United States Department of Agriculture

Economic Research Service

Economic Information Bulletin Number 121

February 2014

The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States

Jean C. Buzby, Hodan F. Wells, and Jeffrey Hyman

United States Department of Agriculture

Economic Research Service
www.ers.usda.gov

Access this report online:
www.ers.usda.gov/publications/eib-economic-information-bulletin/eib-xxx.aspx

Download the charts contained in this report:

- Go to the report's index page www.ers.usda.gov/publications/eib-economic-information-bulletin/eib121.aspx
- Click on the bulleted item "Download eib121.zip"
- Open the chart you want, then save it to your computer

Recommended citation format for this publication:

Buzby, Jean C., Hodan F. Wells, and Jeffrey Hyman. *The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States, EIB-121*, U.S. Department of Agriculture, Economic Research Service, February 2014.

Cover image: Shutterstock.

United States Department of Agriculture

Economic Research Service

Economic Information Bulletin Number 121

February 2014

The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States

Jean C. Buzby, Hodan F. Wells, and Jeffrey Hyman

Abstract

This report provides the latest estimates by USDA's Economic Research Service (ERS) on the amount and value of food loss in the United States. These estimates are for more than 200 individual foods using ERS's Loss-Adjusted Food Availability data. In 2010, an estimated 31 percent or 133 billion pounds of the 430 billion pounds of food produced was not available for human consumption at the retail and consumer levels. This amount of loss totaled an estimated $161.6 billion, as purchased at retail prices. For the first time, ERS estimates of the calories associated with food loss are presented in this report. An estimated 141 trillion calories per year, or 1,249 calories per capita per day, in the food supply in 2010 went uneaten. The top three food groups in terms of share of total value of food loss are meat, poultry, and fish (30 percent); vegetables (19 percent); and dairy products (17 percent). The report also provides a brief discussion of the economic issues behind postharvest food loss.

Keywords: Food consumption, food loss, food recovery, food waste, foodservice, recycling, plate waste, processing.

Acknowledgments

The authors gratefully acknowledge Kevin Hall (National Institutes of Health), Ephraim Leibtag (ERS), Hayden Stewart (ERS), Jay Variyam (ERS), and Gregory Ziegler (Pennsylvania State University) for their reviews of the report. Thanks also to ERS editor Dale Simms and designer Cynthia A. Ray.

Contents

Summary iii

Background 1
Economics of Food Loss 6

Data and Methods 10

Results 11
Amount. 11
Value 13
Calories 18

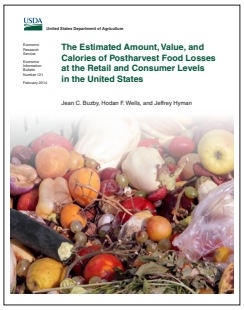
Discussion 22

Appendix: The ERS Loss-Adjusted Food Availability Data and Methods for Estimating the Amount and Value of Postharvest Food Loss 24

References 30

United States Department of Agriculture

A report summary from the Economic Research Service February 2014



Find the full report at *www.ers.usda.gov/publications/eib-economic-information-bulletin/EIB-121.aspx*

The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States

Jean C. Buzby, Hodan F. Wells, and Jeffrey Hyman

What Is the Issue?

"Food loss" represents the amount of edible food, postharvest, that is available for human consumption but is not consumed for any reason; it includes cooking loss and natural shrinkage (e.g., moisture loss); loss from mold, pests, or inadequate climate control; and plate waste. "Food waste" is a component of food loss and occurs when an edible item goes unconsumed, such as food discarded by retailers due to undesirable color or blemishes and plate waste discarded by consumers. Food loss (particularly the food waste component) is becoming an increasingly important topic both domestically and internationally. Better estimates of the amount and value of food loss, including food waste, could help serve as quantitative baselines for policymakers and the food industry to set targets and develop initiatives, legislation, or policies to minimize food waste, conserve resources, and improve human nutrition. Reducing food loss would likely reduce food prices in the United States and the rest of the world, though the effects depend on the nature of supply, including import and export considerations.

What Did the Study Find?

In the United States, 31 percent—or 133 billion pounds—of the 430 billion pounds of the available food supply at the retail and consumer levels in 2010 went uneaten. Retail-level losses represented 10 percent (43 billion pounds) and consumer-level losses 21 percent (90 billion pounds) of the available food supply. (Losses on the farm and between the farm and retailer were not estimated due to data limitations for some of the food groups.)

The estimated total value of food loss at the retail and consumer levels in the United States was $161.6 billion in 2010. The top three food groups in terms of share of total value of food loss were meat, poultry, and fish (30 percent, $48 billion); vegetables (19 percent, $30 billion); and dairy products (17 percent, $27 billion). The total amount of food loss represents 387 billion calories (technically, we mean *Calorie* or kcal *hereafter*) of food not available for human consumption per day in 2010, or 1,249 out of 3,796 calories available per American per day. Recovery costs, food safety considerations, and other factors would reduce the amount of food that could actually be recovered for human consumption.

The study also reviewed the literature and found that food loss is economically efficient in some cases. There is a practical limit to how much food loss the United States or any other country could realistically prevent, reduce, or recover for human consumption given: (1) technical factors (e.g., the perishable nature of most foods, food safety, storage, and temperature considerations); (2) temporal and spatial factors (e.g., the time needed to deliver food to a new destination, and the dispersion of food loss among millions of households, food processing plants, and foodservice locations); (3) individual consumers' tastes, preferences, and food habits (e.g., throwing out milk left over in a bowl of cereal); and (4) economic factors (e.g., costs to recover and redirect uneaten food to another use).

How Was the Study Conducted?

This report uses data from ERS's Loss-Adjusted Food Availability (LAFA) data series. This data series is ERS's core Food Availability data series, adjusted for spoilage, plate waste, and other food losses and converted to daily per capita amounts, calories, and *food pattern equivalents* (previously called servings and *MyPyramid equivalents)*. Here, the LAFA data series' underlying loss assumptions are used to estimate food loss at the retail and consumer levels. The LAFA data series is considered to be preliminary because ERS continues to improve the underlying loss assumptions and the documentation of the data series. In August 2012, new estimates for consumer-level loss were incorporated into the data series. Therefore, the relative contribution of the different food groups out of total food loss has changed from previous ERS publications on food loss. The analysis is an extrapolation from the data as of September 2012 and is not based on an equilibrium model. For each food group covered here, we calculated the amount, value, and representative calories of food loss at the retail and consumer levels in the United States in 2010. The value estimates are based on retail prices.

The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States

Background

In 1977, a *Report to Congress* by the General Accounting Office (GAO) titled "Food Waste: An Opportunity To Improve Resource Use" (GAO, 1977) discussed the U.S. Department of Agriculture's activities related to food loss in the United States, warning that:

> "The United States can no longer be lulled by past agricultural surpluses and must consider a future that may contain a world shortage of food. In an environment of plenty, the United States has not historically been concerned with food losses. Although some attention has been focused on the subject in the agricultural research community, in many instances, plentiful food and low prices did not justify the economic expenditure necessary to reduce loss. In an era of potential scarcity, however, it may be necessary to re-examine the present position on losses." (p. 1) [1]

Today, there is a renewed interest in the issues related to food loss, both domestically and internationally. For example, USDA and the U.S. Environmental Protection Agency (EPA) launched the U.S. Food Waste Challenge on June 4, 2013, and the United Nations' Environment Programme's (UNEP) World Environment Day's major theme in June 2013 was food waste. Some findings from the 1977 GAO report are still relevant today, given the resources used in the production of uneaten food, the negative externalities associated with food loss (e.g., pollution created during food production), and the growing pressures on the global food supply (see box, "Three Reasons for a Growing Interest in Food Loss"). Therefore, it may become increasingly important to estimate the amount and value of food loss, including food waste, as a quantitative baseline for policymakers and the food industry to set targets and develop initiatives, legislation, or policies to minimize food waste, conserve resources, and improve human nutrition (Buzby and Hyman, 2012).

"Food loss" represents the amount of edible food, postharvest, that is available for human consumption but is not consumed for any reason. It includes cooking loss and natural shrinkage (e.g., moisture loss); loss from mold, pests, or inadequate climate control; plate waste; and other causes.[2] "Food waste" is a component of food loss and occurs when an edible item goes unconsumed, such as food discarded by retailers due to blemishes or plate waste discarded by consumers. This report

[1]The 1977 report also concluded that "at present, loss represents a large misallocation of resources. For 1974, about 66 million acres of land and 9 million tons of fertilizer were used to produce food ultimately lost. In energy, about 461 million equivalent barrels of oil were used to produce food ultimately lost" (GAO, 1977). This amount of loss represents about 23 percent of all food produced for direct human consumption in 1974.

[2]The term "postharvest food loss" simply refers to food loss after the food is harvested. Definitions of food waste and food loss vary worldwide (e.g., inedible portions are included in some food waste definitions).

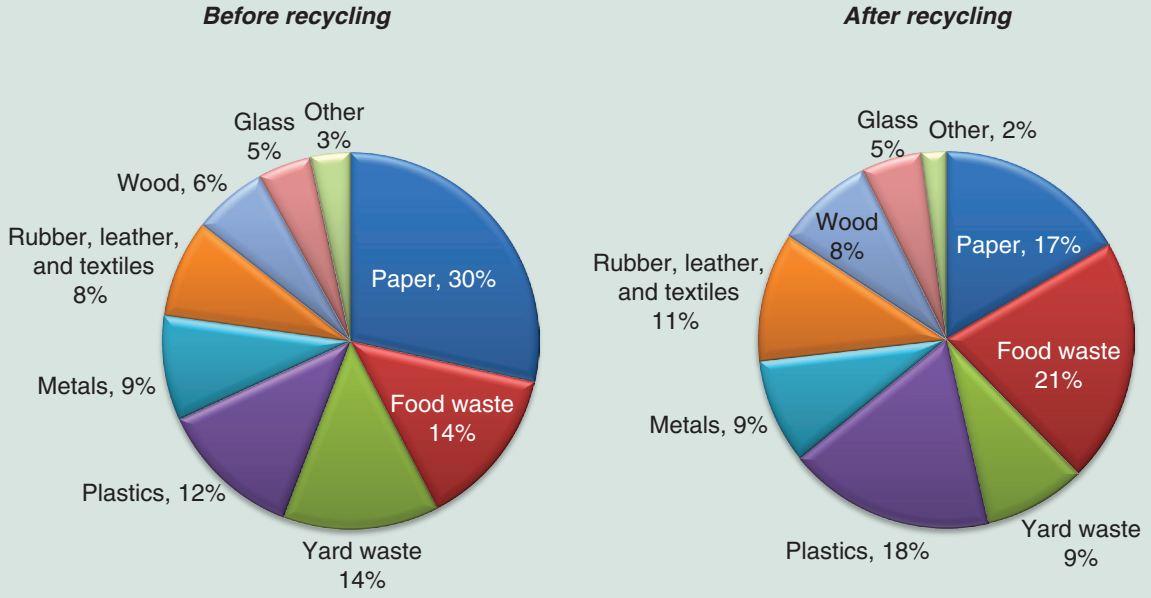
Three Reasons for a Growing Interest in Food Loss

(1) Food loss means a loss of money and other resources

Food loss represents significant amounts of money and other resources invested in food production, including land, fresh water, labor, energy, agricultural chemicals (e.g., fertilizer, pesticides), and other inputs to produce food that does not ultimately meet its intended purpose of feeding people (Buzby et al., 2011). For example, Webber (2012) estimates that food waste represents 2.5 percent of U.S. energy consumption per year, and Hall et al. (2009) estimate that the production of this wasted food required the expenditure of around 300 million barrels of oil and over 25 percent of the total freshwater consumed by agriculture in the United States. A more detailed understanding of the resource implications of food loss in the United States, including estimates of the land used to produce wasted food, is not available.

