footprint.
(http://assets.panda.org/downloads/E.U.rope_2007_gdp_and_ef.pdf)

This report was prepared by

DOVETAIL PARTNERS, INC.

Dovetail Partners is a 501(c)(3) nonprofit organization that provides authoritative information about the impacts and trade-offs of environmental decisions, including consumption choices, land use, and policy alternatives.

FOR MORE INFORMATION OR TO REQUEST ADDITIONAL COPIES OF THIS REPORT, CONTACT US AT:

INFO@DOVETAILINC.ORG

WWW.DOVETAILINC.ORG

612-333-0430

DOVETAIL PARTNERS, INC.
528 Hennepin Ave, Suite 202
Minneapolis, MN 55403
Phone: 612-333-0430
Fax: 612-333-0432
www.dovetailinc.org