



California's Water Footprint

Julian Fulton, Heather Cooley,
and Peter H. Gleick

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Executive Summary

The average Californian uses about 140 gallons of water per day for drinking, bathing, washing clothes, watering gardens, and other household uses. These direct uses of water, however, are only part of the story. Considerably more water is used to produce the goods we consume, and much of this is in the form of “virtual water” – the water required to produce the food we eat, the clothes we wear, the beverages we drink, and the other industrial goods on which we rely. That virtual water may come from California, but it also may come from anywhere in the world where the products we consume are made.

As pressures on water resources intensify, there is growing interest in evaluating the complex ways in which everyday human activities impact the world's water resources. The “water footprint” has emerged as one tool for quantifying this impact. A water footprint is defined as the amount of water that is consumed (i.e., is no longer available for immediate reuse) to produce a product. While some of that water is incorporated into the final good, much of it is consumed through evapotranspiration during the production process. For example, an average 35 gallons of water is consumed to produce a cup of coffee, including the water required to grow the coffee crop.

A water footprint can be calculated at different levels of consumer activity, e.g., for an individual, household, region, state, nation, or even all of humanity. A water footprint of an individual includes the direct uses of water in the home and the indirect uses of water to produce the goods and services the individual consumes. The water footprint of a nation includes the water used to produce the goods and services consumed by the inhabitants of the nation. We present here the first comprehensive assessment of the water footprint of the state of California – one of the largest and most populous states in the United States, a major producer of agricultural and industrial goods, and a significant consumer of water.

Our assessment finds that California's total water footprint is about 64 million acre-feet¹ per year, or 20 trillion gallons of water per year, which is more than double the annual average combined flows of the state's two largest rivers, the Sacramento and San Joaquin Rivers. California's water footprint is a function of its consumption of goods and has an internal and an external component. The internal water footprint is the water required to make the goods that are produced and consumed within California, as well as the direct use of water inside the state. The external water footprint includes the water required to make goods that are imported from other places and then consumed in California.²

¹ One acre-foot is the amount of water that would fill one acre to a depth of one foot, or about 325,851 gallons.

² Note that the water footprint of products produced in California but exported and consumed outside of the state's borders become part of the external water footprint of that region.

As Figure ES 1 shows, most of California's water footprint is external, meaning that Californians are more dependent on water resources from outside the state's borders. An estimated 38 million acre-feet of water is used to produce goods within California – and almost half of that water, or 19 million acre-feet, goes to producing goods that are then exported and consumed outside of California. An additional 44 million acre-feet of water is required to produce the goods that are imported into California and consumed here, making California a net *importer* of virtual water.