According to the U.S. Environmental Protection Agency (EPA), food waste accounted for 34 million tons (almost 14 percent) out of the 250 million tons of municipal solid waste in the United States in 2010 as measured before recycling (EPA, 2011) (see figure). Less than 3 percent of this food waste was recovered and recycled, with the remainder going to landfills or incinerators (EPA, 2011). In 2010, food waste cost roughly $1.3 billion to landfill (Schwab, 2013). After recycling some materials, such as paper and paperboard, food waste was the single largest amount of municipal solid waste categorized by EPA in 2010, with 21 percent of the total (see figure).

Total municipal solid waste generation by material before (250 million tons) and after recycling (161 million tons), 2010



Source: EPA, as of September 17, 2012: http://www.epa.gov/wastes/conserve/materials/organics/food/fd-basic.htm

(2) Food loss means that negative externalities were created throughout the supply chain

Negative externalities can arise throughout the entire food supply chain from the food's production to the disposal of any uneaten food. *Negative externalities* are transaction costs that spill over from an action (e.g., food production or disposal) that can adversely affect society and the environment and that are not incorporated in market prices (e.g., the price of food). In general, food that is produced, regardless of whether it is consumed or wasted, contributes to pressure on the availability of fresh water and other natural resources (Lundqvist et al., 2008), including land needed for urbanization, forests, and protected areas, some of which is necessary for biodiversity and wildlife. Some of these pressures on water, land, and other resources are not fully internalized in prices (e.g., value of wildlife diversity in land prices). A few examples of these externalities include: (1) greenhouse gas emissions from cattle production (Lundqvist et al., 2008); (2) air pollution caused by farm machinery and trucks that transport food; (3) water pollution and damage to marine and freshwater fisheries from agricultural chemical and nutrient runoff during crop and livestock production (Aillery et al., 2005; Ribaudo et al., 2011); and (4) soil erosion, salinization, and nutrient depletion that arise from unsustainable production and irrigation practices (Hansen and Ribaudo, 2008; Sullivan et al., 2004).

Additionally, incinerating food waste creates emissions that harm the environment and landfilling food waste generates methane gas when food waste decomposes anaerobically. Methane is 21 times more powerful in accelerating global warming than carbon dioxide (EPA, 2011). Landfills account for 34 percent of all human-related methane emissions in the United States (EPA, 2011). In addition to methane, landfills produce leachate (a mixture of liquid waste, organic degradation byproducts, and rainwater), which may contaminate groundwater if the landfills are not properly maintained. These negative consequences are offset to some extent when energy is generated from incinerating or landfilling food (e.g., tapping the methane gas).

(3) The world population is growing, so more food will be needed to feed people

Reducing food waste will become an increasingly important strategy in the future to help feed a growing human population. It would help by increasing the amount of food available for consumption (particularly food for subsistence households in developing countries) and by lowering prices. The United Nations predicts that the world population will reach 9.3 billion by 2050 (United Nations, 2011), and this will require a 70-percent increase in food production, net of crops used for biofuels (FAO, 2009). Currently, according to an ERS report, the number of food-insecure people reached 802 million in 2012 (Rosen et al., 2012). Low incomes have an important role in this level of food insecurity. Although most of this population growth will occur in developing countries, developed countries like the United States also face issues of hunger and food insecurity.

In 2012, 49 million people lived in food-insecure households in the United States (Coleman-Jensen et al., 2013) out of a total population of over 305 million. *Food insecurity* is when the food intake of one or more household members is reduced and eating patterns are disrupted at times during the year because the household lacks money and other resources for food. Food-insecure households accounted for 14.5 percent of U.S. households: 9.2 percent had low food security and 5.7 percent had very low food security (see figure).

calculates the amount and value of food *loss* in the United States. It does not calculate the amount and value of food *waste* or the other subcomponents of food loss. Data are unavailable on the portion of food loss that is food waste. The estimates of food loss provided here have had the inedible portions removed (e.g., bones, peach pits, and asparagus stalks). For example, the food loss estimates for meat, poultry, and fish provided are in boneless weight.

Some food loss is inevitable because food is inherently perishable and some food needs to be discarded to ensure food safety. For example, some unsold or uneaten food at restaurants, supermarkets, or in homes is not suitable for consumption. Some losses—like the discard of moldy fruit from the produce shelf at the supermarket and the condemnation of diseased animals at the slaughtering house—are necessary to ensure the safety and wholesomeness of the food supply. Such foods are not recoverable for human use. Likewise at restaurants, plate scraps not taken home by patrons are appropriately discarded out of health considerations. Legal liability and strict food safety rules, such as those in the wake of the mad cow disease scare, inhibit food recovery and redistribution in some cases. Discarding unsafe food and food suspected of being unsafe reduces the individual and societal costs of foodborne illness and, in some cases, the potential legal liability.

Many causes of food loss can occur across the entire food supply chain in developed countries (see box, "Causes of Food Loss and Waste at the Farm, Farm-to-Retail, Retail, and Consumer Levels"). The share of total food loss due to each of these causes is unknown.

This report estimates the amount, value, and calories of food loss at the retail and consumer levels in the United States, both in total and per capita by major food group.[3] No adjustments are made for changes in the demographic makeup of the population. Given the recent and growing interest in food loss and waste domestically, up-to-date estimates on the magnitude of food loss in the United States are timely. This report updates and extends previous ERS publications on food loss in several important ways:

1. The report updates previous ERS estimates of the amount and value of food loss for foods at the retail and consumer levels in the United States in 2010 using data as of September 2012. Previous ERS food loss estimates for 2008 are available in Buzby and Hyman (2012) (amount and value for all commodities), Buzby et al. (2011) (value provided only for fruits and vegetables), and Hodges et al. (2010) (amount estimates in tonnes).
2. The estimates in this report incorporate new consumer-level loss assumptions, which were introduced into the Loss-Adjusted Food Availability (LAFA) data series in August 2012 (see documentation: http://www.ers.usda.gov/data-products/food-availability-(per-capita)-data-system/loss-adjusted-food-availability-documentation.aspx) and which were not used in the aforementioned studies.
3. This report discusses the economics of food loss in greater depth than in previous ERS reports.
4. This report provides ERS's first estimates of the amount of food loss in terms of calories.
5. The LAFA data series is part of the Food Availability Data System, which now faces important data challenges in terms of temporarily suspended or unavailable data for some commodities (ERS, 2011). This means that the 2010 estimates provided in this report may be the last complete year for some time whereby all commodities and food groups are represented in the FADS. This

[3]Here, this report uses the term "calories" to represent "Calories" (i.e., with capital "C") or kilocalories because "calories" is the commonly used spelling in the media and informal publications, Wikipedia provides more information on this distinction (http://en.wikipedia.org/wiki/Calorie).

Causes of Food Loss and Waste at the Farm, Farm-to-Retail, Retail, and Consumer Levels

(Farm Level (not measured in this report)

- Consumption or damage by insects, rodents, birds, or microbes (e.g., molds, bacteria),[a] and damage by unfavorable or extreme weather (e.g., droughts, floods, hurricanes, and freezes).
- Diminishing returns when harvesting additional increments of production and other factors leading to leaving some edible crops unharvested.
- Overplanting or overpreparing due to difficulty predicting number of buyers/customers.

Farm-to-Retail Level (not measured in this report)

- Rejection of some products for human consumption due to industry or government food safety regulations or standards (e.g., livestock condemned at slaughter for food safety reasons).
- Byproducts from food processing landfilled or incinerated (i.e., not diverted to other food uses such as for ingredients in mixed foods).
- Outgrading of blemished, misshapen, or wrong-sized foods due to minimum quality standards by buyers, which are the result of consumer demand for high-quality, cosmetically appealing, and convenient foods.
- Spillage and damage, such as by equipment malfunction (e.g., faulty cold or cool storage) or inefficiencies during harvesting, drying, milling, transporting, or processing.

Retail Level

- Dented cans and damaged packaging. Inappropriate packaging that damages produce.[b]
- Unpurchased holiday foods.
- Spillages, abrasion, bruising, excessive trimming, excessive or insufficient heat, inadequate storage, technical malfunction.[a]
- Overstocking or overpreparing due to difficulty predicting number of customers.
- Culling blemished, misshapen, or wrong-sized foods in an attempt to meet consumer demand.

Consumer Level

- Spillages, abrasion, bruising, excessive trimming, excessive or insufficient heat, inadequate storage, technical malfunction.[a]
- Sprouting of grains and tubers, biological aging in fruit.[a]
- Consumers becoming confused over "use-by" and "best before" dates so that food is discarded while still safe to eat.[b]
- Lack of knowledge about preparation and appropriate portion sizes. For example, lack of consumer knowledge of when a papaya is ripe, how to prepare it, and how to use it as an ingredient are reasons for high papaya loss.[c]
- Industry or government standards may cause some products to be rejected for human consumption (e.g., plate waste can't be re-used at restaurants).
- Psychological tastes, attitudes, and preferences leading to plate waste/scrapings (e.g., human aversion, such as "I don't eat that," or refusal to eat a food for religious reasons).[a] Consumer demand for high cosmetic standards.
- Seasonal factors: more food is wasted in summer.[d]
- Uneaten or leftover holiday foods.

Sources: [a] Zeigler and Floros (2011), [b]Parfitt et al. (2010), [c]Buzby et al. (2009), and [d]Gallo (1980), and the remainder was constructed by the authors, 2012. A previous version of this table was published in Buzby and Hyman (2012). Some of these examples of causes may occur at more than one level (e.g., spillage).

emphasizes the importance of providing the 2010 food loss estimates with detailed information and documentation about the estimates. This documentation will change as new data and information are included in the FADS and if there is a change in the methodology of how the food loss estimates are calculated.

Although ERS adjusts for farm-to-retail level losses for some of the included commodities (e.g., canned fruit and vegetables), ERS does not provide summary estimates of food loss at the farm-to-retail levels because of the lack of comparable data for each individual food in the LAFA data series.

The food loss estimates provided in this report at the retail and consumer levels are greater than the amounts of food that could be recovered and diverted to feed people. As previously mentioned, some uneaten food cannot be efficiently and effectively diverted due to the perishability of most foods, high transportation and distribution costs, and other challenges, such as the need to ensure food safety.

On the other hand, the per capita estimates of the total amount of food available for consumption (i.e., the primary reason why this data series was created) using data from the LAFA data series are high,[4] suggesting that underlying food loss assumptions and resulting food loss estimates for all included commodities and food groups presented here are, on average, understated. In 2010, the estimated calories available per capita per day was 2,547, which is high, even given the current obesity epidemic.[5] If a person with caloric needs of 2,100 calories per day actually consumed 2,547 calories per day, he/she would gain an implausible and unsustainable amount of weight per year or over a lifetime. In other words, if the underlying food loss assumptions were higher, then more food (i.e., associated with the loss) would be subtracted from the unadjusted amounts of food available for consumption and the estimated loss-adjusted amount of calories per capita per day would be lower than the current estimate of 2,547 calories per day and thus more realistic.

Economics of Food Loss

There is a practical limit to how much food loss the United States could realistically prevent, reduce, or recover for human consumption given:

1. technical factors (e.g., the perishable nature of most foods; food safety, storage, and temperature considerations);
2. temporal and spatial factors (e.g., the time needed to deliver food to a new destination, and the dispersion of food loss among millions of U.S. households, food processing plants, and foodservice locations);
3. individual consumers' tastes, preferences, and food habits (e.g., a child's distaste for bread crusts, the habit of throwing out milk left over in a bowl of cereal); and

[4]The primary purpose of the LAFA data series is to estimate consumed amounts of food from the amount of food available in the U.S. food supply. This differs from approaches, such as the National Health and Nutrition Examination Survey (NHANES), that are based on 24-hour recalls and tend to be underestimates of actual consumption. The extent of underestimation is well documented (especially for calories) using doubly labeled water methods. The LAFA estimates of per capita availability are well above NHANES estimates, suggesting that the underlying food loss assumptions in the data series and the ERS food loss estimates provided here are conservative. The LAFA estimates are also higher than the energy requirements of many cohorts of the population as determined by the Institute of Medicine (IOM, 2005). This also suggests that the ERS food loss estimates are conservative.

[5]This 2,547 calories per capita per day is calculated from 3,796 total calories minus 1,249 calories of food loss (see Table 6).

4. economic factors (e.g., cost and other resource constraints, such as to recover and redirect uneaten food to another use). These economic factors are often entwined with the technical, temporal, and spatial factors.

Therefore, it is unrealistic to think that the United States or any other country will ever entirely eliminate food waste. GAO's 1977 *Report to Congress* (p. 44) considers the question of whether losses are economically justifiable:

> "From a business standpoint, the value of food product saved for human use should be equal to, or greater than, the cost of saving it. To the extent that the costs exceed value, good business judgment dictates that the loss is an acceptable cost. In the course of preparing this report, no material has been found that would indicate that opportunities were knowingly overlooked by business owners to conserve food at an acceptable cost. The profit motive should dictate against such loss. The slowness of technology transfer, however, can serve to impede the implementation of loss-reducing techniques. It is, therefore, possible that opportunities to make loss physically and economically preventable are not being utilized. In sum, at this point, losses that have been identified are, for the most part, economically justifiable."

There really are two separate challenges in reducing food loss and its environmental and other impacts: (1) how to reduce the amount of uneaten food in the first place (*prevention*), and (2) what to do with uneaten food once it is generated (*disposal*). As the first challenge is met more fully, the second becomes less of an issue. The impact on food prices and markets of a reduction in food loss depends on if the loss was prevented in the first place or if what would be counted here as "food loss" is diverted to other economic uses. If uneaten food is simply diverted to other economic uses beyond human consumption (e.g., animal feed or energy generation) so that domestic demand for food and domestic food production remains roughly the same, then there won't be downward pressure on food prices and the agriculture and food industry's business will remain roughly unchanged.

However, if food loss is prevented or reduced to the extent that less food is needed to feed people (i.e., the demand for food decreases), then this would likely reduce food prices in the United States and the rest of the world. However the effects on food prices will depend on the relevant supply and demand elasticities (i.e., economic measures of the responsiveness of supply and demand to a change in its price). For example, if more food is exported to offset the effect on food markets from domestic reductions in food loss, then food prices may not decrease as much as without the boost in exports. If the domestic demand for food decreases, then the demand for inputs like land, labor, and capital may decline as well. If per capita food loss is significantly reduced by increased food consumption by people already consuming above their energy needs, then the costs associated with increased obesity may grow. It is important to note that the value of food loss estimated in this report is for one snapshot in time and would change as retail prices change in response to supply and demand factors.

All of the loss assumptions used in the LAFA data series are currently available on the ERS website, and some of this commodity-specific information may be helpful when analyzing food loss for a particular commodity at the retail or consumer level (ERS, 2012a). Additional types of economic costs could be included in a benefit-cost analysis of a specific loss-reducing initiative. These costs could include the costs of disposing of unused food, the cost and value of food going to a lower value use (e.g., animal feed), and the lost opportunity cost of resources wasted. Data are largely unavailable on exactly where, why, and how food losses and waste occur and the economic incentives to reduce these losses.

In some cases, the amount and value estimates in this report are likely too aggregated to provide helpful measures of the economic incentives for a specific food company to reduce food loss. A food company would need more tailored estimates to help inform its decision to reduce food loss, particularly if the decision involves multi-ingredient foods or commodities not covered in the LAFA data series (e.g., LAFA provides data on commodities and whole foods such as eggs, beef, and fresh spinach). For example, a food company may weigh the costs of switching to more expensive packaging for fresh meat against the benefits of having that packaging extend the shelf life of the meat. In short, companies will adopt a loss-reducing practice if it is *economically justifiable,* that is, if the benefits outweigh the costs. This cost-benefit analysis may include consideration of consumer goodwill toward a firm, such as when a sandwich shop donates uneaten yet wholesome food to a community feeding organization at the end of each day.

More specific food loss estimates could help policymakers in designing food-loss-reducing regulations. Publicizing where and how much food goes uneaten and the value of this loss may help inform policymakers about the issue and help increase the efficiency of the farm-to-fork food system and food recovery efforts to feed the growing human population. Other policy issues related to food loss include sustainability, the impact on international trade, and government funding of research and development for loss-reducing technologies (e.g., for food, food packaging, and food system practices).

Losses at the consumer level occur for many reasons, such as different tastes and preferences or consumers buying more than they need (see box, "Causes of Food Loss and Waste at the Farm, Farm-to-Retail, Retail, and Consumer Levels"). For many Americans, food purchases are a small component of all household spending, weakening incentives to reduce food loss on monetary grounds alone. The average American spent 11.2 percent of disposable income on food in 2010.[6] Consumer food loss is widespread, so mitigating it will be challenging. There are an estimated 119 million households (U.S. civilian population), over a half a million dining establishments (i.e., full-service restaurants, fast-food outlets), and numerous other places where people eat (e.g., schools, institutions, and prisons) across the United States.

This range of food loss combined with economies of scale suggest that large, industry-led initiatives or government-led policies, such as information campaigns and additional changes in Federal laws, may have the greatest potential to reduce food loss in the next decade. One example of a large initiative to reduce food waste is the Waste Resources Action Programme (WRAP). WRAP estimates that between 2007 and 2012, household food waste in the United Kingdom decreased 15 percent despite a 4-percent increase in the number of households (Goodwin, 2013). This is presumably due in part to its campaign to raise awareness of the issue by consumers, businesses, and local authorities (e.g., *Love Food Hate Waste* launched in 2007).[7] There have been other major campaigns launched to raise public awareness of food waste and to promote reduction, such as the Food Wise Hong Kong Campaign launched in December 2012. In the United States, there have been several laws (e.g., Bill Emerson Good Samaritan Food Donation Act, Internal Revenue Code 170(e)(3), and the U.S. Federal Food Donation Act of 2008) that have encouraged food donation by providing liability protection to donors or tax incentives, though the full impact on food loss or food waste has not been measured.[8]

---

[6]In 2010, the average American spent $4,016 on food (both for at-home and away-from-home consumption) (ERS, 2012b) out of an average disposable income of $36,016 in 2010 (BLS, 2012).

[7]For more information on WRAP, see Quested and Parry (2011) and www.wrap.org.uk

[8]See http://www.usda.gov/oce/foodwaste/resources/donations.htm for more information.

Currently, there is a growing list of participants in the U.S. Food Waste Challenge undertaking activities to reduce, recover, or recycle food waste, and these participants include six USDA agencies, major food companies, smaller private firms, universities and colleges, sports teams, and entertainment resorts, among others.[9] Even a modest, yet economically feasible, decrease in food loss from small loss-reducing initiatives or newly adopted processing, packaging, and storage technologies could lessen the environmental impacts of food waste generation and disposal. And if wholesome food is recovered for human consumption in this process, it could reduce food insecurity by supplementing existing food assistance efforts and could potentially provide tax savings to farms, food retailers, and foodservice establishments that donate food. However, no single intervention would be a panacea and, as previously mentioned, food loss will never be entirely eliminated. Substantial inroads in reducing food loss would likely require a combination of approaches. Prior to the adoption of new initiatives, policies, or laws to reduce food loss, both the costs and benefits should be considered. For example, while redirecting edible and wholesome food to food banks takes advantage of food already available for consumption, food safety and transportation challenges and costs need to be considered.

In the end, economic incentives and consumer behavior will be paramount in reducing food loss, and these efforts must coexist with obtaining an acceptable return on investment by food industry members; protecting the environment and worker safety; and fulfilling consumer demand for food safety, quality, variety, and affordability.

[9]See http://www.usda.gov/oce/foodwaste/participants.htm for details.

Data and Methods

ERS's Loss-Adjusted Food Availability (LAFA) data are derived from ERS per capita Food Availability data adjusted to remove the inedible portions (e.g., bones, pits, and peels) and to account for food spoilage, plate waste, and other losses (e.g., cooking loss). The primary purpose of the LAFA data is to more closely estimate actual per capita intake. In addition to providing the estimated amount of pounds per capita ingested per year and per day, the data series also provides estimates of the loss-adjusted number of calories consumed daily (per capita) and daily *food pattern equivalents* (previously called servings and *MyPyramid equivalents*). Here, we use the underlying food loss assumptions in the LAFA data series as of September 2012 to estimate food loss for 2010 at the retail and consumer levels, both per capita and in total for the United States. The series currently covers more than 200 agricultural commodities from 1970 to the most recent year of data. The data for individual commodities are aggregated into food groups to facilitate comparison with Federal dietary recommendations.[10]

The appendix discusses the construction of the LAFA data series, provides a list of commodities covered (see appendix box, "Commodity Coverage in the 2010 Loss-Adjusted Food Availability Data," p. 26), and discusses some of the limitations of the data. The appendix also provides detail on the steps that we followed for estimating the amount, value (i.e., using 2010 retail prices), and calories of food loss in the United States. This data series is considered to be *preliminary* because ERS continues to improve the underlying food loss assumptions and documentation (for details, see http://www.ers.usda.gov/data-products/food-availability-(per-capita)-data-system/loss-adjusted-food-availability-documentation.aspx). The LAFA data can be accessed on the ERS website through Excel spreadsheets that provide all of the current loss assumptions and a largely consistent structure for the data series (i.e., the sequence of steps by which the different types of losses are removed from the system) (ERS, 2012a).

[10]Currently, the series is calibrated for comparison against the 2005 *Dietary Guidelines for Americans*, but ERS has plans to update the LAFA data with the 2010 *Dietary Guidelines for Americans.*

Results

The results from our analysis of ERS' Loss-Adjusted Food Availability data pertain to the amount, value, and calories of food loss at the retail and consumer levels in the United States in 2010. Each subsection includes two tables (one for total and one for per capita estimates) and a figure that divides the total food loss estimate into shares by food group.

Amount

ERS estimates that 31 percent or 133 billion pounds of the 430 billion pounds of the edible and available food supply at the retail and consumer levels in the United States in 2010 went uneaten (table 1). Retail-level losses represented 10 percent (43 billion pounds) and consumer-level losses 21 percent (90 billion pounds) of the available food supply. Losses on the farm and between the farm and retailer were not estimated due to data limitations for some of the food groups. Had these losses been included, total postharvest loss in the United States would be over 31 percent of the food supply. For example, for fresh produce alone, an estimated 12 percent goes uneaten in developed countries from production to retail sites, with a range from 2 to 23 percent for individual commodities (Kader, 2005).

Our estimates are based on the current loss assumptions in the LAFA data series, which include retail-level loss estimates from Buzby et al. (2009). That study—comparing supplier shipment data with point-of-sale data from six large supermarket retailers—found that annual supermarket losses for 2005 and 2006 averaged 11.4 percent for fresh fruit, 9.7 percent for fresh vegetables, and 4.5 percent for fresh meat, poultry, and seafood. ERS is currently in the process of obtaining 2011 and 2012 retail-level food loss estimates for these commodities.[11] The loss assumptions for all other foods in the data series at the retail level have not been updated (i.e., added fats and oils, added sugars and sweeteners, grains, dairy products, and processed fruit and vegetables (frozen, canned, dried, and juice).[12]

New (2010) estimates of consumer-level loss for most commodities (Muth et al., 2011) were incorporated into the LAFA data series in August 2012 (see ERS (2012a) for details).[13] This is the primary reason why the shares of loss by food group differ from other recent ERS publications, particularly the drop in share for the meat, poultry, and fish group (Buzby and Hyman, 2012; Buzby et al., 2011).