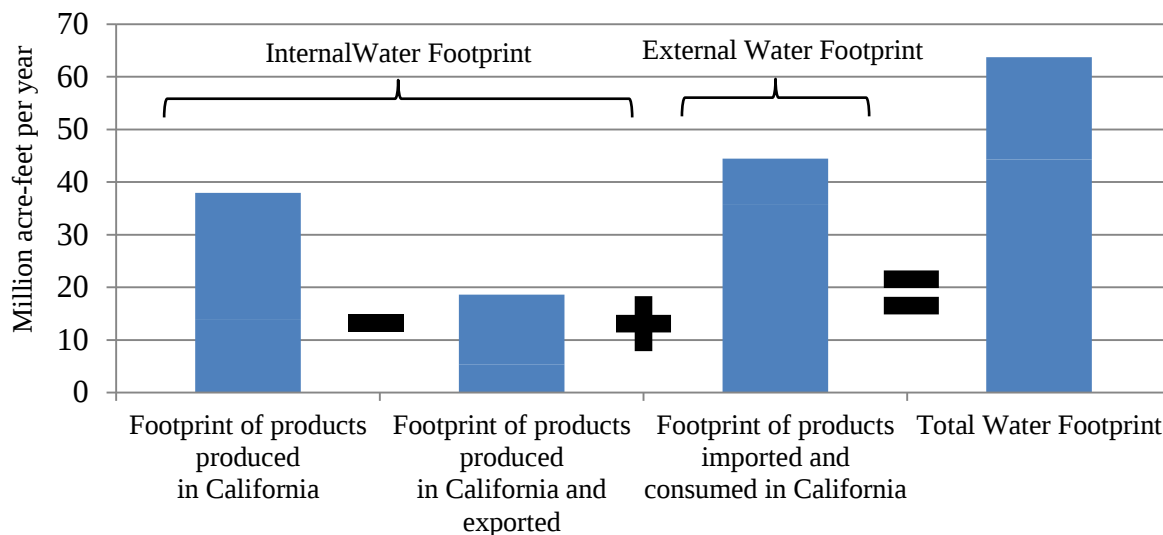
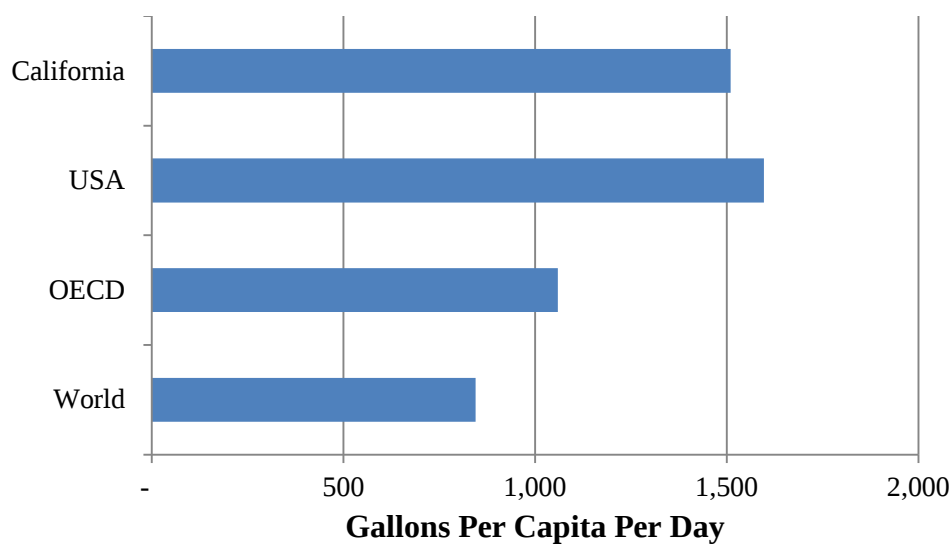


Figure ES 1. Major Components of California's Water Footprint

On a per-capita basis, the water footprint of the average Californian is 1,500 gallons per day. By comparison, the average Californian's water footprint is slightly less than the average American but considerably more than the average resident in other developed (OECD) countries or the world (Figure ES 2).



E.S. Figure 2. Water Footprints in Gallons Per Capita Per Day

Source: USA estimate from OECD; world estimate from Mekonnen and Hoekstra 2011

As shown in Figure ES 3, more than 90% of California's water footprint is associated with agricultural products. Meat and dairy products have especially large water footprints due to the amount of water-intensive feed required to raise the animals. An additional 4% of California's water footprint is associated with direct household water consumption (e.g., for landscape irrigation), and the remaining 3% with other industrial products we consume, such as clothing and electronics.