When the 133 billion pounds of food loss at the retail and consumer levels in 2010 is broken down by food group, the top three food groups in terms of loss are: (1) dairy products (25 billion pounds or 19 percent); (2) vegetables (25 billion pounds or 19 percent); and (3) grain products (18.5 billion pounds or 14 percent) (fig. 1).

---

[11]Some data users have suggested that the total retail-level loss estimates of 10 percent and 43 billion pounds are high given modern packaging, cold-chain, and inventory tracking technologies and other business practices that are commonly used by retailers.

[12]The LAFA data series is based on individual commodities/foods, not processed products. The added fats and oils group includes foods that are typically added to other foods when eaten and do not include the naturally occurring fats in meat and dairy products, for example. Similarly, added sugars and syrups are caloric foods added to foods during processing or preparation. Added sugars and sweeteners do not include naturally occurring sugars, such as those found in milk and fruit. Non-caloric sweeteners are not included in the LAFA data series.

[13]RTI International used a numerical estimation method to calculate consumer-level food loss estimates using Nielsen Homescan data and National Health and Nutrition Examination Survey (NHANES) data. ERS then analyzed how the LAFA per capita data would change if the proposed RTI estimates of consumer-level food loss were incorporated into the data series (Muth et al., 2011).

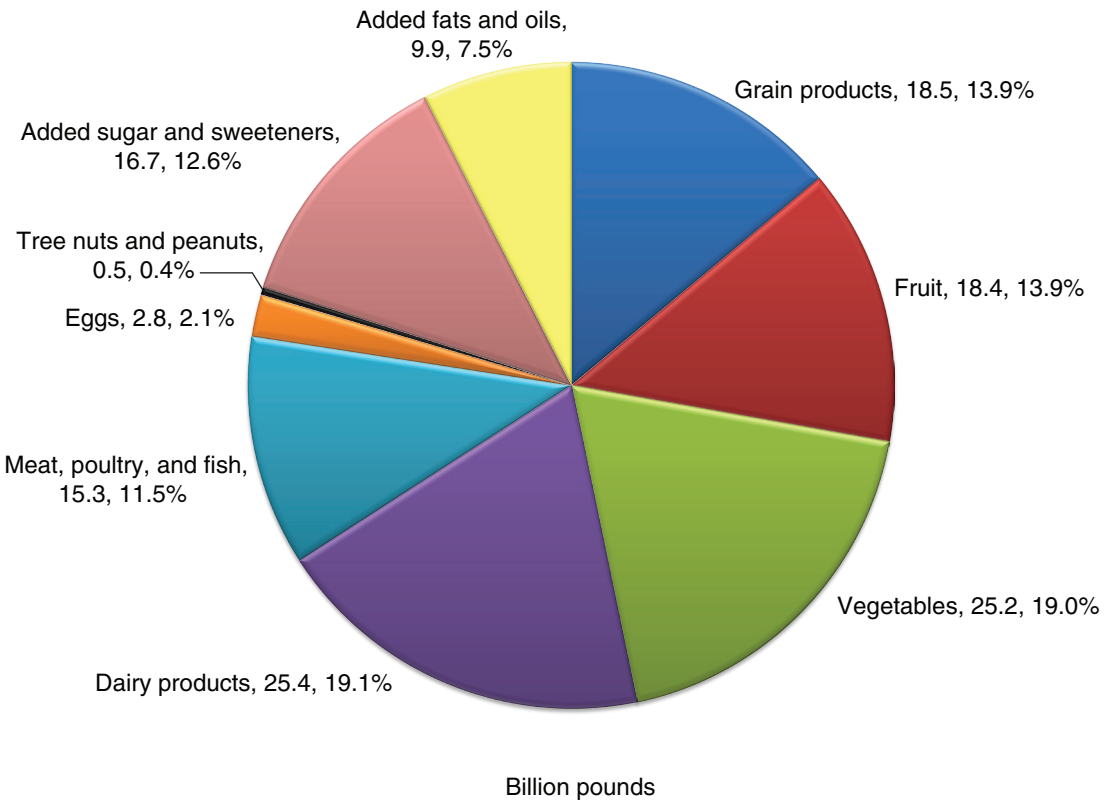
Table 1
Estimated total food loss in the United States, 2010

Commodity	Food Supply[a]	Losses from food supply[b]					
		Retail level		Consumer level		Total retail and consumer level	
	Billion pounds	Billion pounds	Percent	Billion pounds	Percent	Billion pounds	Percent
Grain products	60.4	7.2	12	11.3	19	18.5	31
Fruit	64.3	6.0	9	12.5	19	18.4	29
Fresh	37.6	4.4	12	9.5	25	13.9	37
Processed	26.7	1.6	6	2.9	11	4.5	17
Vegetables	83.9	7.0	8	18.2	22	25.2	30
Fresh	53.5	5.2	10	12.8	24	18.0	34
Processed	30.4	1.8	6	5.3	18	7.1	24
Dairy products	83.0	9.3	11	16.2	20	25.4	31
Fluid milk	53.8	6.5	12	10.5	20	17.0	32
Other dairy products	29.1	2.8	10	5.7	19	8.5	29
Meat, poultry, and fish	58.4	2.7	5	12.7	22	15.3	26
Meat	31.6	1.4	4	7.2	23	8.6	27
Poultry	22.0	0.9	4	3.9	18	4.8	22
Fish and seafood	4.8	0.4	8	1.5	31	1.9	39
Eggs	9.8	0.7	7	2.1	21	2.8	28
Tree nuts and peanuts	3.5	0.2	6	0.3	9	0.5	15
Added sugar and sweeteners	40.8	4.5	11	12.3	30	16.7	41
Added fats and oils	26.0	5.4	21	4.5	17	9.9	38
Total	430.0	43.0	10	89.9	21	132.9	31

[a]Food supply at the retail level, which is the foundation for the retail- and consumer-level loss stages in the loss-adjusted data series.
[b]Totals may not add due to rounding.
Per capita losses at the retail and consumer levels for each commodity (not shown) were estimated by multiplying the quantity of that commodity available for consumption by the appropriate loss assumption. Individual loss estimates were then multiplied by the U.S. population and summed up into their respective food groups and retail or consumer levels.

Source: ERS (2012a) and the U.S. population on July 1, 2010 (309.75 million).

Figure 1
Estimated total amount of food loss in the United States by food group, 2010



Source: ERS (2012a).

In 2010, the average amount of food loss per American was 429 pounds, of which 139 pounds at the retail level and 290 pounds at the consumer level went uneaten (table 2). At the consumer level, 59 pounds of vegetables, 52 pounds of dairy products, and 41 pounds of meat, poultry, and fish per capita from the food supply in 2010 went uneaten.

Value

The total value of food loss at the retail and consumer levels was an estimated $161.6 billion in 2010 (table 3). The two food groups with the highest value of losses were meat, poultry, and fish ($48.5 billion) and vegetables ($30 billion). These estimates are based on the value of foods as purchased at retail prices. The calculations are described more fully in the appendix.

When the total value of food loss at the consumer level in 2010 is broken down by food group, the meat, poultry, and fish group comprises almost a third (30 percent) of the total (fig. 2), a much greater share than by weight (12 percent in figure 1) because foods in this group tend to cost more per pound than many other foods.

Table 2
Estimated per capita amount of food loss in the United States, 2010

Commodity	Food Supply[a]	Losses from food supply[b]					
		Retail level		Consumer level		Total retail and consumer level	
	Pounds	*Pounds*	*Percent*	*Pounds*	*Percent*	*Pounds*	*Percent*
Grain products	195	23	12	36	19	60	31
Fruit	208	19	9	40	19	59	29
Fresh	121	14	12	31	25	45	37
Processed	86	5	6	9	11	15	17
Vegetables	271	23	8	59	22	81	30
Fresh	173	17	10	41	24	58	34
Processed	98	6	6	17	18	23	24
Dairy products	268	30	11	52	20	82	31
Fluid milk	174	21	12	34	20	55	32
Other dairy products	94	9	12	18	19	27	29
Meat, poultry, and fish	189	9	5	41	22	49	26
Meat	102	5	4	23	23	28	27
Poultry	71	3	4	13	18	15	22
Fish and seafood	16	1	8	5	31	6	39
Eggs	32	2	7	7	21	9	28
Tree nuts and peanuts	11	1	6	1	9	2	15
Added sugar and sweeteners	132	14	11	40	30	54	41
Added fats and oils	84	18	21	15	17	32	38
Total	1,388	139	10	290	21	429	31

[a]Food supply at the retail level, which is the foundation for the retail- and consumer-level loss stages in the loss-adjusted data series.
[b]Totals may not add due to rounding.
Per capita losses at the retail and consumer levels for each commodity (not shown) were estimated by multiplying the quantity of that commodity available for consumption by the appropriate loss assumption. Individual loss estimates were then multiplied by the U.S. population and summed up into their respective food groups and retail or consumer levels.

Source: ERS (2012a) and the U.S. population on July 1, 2010 (309.75 million).

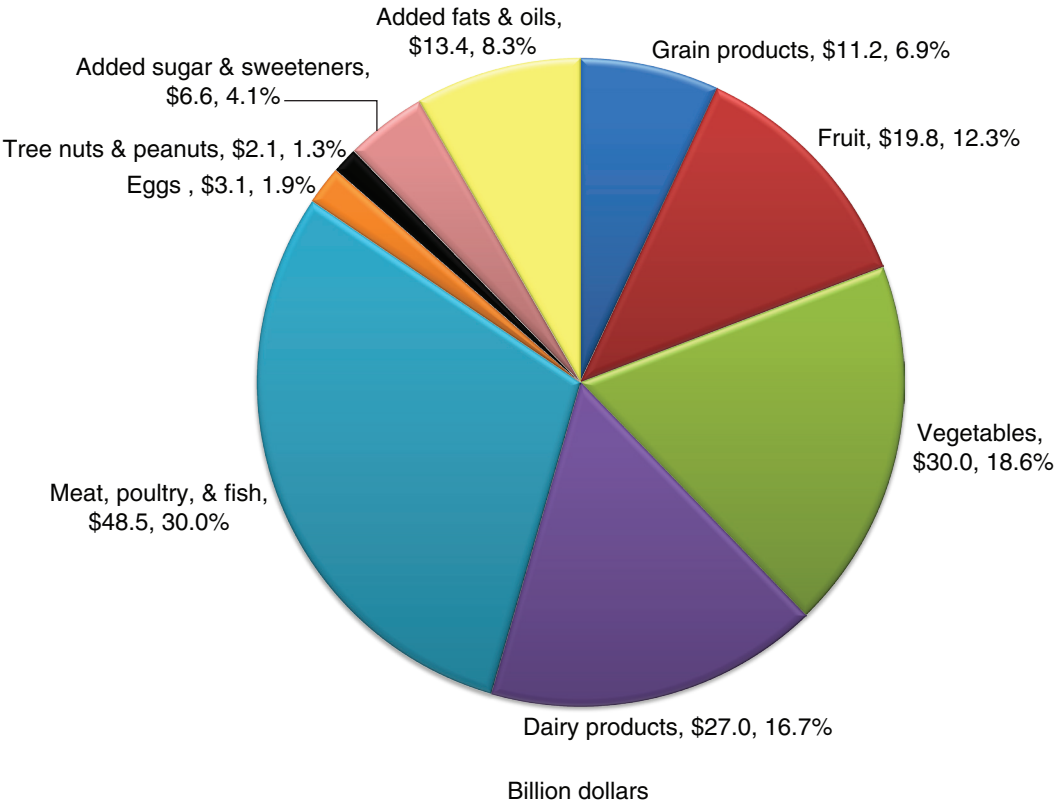
Table 3
Estimated total value of food loss at the retail and consumer levels in the United States, 2010

Commodity	Food Supply[a]	Losses from food supply[b]					
		Retail level		Consumer level		Total retail and consumer level	
	Billion dollars	*Billion dollars*	*Percent*	*Billion dollars*	*Percent*	*Billion dollars*	*Percent*
Grain products	36.1	4.3	12	6.9	19	11.2	31
Fruit	62.2	5.8	9	14.1	23	19.8	32
Fresh	37.1	4.2	11	10.4	28	14.7	40
Processed	25.0	1.5	6	3.7	15	5.2	21
Vegetables	0.1	9.6	9	$20.4	19	30.0	28
Fresh	62.1	6.9	11	$13.2	21	20.1	32
Processed	46.6	2.8	6	$7.2	15	10.0	21
Dairy products	91.5	8.3	9	18.6	20	27.0	29
Fluid milk	20.0	2.4	12	4.0	20	6.4	32
Other dairy products	71.5	5.9	8	14.6	20	20.5	29
Meat, poultry, and fish	181.9	8.8	5	39.7	22	48.5	27
Meat	83.4	3.8	5	19.3	23	23.2	28
Poultry	73.6	2.9	4	12.5	17	15.4	21
Fish and seafood	24.8	2.1	8	7.9	32	9.9	40
Eggs	10.9	0.8	7	2.3	21	3.1	28
Tree nuts and peanuts	12.1	0.7	6	1.3	11	2.1	17
Added sugar and sweeteners	16.4	1.8	11	4.8	29	6.6	40
Added fats and oils	34.2	6.6	19	6.8	20	13.4	39
Total	554.0	46.7	8	114.9	21	161.6	29

[a]Food supply at the retail level, which is the foundation for the retail- and consumer-level loss stages in the loss-adjusted data series.
[b]Totals may not add due to rounding.
Per capita losses at the retail and consumer levels for each commodity (not shown) were estimated by multiplying the quantity of that commodity available for consumption by the appropriate loss assumption. Individual loss estimates were then multiplied by the U.S. population and summed up into their respective food groups and retail or consumer levels.

Source: ERS (2012a) and the U.S. population on July 1, 2010 (309.75 million).

Figure 2
Estimated total value of food loss in the United States by food group, 2010



Source: ERS (2012a).

Per capita, food loss in 2010 totaled $522 per year at retail prices: $151 per year at the retail level and $371 at the consumer level (table 4). The latter amounts to 9.2 percent of the average dollar value spent on food per consumer in 2010 ($4,016) (ERS, 2012b) and 1 percent of the average disposable income ($36,016) (BLS, 2012). The yearly total of 290 pounds (table 2) of food loss per capita in 2010 at the consumer level, at an estimated retail price of $371, translates into 0.8 pound or roughly $1 per day. This is slightly lower than the $390 of food loss per capita in 2008 estimated in Buzby and Hyman (2012), largely because new consumer-level food loss estimates were adopted in the LAFA system in August 2012. At the consumer level, three food groups made up 68 percent of the total food loss: meat, poultry, and fish ($128/year per capita); vegetables ($66/year); and dairy products ($60/year).

For comparison, another recently published study that used the same LAFA data but different assumptions and retail prices estimated that the economic and climate change impacts of food loss for 134 commodities in the United States cost $198 billion in 2009 (Venkat, 2012). This translates into $400 per person.

Table 4
Estimated per capita value of food loss at the retail and consumer levels in the United States, 2010

Commodity	Food Supply[a]	Losses from food supply[b]					
		Retail level		Consumer level		Total retail and consumer level	
	Dollars	*Dollars*	*Percent*	*Dollars*	*Percent*	*Dollars*	*Percent*
Grain products	117	14	12	22	19	36	31
Fruit	201	19	9	45	23	64	32
Fresh	120	14	11	34	28	47	40
Processed	81	5	6	12	15	17	21
Vegetables	351	31	9	66	19	97	28
Fresh	201	22	11	43	21	65	32
Processed	150	9	6	23	15	32	21
Dairy products	295	27	9	60	20	87	29
Fluid milk	65	8	12	13	20	21	32
Other dairy products	231	19	8	47	20	66	29
Meat, poultry, and fish	587	28	5	128	22	157	27
Meat	269	12	5	62	23	75	28
Poultry	238	9	4	40	17	50	21
Fish and seafood	80	7	8	25	32	32	40
Eggs	35	2	7	8	21	10	28
Tree nuts and peanuts	39	2	6	4	11	7	17
Added sugar and sweeteners	53	6	11	15	29	21	40
Added fats and oils	111	21	19	22	20	43	39
Total	1,788	151	8	371	21	522	29

[a]Food supply at the retail level, which is the foundation for the retail- and consumer-level loss stages in the loss-adjusted data series.
[b]Totals may not add due to rounding.
Per capita losses at the retail and consumer levels for each commodity (not shown) were estimated by multiplying the quantity of that commodity available for consumption by the appropriate loss assumption. Individual loss estimates were then multiplied by the U.S. population and summed up into their respective food groups and retail or consumer levels.

Source: ERS (2012a) and the U.S. population on July 1, 2010 (309.75 million).

Calories

This report provides ERS's first estimates of the number of calories of food loss at the retail and consumer levels in the United States to help put the magnitude of this food loss into perspective. In total, out of the entire U.S. food supply in 2010, an estimated 387 billion calories of food were available each day but were not consumed for any reason (table 5). This amount of food loss translates into 141 trillion calories per year. Of course, many factors would affect whether these foods could be diverted to feed people in real life, such as food safety considerations and storage and transportation costs. Additionally, this food loss estimate is based on calories alone and does not address the more complex nutritional needs of individual people, such as for specific vitamins and minerals.

Interestingly, the food group shares of total calories that went uneaten (fig. 3) are noticeably different than the shares for the amount (fig. 1) or value (fig. 2) of food loss. In particular, the shares for added fats and oils, added sugars and sweeteners, and grains are much higher for the calories figure, reflecting these foods' caloric density per pound.

Daily food loss for the average American totaled 1,249 calories (out of 3,796 calories available per capita per day), of which 460 calories occurred at the retail level and 789 calories occurred at the consumer level (table 6). At the consumer level, the average daily food loss per American included 187 calories of added sugar and sweeteners, 166 calories of grain products, and 154 calories of added fats and oils. In comparison, Kevin Hall and others at the National Institutes of Health used data from the Food and Agriculture Organization's (FAO) food balance sheets and a mathematical model of human energy expenditure to calculate the energy content of food waste in the United States. Hall et al. (2009) estimated that food waste, on average, is equivalent to 1,400 calories per person per day or 150 trillion total calories per year versus ERS's estimate of 1,249 calories per person per day and 141 trillion total calories per year.

Table 5
Estimated total calories of food loss at the retail and consumer levels in the United States, 2010

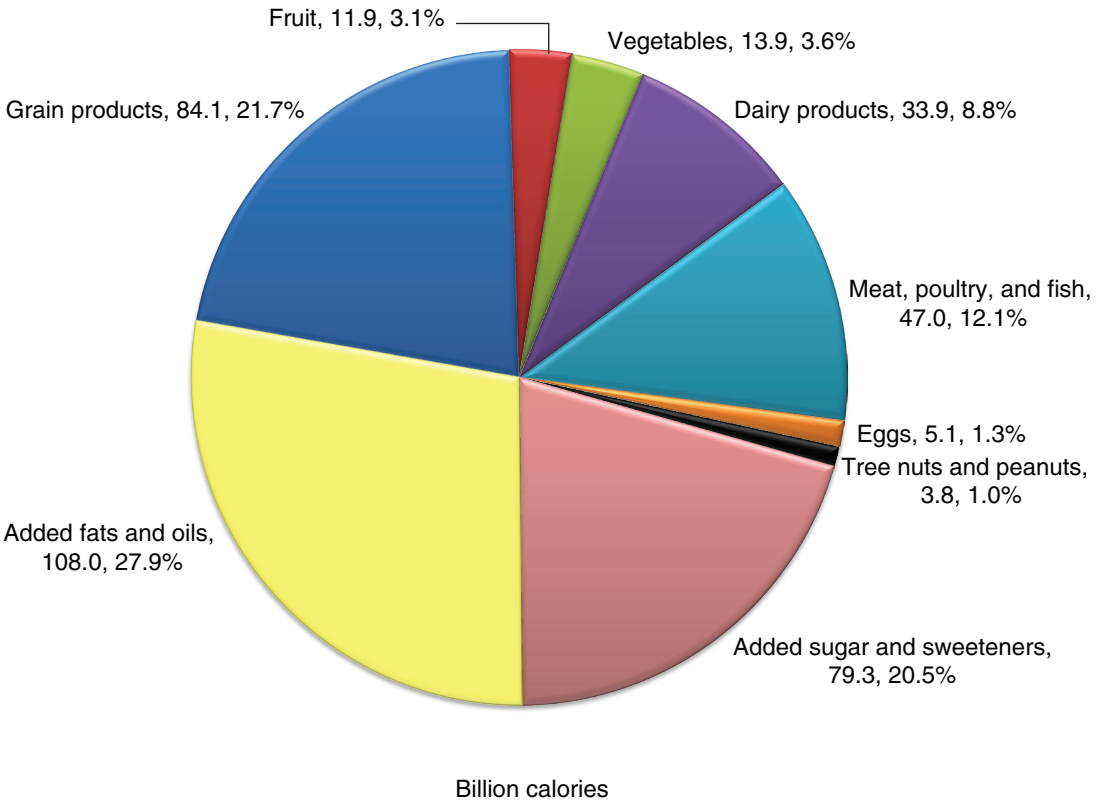
Commodity	Food Supply[a]	Losses from food supply[b]					
		Retail level		Consumer level		Total retail and consumer level	
	Billion calories	*Billion calories*	*Percent*	*Billion calories*	*Percent*	*Billion calories*	*Percent*
Grain products	273.0	32.8	12	51.3	19	84.1	31
Fruit	37.1	3.1	8	8.8	24	11.9	32
Fresh	19.4	2.1	11	6.5	33	8.5	44
Processed	17.7	1.1	6	2.3	13	3.4	19
Vegetables	52.6	3.8	7	10.1	19	13.9	26
Fresh	22.4	2.0	9	6.7	30	8.7	39
Processed	30.2	1.8	6	3.4	11	5.2	17
Dairy products	183.1	8.1	9	23.4	21	33.9	30
Fluid milk	113.7	5.1	12	6.8	20	10.8	32
Other dairy products	62.2	2.4	8	16.6	21	23.0	29
Meat, poultry, and fish	7.2	0.6	4	38.9	21	47.0	26
Meat	113,688	5,069	4	25.7	23	30.8	27
Poultry	62,164	2,417	4	10.9	18	13.3	21
Fish and seafood	7,208	583	8	2.2	31	2.8	39
Eggs	15.5	1.1	7	4.0	26	5.1	33
Tree nuts and peanuts	25.8	1.5	6	2.3	9	3.8	15
Added sugar and sweeteners	193.0	21.2	11	58.0	30	79.3	41
Added fats and oils	282.1	60.2	21	47.8	17	108.0	38
Total	1,175.8	142.3	12	244.5	21	386.9	33

[a]Food supply at the retail level, which is the foundation for the retail- and consumer-level loss stages in the loss-adjusted data series.
[b]Totals may not add due to rounding.
Per capita losses at the retail and consumer levels for each commodity (not shown) were estimated by multiplying the quantity of that commodity available for consumption by the appropriate loss assumption. Individual loss estimates were then multiplied by the U.S. population and summed up into their respective food groups and retail or consumer levels.