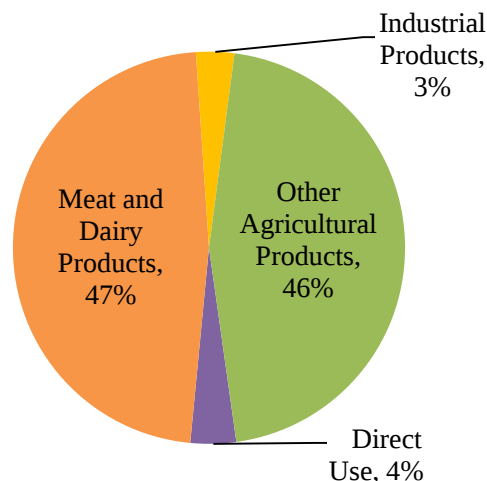


Figure ES 3. California's Water Footprint by Sector

Much of the water that makes up California's water footprint is in the form of goods Californians consume that are produced outside the state. About half is associated with water use in other U.S. states and 11% is associated with water use in Mexico, Canada, and China (Figure ES 4). These findings suggest that California's economic and social well-being is intimately connected with water resources beyond our borders and is vulnerable to water-supply constraints in those regions. Additionally, Californians can exacerbate local environmental or social concerns outside of its borders through the consumption of goods produced in those regions.

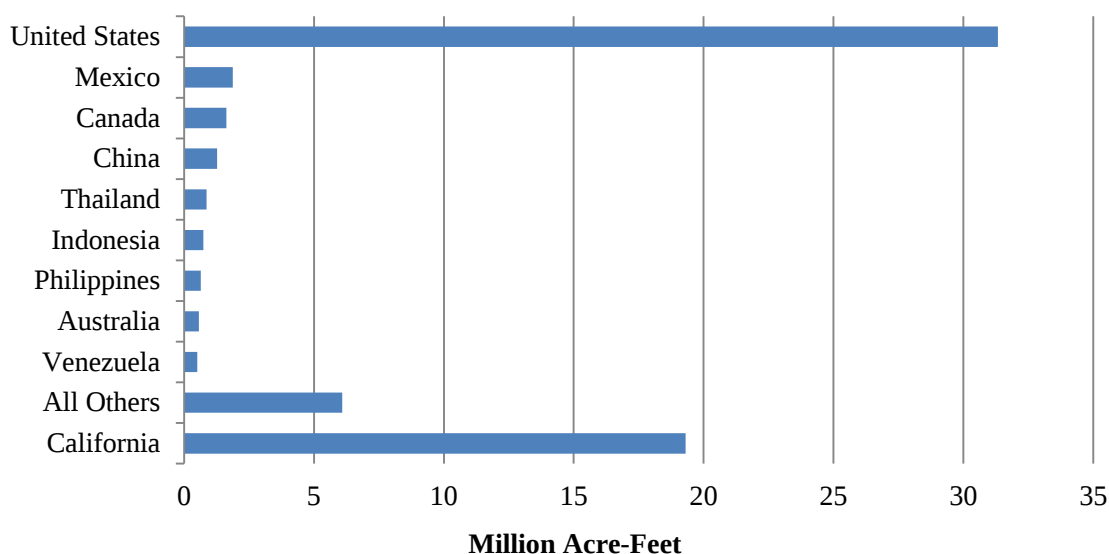


Figure ES 4. California's Water Footprint by Location

Note: This refers to the location and quantity of water resources consumptively used in the production of products consumed in California.

The water footprint, when combined with data on the monetary value of production and trade, highlights some of the connections between water use and California's economy, including the economic productivity of water. The economic productivity of water is measured in dollars per gallon of water consumed. Overall, California's economy generates about \$3.1 trillion in revenue (sales) while using 38 million acre-feet (MAF) of in-state water resources, equivalent to \$0.25 per gallon of water (Figure ES 5). Exports generate \$0.6 trillion in revenue for California using 19 MAF, or \$0.10 per gallon. California imports \$0.8 trillion worth of goods that have a total water footprint of 44 million acre-feet; thus, we are paying the equivalent of about \$0.05 for every gallon of water imported into the state in the form of goods.