Source: ERS (2012a) and the U.S. population on July 1, 2010 (309.75 million).

Figure 3

Estimated total number of calories of food loss in the United States per day by food group, 2010



Source: ERS (2012a).

Table 6

Estimated daily per capita calories of food loss at the retail and consumer levels in the United States, 2010

Commodity	Food Supply[a]	Losses from food supply[b]					
		Retail level		Consumer level		Total retail and consumer level	
	Calories	*Calories*	*Percent*	*Calories*	*Percent*	*Calories*	*Percent*
Grain products	881	106	12	166	19	271	31
Fruit	120	10	8	28	24	38	32
Fresh	63	7	11	21	33	28	44
Processed	57	3	6	7	13	11	19
Vegetables	170	12	7	33	19	45	26
Fresh	72	6	9	22	30	28	39
Processed	97	6	6	11	11	17	17
Dairy products	367	34	9	75	21	109	30
Fluid milk	109	13	12	22	20	35	32
Other dairy products	258	21	8	53	21	74	29
Meat, poultry, and fish	591	26	4	126	21	152	26
Meat	367	16	4	83	23	99	27
Poultry	201	8	4	35	18	43	21
Fish and seafood	23	2	8	7	31	9	39
Eggs	50	3	7	13	26	16	33
Tree nuts and peanuts	83	5	6	7	9	12	15
Added sugar and sweeteners	623	69	11	187	30	256	41
Added fats and oils	911	194	21	154	17	349	38
Total	3,796	460	12	789	21	1,249	33

[a]Food supply at the retail level, which is the foundation for the retail- and consumer-level loss stages in the loss-adjusted data series.

[b]Totals may not add due to rounding.

Per capita losses at the retail and consumer levels for each commodity (not shown) were estimated by multiplying the quantity of that commodity available for consumption by the appropriate loss assumption. Individual loss estimates were then multiplied by the U.S. population and summed up into their respective food groups and retail or consumer levels.

Source: ERS (2012a) and the U.S. population on July 1, 2010 (309.75 million).

Discussion

In 2010, an estimated 133 billion pounds of food at the retail and consumer levels in the United States went uneaten, and this amount is valued at $161.6 billion using retail prices. This amount of food loss translates into 141 trillion calories in 2010. These estimates suggest that annual food loss in the United States is substantial.

As with any research with quantitative values, the resulting estimates produced here may be low or high. ERS food loss estimates could be low for various reasons. Many foods are not included in the system (e.g., soybeans, soy milk, and coconut milk) and so losses for these foods are not counted. Additionally, the LAFA data series suggests that the average American consumed 2,547 calories per day in 2010, which is high even considering the prevalence of obesity in the United States, implying that the estimated food loss is low or that there are other issues. The LAFA estimates are also higher than the energy requirements of most age cohorts as determined by the Institute of Medicine ((IOM), 2005), further suggesting that the ERS food loss estimates are conservative. Hall et al. (2009) suggest that the loss estimates from the LAFA estimate are low and/or that the assumptions of a roughly constant proportion of food waste are becoming progressively worse over time (p. 3).[14] Hall et al. (2009), however, do not offer suggestions on how to obtain better estimates of food loss, and the study predates the incorporation of new consumer-level loss estimates from Muth et al. (2011) into the LAFA data series in August 2012. Also, the estimated $161.6 billion of food loss was calculated using retail prices. Had we used foodservice prices (which are typically higher), then the estimated value of food loss would have been higher.

There are several reasons why the ERS food loss estimates could be high. Some of the individual loss estimates may be high, particularly at the retail level. The ERS food loss estimates assume that food loss has no residual value or economic use. But in reality, there may be a residual use if the food loss is diverted to another economic use, such as for animal feed or to create energy.[15] That is, by redirecting food for use as energy inputs, for example, less food or other inputs would need to be purchased from other sources for these purposes. In essence, if data had been available on the amount of food diverted to lower value uses and on the economic value of these uses, then the ERS estimate of the total amount of food loss could have been adjusted downwards. However, data limitations preclude these refinements. The U.S. Environmental Protection Agency (EPA) has developed a food waste hierarchy of preferred uses for available food that goes unconsumed by people (see box, "EPA's Food Recovery Hierarchy"). It is possible that some of the factors that might cause the estimates to be high or low could cancel each other out.

There is a practical limit to how much food loss the United States can prevent or reduce given technical and spatial factors; consumers' tastes, preferences, and food habits; and economic factors. Therefore, the amount of food loss that could be prevented or reduced will be less than the ERS food loss estimates. Nevertheless, these updated estimates are a unique contribution to the literature and are useful in providing perspective to the issue of food loss in the United States.

---

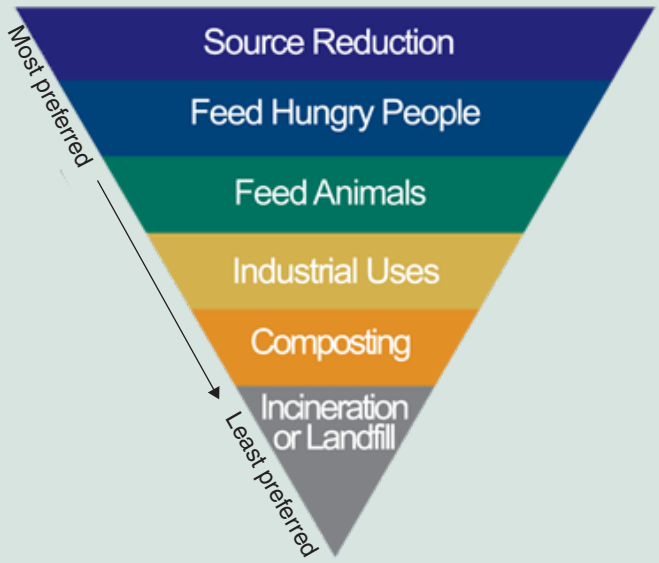
[14]Hall et al. (2009) write that "food waste has progressively increased from about 30 percent of the available food supply in 1974 to almost 40 percent in recent years" using the Food and Agriculture Organization's balance sheets. By contrast, what they call the 'USDA' food waste estimate (calculated by subtracting the USDA food availability data adjusted for spoilage and wastage from the FAO food supply data) is an approximately constant proportion of the total food supply. They conclude that "while the USDA estimate of food waste was within 5 percent of our calculation in 1974, it was ~25 percent too low in 2003."

[15]As an aside, these uses of the food waste may harm the environment less than landfilling or incinerating the food waste. Here, the creation of energy using food waste does not include corn used for ethanol, which was already removed as a direct industrial use of corn in the supply and disappearance (i.e., use) balance sheets.

EPA's Food Recovery Hierarchy

The U.S. Environmental Protection Agency (EPA) endorses its food recovery hierarchy, where the ideal situation would be to reduce the production of food waste at the source. When food waste is generated, the first preference is to recover wholesome food from all points in the food production, marketing, and consumption chain to feed people who are food insecure. Providing food for livestock, zoo animals, and pets would be the second best option, followed by recycling food and food waste for industrial purposes. These three options would help conserve resources and reduce food waste disposal costs. For example, the feasibility of anaerobic digesters that use feedstock, food and agricultural waste, and wastewater plant biosolids to produce biogas fuel and other valuable outputs (e.g., compost material) is being explored in developed countries.

Food recovery hierarchy



Source: http://www.epa.gov/osw/conserve/materials/organics/food/fd-gener.htm#food-hier

Composting food to improve soil fertility is a relatively low-priority option, and its use is not widespread in the United States. However, some cities, counties, and State agencies are investigating the benefits of curbside collection of residential food waste (e.g., in bins or compostable kitchen bags) to compost with collected yard trimmings. According to the EPA (2009), there were around 3,510 community composting programs in operation in the United States in 2008, so expanding these to incorporate food waste might be a viable option. The last resort should be using landfills and incinerators to dispose of food waste because of the negative impacts on the environment. These impacts are partly offset if energy is created during incineration and landfilling (e.g., tapping the methane gas).

Appendix—The ERS Loss-Adjusted Food Availability Data and Calculation Details for the Amount and Value of Food Loss

Since 2005, the updated Food Availability (Per Capita) Data system has had three separate but related data series that each look differently at the food available for consumption in the United States. The first series, the Food Availability data, is the foundation for the other two series: (1) the Nutrient Availability data[16] and (2) the Loss-Adjusted Food Availability (LAFA) data (formerly called the Food Guide Pyramid Servings data). This loss-adjusted series is the foundation of this report and is essentially the Food Availability data adjusted for food spoilage and other losses to more closely approximate actual per capita intake (http://www.ers.usda.gov/data-products/food-availability-(per-capita)-data-system/loss-adjusted-food-availability-documentation.aspx). The primary purpose of the LAFA data is to estimate daily per capita food intake and present this information in two forms: the number of calories consumed daily and the number of food pattern equivalents consumed daily.[17] Here, we use the embedded food loss assumptions to estimate food loss at the retail and consumer levels for 2010 using the LAFA data as of September 2012.

Construction of the Core Food Availability Data

In essence, the Food Availability data measure the use of basic commodities—such as wheat, beef, and shell eggs—produced at the farm level or an early stage of processing and available for human consumption. They do not measure food use of highly processed foods–such as bakery products, frozen dinners, and soups–in their finished form. Ingredients of highly processed foods, however, are included as components of less processed foods such as sugar, flour, fresh vegetables, and meat.

The Food Availability data series is based on records of annual commodity flows from production to end uses. This involves the development of supply and disappearance (i.e., "supply and use") balance sheets for each major commodity from which human foods are produced. In general, the total annual available supply of each commodity consists of the sum of production, imports, and beginning stocks. These three components are either directly measured or estimated by government agencies using sampling and statistical methods. From this total supply, exports, ending stocks, and total measurable nonfood uses are subtracted. For most commodity categories, measurable nonfood uses are farm inputs (feed and seed) and industrial uses. In a few cases, supplies for human food use are measured directly and one of the other use components becomes the residual. This is the case for wheat, in which flour production is measurable and available from manufacturers' reports on flour milling and, therefore, use for livestock feed becomes the residual.

Per capita food availability is calculated by dividing the annual total food supply for a specific year by the U.S. total resident population plus Armed Forces overseas for that same year. Yearly population estimates are from the U.S. Census Bureau. For commodities not shipped overseas in substantial amounts, such as fluid milk and cream, ERS uses the resident population as the base. No adjustments are made for changes in the demographic makeup of the population.

---

[16]This nutrient series is compiled by USDA's Center for Nutrition Policy and Promotion (CNPP) in what it calls the *Nutrient Content of the U.S. Food Supply* and is outside the scope of this report.

[17]These food pattern equivalents were formerly called the Food Guide Pyramid serving equivalents and are defined by the 2005 *Dietary Guidelines for Americans* and its supporting *MyPyramid Plan* Food Guidance System.

Construction of the Loss-Adjusted Food Availability Data

The current ERS per capita Food Availability data were converted into daily per capita food pattern equivalents comparable to those identified in Federal dietary recommendations using a multistage process. Each commodity was assigned to one of five major food groups (fruit, vegetables, meat, dairy, and grains) or to one of two additional groups for discretionary added fats and oils and added sugar/sweeteners. The core Food Availability data were adjusted for spoilage and other losses by subtracting estimated losses from the "primary" weight reported in the data series to create the Loss-Adjusted Food Availability data series. Depending on the commodity, loss was estimated at up to three different stages in the marketing system (i.e., farm-to-retail, retail, and consumer). ERS calculates summary estimates of food loss for each commodity in the Loss-Adjusted Food Availability data series at the retail and consumer levels. Although the data system also takes into account food losses between the farm and retailer, ERS cannot calculate summary estimates of food loss between the farm and retailer because of data limitations for some of the food groups. Onfarm or pre-harvest losses, such as from hail damage on a field crop, are not included in the system. Inedible portions of all foods—seeds, pits, and inedible peels—were also subtracted from the data, and thus the loss-adjusted food availability estimates and the food loss estimates do not include inedible parts. For example, estimates for meat, poultry, and fish are provided as boneless weight. The data were converted from pounds per capita per year to grams (or ounces) per capita per day to be comparable with Federal dietary recommendations.

Estimation Details for this Report

Given the recent and growing interest in food loss and waste domestically (e.g., U.S. Food Waste Challenge), up-to-date estimates on the magnitude of food loss in the United States are timely. This report updates the ERS loss estimates to 2010 and extends previous ERS estimates and publications on food loss in several important ways, such as incorporating new consumer-level loss assumptions and providing calorie estimates for the first time.

We used prices consumers would have paid, on average, for foods if bought at retail. In total, we compiled estimates of the amount and value of food loss for more than 200 individual foods in the Loss-Adjusted Food Availability (LAFA) data and then aggregated these values to estimate the total value of food loss at both the retail and consumer levels in the United States in 2010 and the value by food group. The analytical method for calculating the amount, value, and calories of food loss for each commodity in the LAFA data consisted of five key steps.

First, we identified the individual commodities in the LAFA data for our analysis by each food group. In particular, we identified 62 fresh and processed fruit, 67 fresh and processed vegetables, and 86 other individual foods in the LAFA data for our analysis (see Appendix Box). The LAFA data can be accessed online through Excel spreadsheets that provide all of the current loss assumptions and the structure of the calculations for each food in the data series. More information on the LAFA data is summarized on the ERS website (ERS, 2011).

Second, we estimated national average retail prices in 2010 using Nielsen Homescan data for each individual commodity in the LAFA data series consumed at home in 2010. This method for determining average prices was used in previous research (e.g., Reed et al. (2004), Stewart et al. (2011), Buzby et al. (2011), and Buzby and Hyman (2012)). Members of the Homescan consumer panel in 60,648 households reported the foods they purchased, the quantities they bought, and the prices they

Commodity Coverage in the 2010 Loss-Adjusted Food Availability Data

The "Dairy" spreadsheet has **34** commodities—Plain whole milk, Plain 2-percent milk, Plain 1-percent milk, Skim milk, Whole flavored milk, Low-fat flavored milk, Buttermilk, Refrigerated yogurt, Cheddar cheese, Other American cheese, Provolone cheese, Romano cheese, Parmesan cheese, Mozzarella cheese, Ricotta cheese, Other Italian cheese, Swiss cheese, Brick cheese, Muenster cheese, Blue cheese, Other miscellaneous cheese, Regular cottage cheese, Low-fat cottage cheese, Regular ice cream, Low-fat ice cream (ice milk), Frozen yogurt and other miscellaneous frozen products, Evaporated and condensed canned whole milk, Evaporated and condensed bulk whole milk, Evaporated and condensed bulk and canned skim milk, Dry whole milk, Nonfat dry milk, Dry buttermilk, Dairy share of half-and-half, and Dairy share of eggnog.

The "Fats" spreadsheet has **15** commodities—Added fats and oils, Butter, Margarine, Lard, Edible beef tallow, Shortening, Salad and cooking oils, Other edible fats and oils, Dairy fats, Fat share of half and half, Light cream, Heavy cream, Sour cream, Cream cheese, and Fat share of eggnog.

The "Fruit" spreadsheet has **62** commodities—Fresh oranges, Fresh tangerines, Fresh grapefruit, Fresh lemons, Fresh limes, Fresh apples, Fresh apricots, Fresh avocados, Fresh bananas, Fresh blueberries, Fresh cantaloupe, Fresh cherries, Fresh cranberries, Fresh grapes, Fresh honeydew, Fresh kiwifruit, Fresh mangoes, Fresh papaya, Fresh peaches, Fresh pears, Fresh pineapple, Fresh plums, Fresh strawberries, Fresh watermelon, Canned apples and applesauce, Canned apricots, Canned sweet cherries, Canned tart cherries, Canned peaches, Canned pears, Canned pineapple, Canned plums, Canned olives, Frozen blackberries, Frozen blueberries, Frozen raspberries, Frozen strawberries, Other frozen berries, Frozen apples, Frozen apricots, Frozen sweet cherries, Frozen tart cherries, Frozen peaches, Frozen plums and prunes, Other frozen fruit, Dried apples, Dried apricots, Dried dates, Dried figs, Dried peaches, Dried pears, Dried plums, Raisins, Grapefruit juice, Lemon juice, Lime juice, Orange juice, Apple juice, Cranberry juice, Grape juice, Pineapple juice, and Prune juice.

The "Grain" spreadsheet has **9** commodities—White and whole wheat flour, Durum flour, Rice, Rye flour, Corn flour and meal, Corn hominy and grits, Corn starch, Barley products, and Oat products.

The "Meat" spreadsheet has **24** commodities—Beef, Veal, Pork, Lamb, Chicken, Turkey, Fresh and frozen fish, Fresh and frozen shellfish, Canned salmon, Canned sardines, Canned tuna, Canned shellfish, Other canned fish, Cured fish, Eggs, Peanuts, Almonds, Hazelnuts (filberts), Pecans, Walnuts, Macadamia nuts, Pistachio nuts, Other tree nuts, and Coconut.

The "Sugar" spreadsheet has **6** commodities—Cane and beet sugar, High fructose corn sweetener, Glucose, Dextrose, Honey, and Edible syrups.

The "Vegetable" spreadsheet has **67** commodities—Fresh artichokes, Fresh asparagus, Fresh bell peppers, Fresh broccoli, Fresh Brussels sprouts, Fresh cabbage, Fresh carrots, Fresh cauliflower, Fresh celery, Fresh collard greens, Fresh sweet corn, Fresh cucumbers, Fresh eggplant, Fresh escarole and endive, Fresh garlic, Fresh kale, Fresh head lettuce, Fresh Romaine and leaf lettuce, Fresh lima beans, Fresh mushrooms, Fresh mustard greens, Fresh okra, Fresh onions, Fresh potatoes, Fresh pumpkin, Fresh radishes, Fresh snap beans, Fresh spinach, Fresh squash, Fresh sweet potatoes, Fresh tomatoes, Fresh turnip greens, Canned asparagus, Canned snap beans, Canned cabbage (sauerkraut), Canned carrots, Canned sweet corn, Canned cucumbers (pickles), Canned green peas, Canned mushrooms, Canned chile peppers, Canned potatoes, Canned toma-

toes, Other canned vegetables, Frozen asparagus, Frozen snap beans, Frozen broccoli, Frozen carrots, Frozen cauliflower, Frozen sweet corn, Frozen green peas, Frozen lima beans, Frozen potatoes, Frozen spinach, Miscellaneous frozen vegetables, Dehydrated onions, Dehydrated potatoes, Potato chips and shoestring potatoes, Dry peas and lentils, Dry edible beans, Dry black beans, Dry great northern beans, Dry lima beans, Dry navy beans, Dry pinto beans, Dry red kidney beans, and Other dry beans.

Total: **215** commodity categories.[1] Some of these categories, such as "other frozen fruit," include more than one commodity so there are more than 215 commodities in total represented in the Food Availability Data System.

---

[1]Two commodities (eggnog; half-and-half) were split into a dairy share and a fat share. To avoid double counting, we reduce the sum (217) of the above groups to 215.

Source: Computed by Jeanine Bentley, ERS, August 6, 2012.

paid. The data include purchases at retail outlets—such as supercenters, grocery stores, farmers' markets, mass merchandisers, and drugstores—but not at restaurants or other foodservice outlets. This means that foods consumed away from home are not included in our estimated prices. Nielsen further provides projection factors that allow data users to estimate what all households across the United States paid for foods and the quantities they bought.

Third, as a validation step, when our estimates fell outside of the expected range, we examined the data more closely to determine if there had been computational errors or outliers. Additionally, it is likely that some households made mistakes when reporting information to Nielsen or, because the recording process is time-consuming, failed to report some purchases. However, validation studies confirm the suitability of Homescan data. For example, Einav et al. (2008) found that errors in the Homescan data are of the same order of magnitude as reporting errors in major government-collected data sets. Moreover, their findings suggest that errors in Homescan data are unlikely to affect estimates of average prices paid by all households.

Fourth, we multiplied the estimated price by the annual amount of food loss for each individual food in the LAFA data series at the retail and consumer levels. The amounts of loss for each type of commodity were calculated by multiplying per capita quantities available at each level by the corresponding food loss assumptions and by the U.S. population on July 1, 2010 (309.75 million). We then estimated the total value of losses by summing individual valuations over each commodity group in the LAFA data series.

Fifth, we estimated the number of calories representing food loss in 2010 for each commodity in the LAFA data series. One strength of this data series is that it estimates the calories available for each commodity in a given year. Using this information with the retail- and consumer-level loss estimates, we were able to estimate the number of calories from the food supply at both levels that went uneaten.

We basically followed the same steps as used in Buzby and Hyman (2012) and Buzby et al. (2011), with a few exceptions:

1. For five fresh vegetables, we used specific consumer price indexes (CPIs) to inflate the 2006 Nielsen fresh vegetable prices to 2010 prices [2006 was the most recent year available]. In particular, we used the lettuce CPI for fresh romaine and leaf lettuce. For fresh broccoli, sweet

corn, cucumbers, and spinach, we used the CPI for "other fresh vegetables," which is for fresh vegetables other than for potatoes, lettuce, and tomatoes. In the earlier two articles, we inflated the 2006 fresh prices with the CPI value for all fresh vegetables from the U.S. Bureau of Labor Statistics (BLS).

2. For fresh apricots, there were enough observations of fresh apricots in the 2010 Nielsen Homescan data that there was no need to adjust from an earlier price as in Buzby et al. (2011).
3. For veal, Buzby and Hyman (2012) used fresh veal only from 2008 Nielsen data to estimate the 2008 price for veal. In this report, we used both fresh and frozen veal together.

Limitations of the Data

As with the basic Food Availability data, the Loss-Adjusted Food Availability data series does not measure actual consumption or the quantities ingested. This is because neither series is based on direct observations of individual intake. Therefore, data are not available by socioeconomic, demographic, and geographic (State, regional, or city) breakdowns, and in most cases, it is not known if such data exist. Detailed documentation is available on ERS's website (ERS, 2012a).

The limited ability of researchers to measure food loss accurately suggests that actual loss rates may differ from the assumptions used in this data series. In general, the underlying estimates of farm-to-retail (not measured in this report), retail, and consumer-level food losses used in the Loss-Adjusted Food Availability data series may be understated or overstated due to limitations in the underlying published studies. Food loss, particularly at the consumer level, is by nature difficult to measure accurately. Participants in household surveys on food waste tend to be highly "reactive"—changing their behavior during the survey period instead of acknowledging how much food they typically discard—or misstating their true levels of product discard (Gallo, 1980). Studies that observe food loss by inspecting landfill garbage are also prone to errors. Such studies are not nationally representative and may not account for food fed to pets and other animals, put in garbage disposals, or composted at home (Gallo, 1980). Plate waste studies, such as for schoolchildren at lunchtime (Buzby and Guthrie, 2002), often target only a slice of the total U.S. population, and the findings cannot be easily or reliably extrapolated to other demographic categories.