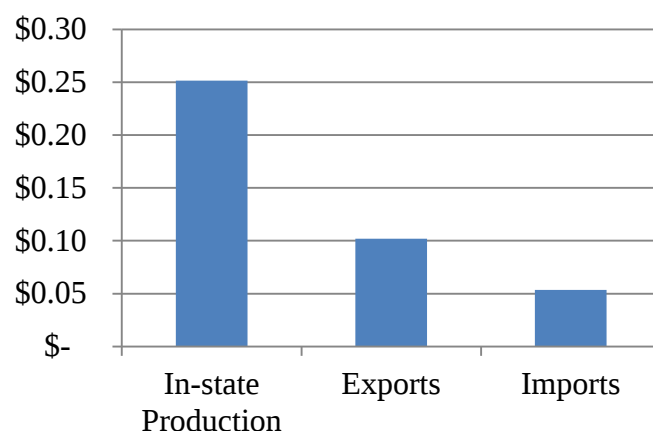


Figure ES 5. Dollars per Gallon of Production and Trade

These findings indicate that the economic productivity of exports (\$0.10 in export sales per gallon of water) is greater than of imports (\$0.05 per gallons) but far less than the productivity of California's entire economy (\$0.25 in sales per gallon). The reduced economic benefit of those exports suggests that California could realize an economic benefit if more of the available water were used for higher value products. We note that while these findings can inform state and national policies and decisions, maximizing the economic value per unit of water used is only one consideration in water policy and decision making. Environmental outcomes, social preferences, and equity issues are also important and must be taken into consideration.

Conclusions

Conventional water-use assessments tend to focus on water supply and direct water use in discrete sectors of society. This approach, however, offers incomplete information on impacts to water resources, which are interconnected through economic activity to our daily consumption of goods. By focusing on actions of discrete sectors, conventional analyses also limit our range of options for addressing water resource impacts – for example irrigation efficiency measures in agriculture.

A water footprint analysis provides a unique perspective on California's relationship with water that acknowledges the interconnections between everyday activities and impacts to water resources – both at home and around the world. It is a perspective that can be valuable for water managers, policymakers, and the concerned public, providing new leverage points for reducing those impacts and creating a more sustainable society. These may include policies that consider the environmental implications of various trade regime options, or educational programs to help individuals and institutions make better decisions about their purchasing habits.

This study from the Pacific Institute includes extensive detail on California's water footprint for the overall economy, the production and consumption of specific products, and information on different types of water, including both "green" and "blue" water (representing rainwater/soil moisture or surface irrigation water, respectively). We also offer preliminary estimates of California's grey water footprint, which is an indicator of water-quality impacts of water use.

Our work on California's water footprint is just beginning. The water footprint concept is constantly evolving and further analysis will expand and refine the analysis presented here; currently we are looking at California's water footprint related to energy products such as electricity, natural gas, and transportation fuels. Future work includes identifying how the footprint has changed over time under different climatic conditions, trade regimes, and policies, and offering improved estimates of uncertainty, as well as developing a better understanding of the roles that different regions play in the overall water footprint of the state. Water quality issues are also important to incorporate into the water footprint indicator in a meaningful way, and we are working with other researchers to develop these methods. Most importantly, ongoing water footprint work will provide more contextualized information for citizens, businesses, government, and all stakeholders in California's water future.

California's Water Footprint

Introduction

We use water for a variety of purposes in our daily lives: for drinking, bathing, washing our clothes, etc. These direct uses of water, however, are only part of the story. Water is also required to produce nearly everything we use and consume, from the food we eat and the clothes we wear to the technological devices that are integral to our modern society. Because this indirect water isn't visible in the product, it is also often referred to as “embedded,” “embodied,” or “virtual” water. A full measure, therefore, of the water footprint of an individual, industrial sector, or society is the combination of direct water use and the water used indirectly to provide the goods and services consumed.

As pressures on water resources intensify globally, there is growing interest in evaluating the complex ways in which everyday human activities impact the world's water resources. Traditionally water has been thought of as a local or regional issue, but as globalization has forged increasing interconnectedness among people and economies, better understanding is needed of the ways in which observed impacts to water systems have important global dimensions. The “water footprint” has emerged as one tool for identifying and quantifying these impacts.