Food loss for individual commodities, in particular, may vary over time. There are good reasons why food loss for a particular commodity could increase or decrease. On the one hand, new food technologies and food production/processing practices may reduce food losses over time (e.g., improvements in the preservation of bread, nanotechnologies in food packaging to reduce spoilage) (Buzby, 2010). On the other hand, food loss for a particular commodity could increase, such as from greater trimming of food to cut down on fats. However, the ERS data currently do not capture most of these changes in food loss because for most commodity- and food-loss-level pairings, the same loss assumption is applied throughout the span of the data in the LAFA data series (e.g., the retail-level loss estimate for fresh apples is the same 8.6 percent over 1970-2011). The exception is that the retail-level loss estimates for beef account for greater trimming of fat over time.

Additionally, ERS's LAFA data series uses well-documented data for inedible loss assumptions, but these amounts are not consistently applied to the data series in the same step or level. In particular, the data series removes the inedible share for fresh fruits, fresh vegetables, and eggs at the consumer level while the inedible shares for meat, poultry, and fish are removed at the primary-to-retail level,

so that these estimates in the LAFA data series are presented in boneless weight.[18] What this means, in effect, is that for fresh fruits, fresh vegetables, and eggs, the inedible share is included at the retail weight but then subtracted prior to the consumer weight.

Despite the limitations, both the per capita Food Availability data and the per capita Loss-Adjusted Food Availability data are useful for economic analyses because they serve as indirect measures of trends in food consumption and food loss. In other words, both data series provide an indication of whether Americans, on average, are consuming more or less of various foods over time. As we have seen in this report, the Loss-Adjusted Food Availability series also provides estimates of food loss by commodity, by food group, and in total.

[18]In the ERS Food Availability Data system, the weight at the primary distribution level is dictated for each commodity by the structure of the marketing system and data availability. In most cases, the primary weight is the farm weight. For meat and poultry, the primary weight is the carcass weight, which is then converted to a boneless weight when accounting for farm-to-retail losses.

References

Aillery, M., N. Gollehon, R. Johansson, J. Kaplan, N. Key, and M. Ribaudo. 2005. *Managing Manure to Improve Air and Water Quality*, Economic Research Service, U.S. Department of Agriculture, Economic Research Report No. 9 (Sept.). www.ers.usda.gov/publications/err-economic-research-report/err9.aspx.

Bureau of Labor Statistics (BLS). 2012. Table 4.10 Personal income, 1990, 2000, 2010, and projected 2020. Washington, DC.

Buzby, J.C. 2010. "Nanotechnology for Food Applications: More Questions than Answers," *The Journal of Consumer Affairs*, 44, 528-545. http://onlinelibrary.wiley.com/doi/10.1111/j.1745-6606.2010.01182.x/full, accessed November 12, 2013.

Buzby, J.C., and J.F. Guthrie. 2002. "Plate Waste in School Nutrition Programs: Final Report to Congress." E-FAN-02-009, Economic Research Service, U.S. Department of Agriculture. http://webarchives.cdlib.org/sw1s17tt5t/http://ers.usda.gov/Publications/efan02009/.

Buzby, J.C., and J. Hyman. 2012. "Total and Per Capita Value of Food Loss in the United States." *Food Policy*, 37, 561-570. http://www.sciencedirect.com/science/article/pii/S0306919212000693, accessed November 12, 2013.

Buzby, J.C., J. Hyman, H. Stewart, and H.F. Wells. 2011. "The Value of Retail- and Consumer-Level Fruit and Vegetable Losses in the United States," *The Journal of Consumer Affairs* Fall, 492-515. http://onlinelibrary.wiley.com/doi/10.1111/j.1745-6606.2011.01214.x/abstract, accessed November 12, 2013.

Buzby, J.C., H.F. Wells, B. Axtman, and J. Mickey. 2009. *Supermarket Loss Estimates for Fresh Fruit, Vegetables, Meat, Poultry, and Seafood and Their Use in the ERS Loss-Adjusted Food Availability Data*. EIB-44, March, Economic Research Service, U.S. Department of Agriculture. http://www.ers.usda.gov/media/183501/eib44.pdf.

Coleman-Jensen, A., M. Nord, and A. Singh. 2013. *Household Food Security in the United States in 2012*. ERR-155, Economic Research Service, U.S. Department of Agriculture. http://www.ers.usda.gov/publications/err-economic-research-report/err155.aspx.

Einav, L., E. Leibtag, and A. Nevo. 2008. *On the Accuracy of Nielsen Homescan Data*. ERR-69. Economic Research Service, U.S. Department of Agriculture. http://www.ers.usda.gov/publications/err-economic-research-report/err69.aspx, accessed November 12, 2013.

Environmental Protection Agency (EPA). 2009. "Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2008." Washington, DC.

Environmental Protection Agency (EPA). 2011. "Basic Information about Food Waste." Washington, DC.

Economic Research Service (ERS). 1989. *Major Statistical Series of the U.S. Department of Agriculture: Consumption and Utilization of Agricultural Products*, U.S. Department of Agriculture.

Economic Research Service (ERS). 2011. Loss-Adjusted Food Availability Documentation, U.S. Dept. of Agriculture. http://www.ers.usda.gov/data-products/food-availability-(per-capita)-data-system/loss-adjusted-food-availability-documentation.aspx.

Economic Research Service (ERS). 2012a. Loss-Adjusted Food Availability Data in the Food Availability (Per Capita) Data System. U.S. Department of Agriculture. http://www.ers.usda.gov/data-products/food-availability-(per-capita)-data-system.aspx.

Economic Research Service (ERS). 2012b. "Table 13—Per Capita Food Expenditures." http://www.ers.usda.gov/data-products/food-expenditures.aspx#26636.

Food and Agriculture Organization (FAO). 2009. *How to Feed the World in 2050*. United Nations, Rome.

Gallo, A.E. 1980. "Consumer Food Waste in the United States," *National Food Review*, Economic Research Service, U.S. Department of Agriculture.

General Accounting Office (GAO). 1977. *Food Waste: An Opportunity to Improve Resource Use*. Comptroller General of the United States, Washington, DC.

Hansen, L., and M. Ribaudo. 2008. *Economic Measures of Soil Conservation Benefits: Regional Values for Policy Assessment*, Economic Research Service, U.S. Department of Agriculture, Technical Bulletin No. 1922 (Sept.). www.ers.usda.gov/publications/tb-technical-bulletin/tb1922.aspx.

Goodwin, L. 2013. "Inquiry into the EU's Contribution to Food Waste Prevention by the House of Lords European Union Committee (Sub-Committee D): Supplementary Memorandum by WRAP (the Waste & Resources Action Programme)." Oxon, United Kingdom.

Hall, K.D., J. Guo, M. Dore, and C.C. Chow. 2009. "The Progressive Increase of Food Waste in America and its Environmental Impact." *PLoS ONE,* 4, 6.

Hodges, R.J., J.C. Buzby, and B. Bennett. 2010. "Postharvest Losses and Waste in Developed and Developing Countries: Opportunities to Improve Resource Use," *Journal of Agricultural Science*, 1-9. Vol. 149, Supplement S1 (Nov.):37-45. doi: 10.1017/S0021859610000936. http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=8030717, accessed November 12, 2013.

Institutes of Medicine (IOM). 2005. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids*. The National Academies Press, Washington, DC.

Kader, A.A. 2005. "Increasing Food Availability by Reducing Postharvest Losses of Fresh Produce," *Acta Horticulturae* 682: 2169-2176.

Kantor, L.S. 1998. *A Dietary Assessment of the U.S. Food Supply: Comparing Per Capita Food Consumption with Food Guide Pyramid Serving Recommendations*. Economic Research Service, U.S. Department of Agriculture. http://webarchives.cdlib.org/sw12j6951w/http://www.ers.usda.gov/Publications/AER772/.

Kantor, L.S., K. Lipton, A. Manchester, and V. Oliveira. 1997. "Estimating and Addressing America's Food Losses," *FoodReview*, Economic Research Service (ERS), U.S. Dept. of Agriculture.

Lundqvist, J., C. de Fraiture, and D. Molden. 2008. "Saving Water: From Field to Fork—Curbing Losses and Wastage in the Food Chain." Stockholm International Water Institute (SIWI) Policy Brief. Stockholm, Sweden.

Muth, M.K., S.A. Karns, S.J. Nielsen, J.C. Buzby, and H.F. Wells. 2011. "Consumer-Level Food Loss Estimates and Their Use in the ERS Loss-Adjusted Food Availability Data." Economic Research Service, U.S. Department of Agriculture. Technical Bulletin No. (TB-1927), Jan. http://www.ers.usda.gov/publications/tb-technical-bulletin/tb1927.aspx, accessed November 12, 2013.

Parfitt, J.P., M. Barthel, and S. Macnaughton. 2010. "Food Waste within Food Supply Chains: Quantification and Potential for Change to 2050." *Philosophical Transactions of the Royal Society Biological Sciences*, 365, 3065-3081.

Quested, T., and A. Parry. 2011. "New Estimates for Household Food and Drink Waste in the UK." Oxon, Waste & Resources Action Programme (WRAP).

Reed, J., E. Frazão, and R. Itskowitz. 2004. *How Much Do Americans Pay for Fruits and Vegetables?* Economic Research Service, U.S. Department of Agriculture, Agricultural Information Bulletin No. 790 (July).

Ribaudo, M., Jorge Delgado, L. Hansen, M. Livingston, R. Mosheim, and J. Williamson. 2011. *Nitrogen in Agricultural Systems: Implications for Conservation Policy*, Economic Research Service, U.S. Department of Agriculture, Economic Research Report No. 127 (Sept.) www.ers.usda.gov/publications/err-economic-research-report/err127.aspx.

Rosen, S., B. Meade, S. Shapouri, A. D'Souza, and N. Rada. 2012. *International Food Security Assessment, 2012-12*. Economic Research Service (ERS), U.S. Department of Agriculture.

Schwab, J. 2013, Environmental Protection Agency. Personnel communication with J. Buzby, Washington, DC.

Stewart, H., J. Hyman, J. Buzby, E. Frazão, and A. Carlson. 2011. *How Much do Fruits and Vegetables Cost?* Economic Research Service, U.S. Department of Agriculture. Economic Information Bulletin No. 71 (Feb.), http://www.ers.usda.gov/publications/eib-economic-information-bulletin/eib71.aspx.

Sullivan, P., D. Hellerstein, L. Hansen, R. Johansson, S. Koenig, R. Lubowski, W. McBride, D. McGranahan, M. Roberts, S. Vogel, and S. Bucholtz. 2004. *The Conservation Reserve Program: Economic Implications for Rural America*. Economic Research Service, U.S. Department of Agriculture, Agricultural Economic Report No. 834 (Oct.), www.ers.usda.gov/publications/aer-agricultural-economic-report/aer834.aspx.

United Nations (UN). 2011. World Population Prospects, the 2010 Revision. Department of Economic and Social Affairs, P.D., Population Estimates and Projections Section, ed., Rome, United Nations.

Venkat, K. 2012. "The Climate Change and Economic Impacts of Food Waste in the United States," *International Journal on Food System Dynamics,* 2, 431-446.

Webber, M.E. 2012. "More Food, Less Energy," *Scientific American*, pp. 74-79.

Ziegler, G., and J.D. Floros. 2011. "A Future Perspective to Mitigate Food Losses: The Role of Food Science and Technology," IFT 2011 Annual Meeting & Food Expo (New Orleans, LA).