In recent years, there has been an explosion of interest in developing the methods and data necessary for evaluating and comparing water footprints. With some exceptions, this research has focused on the scale of national consumption and international trade. We present here the first comprehensive assessment of the water footprint of the State of California – one of the largest and most populous states in the United States, a major producer of agricultural and industrial goods, and a significant consumer of water.

A Note about Water Use

The water literature is rife with confusing and often misleading terminology to describe water use, e.g., water withdrawal, consumptive use, non-consumptive use, real water, paper water, and more. It is important to clarify these terms, as different meanings can lead to different or conflicting conclusions. Water *withdrawals* are commonly defined as the water taken from a source and used for some human need. These withdrawals can be divided into two categories: consumptive and non-consumptive water use. The term *consumptive use* or *consumption* typically refers to “water withdrawn from a source and made unavailable for reuse in the same basin, such as through conversion to steam, losses to evaporation, seepage to a saline sink, or contamination” (Gleick 2003). Additionally, water that is incorporated into goods or plant and animal tissue is unavailable for reuse, and thus is also considered a consumptive use. Non-consumptive use, on the other hand, refers to water that can be made available for reuse within the basin from which it was extracted, such as through return flows or recoverable wastewater discharge into water bodies.

What is a Water Footprint?

Consumptive and non-consumptive uses of water occur at almost every step along the supply chain of a product. The water footprint concept has been developed to estimate the amount of water consumed in the production of goods and services. The production of goods is often much more water-intensive than services, and water footprints have been calculated for a range of goods, from food to clothing to energy (see www.waterfootprintnetwork.org). For example, an average 35 gallons of water is consumed to produce a cup of coffee, including the water required to grow the coffee crop. The water footprint of a cotton shirt includes the water for growing cotton, processing and dyeing fabric, and various finishing procedures – and the footprint of a typical shirt has been estimated at over 650 gallons (Chapagain et al. 2006, Mekonnen and Hoekstra 2010a).¹ A megawatt hour (MWh) of electricity, enough to supply the average U.S. household for about a month, consumes an average of 288 gallons for generation in the western U.S. (Cooley et al. 2011), but can consume up to 65,000 gallons for inefficient hydroelectricity produced in a hot, dry climate (Mekonnen and Hoekstra 2012).

The total quantity of water consumed to produce a good is often referred to as the “embedded” or “embodied” or “virtual” water content.² While some of that water is incorporated into the final good, much of it is consumed through evapotranspiration during the production of the good. A “water footprint” provides a metric and methodology for quantifying virtual water and includes additional qualitative features about the water used, including where the water comes from, the kinds and quality of water used, and more, as discussed below.

Because a water footprint is based on the goods and services consumed, it can be calculated at different levels of consumer activity, i.e., for individuals, households, regions, states, nations, or even all of humanity. In a recent analysis, Hoekstra and Mekonnen (2012) found that the water footprint of global consumption is about 9,000 cubic kilometers per year, or 7,400 million acre-feet (MAF) per year,³ or about 500 times the average annual flow of the Colorado River in its natural state (Cohen et al. 2001). The water footprint, however, varies tremendously from country to country. The United States, for example, has one of the highest per-capita water footprints in the world, at about 2,055 gallons per capita per day (GPCD) (Mekonnen and Hoekstra 2011a).⁴ Other developed countries have an average water footprint of 1,300 GPCD (Mekonnen and Hoekstra 2011a).

Trade is an important consideration when calculating water footprints, as the various processes required to produce a final good often take place in different countries. Using the example of a cotton t-shirt, the cotton may be grown in India, woven into fabric and dyed in China, and finished in Mexico before heading to market in the U.S. Thus the water footprint of that t-shirt

¹ This does not include the water used to wash the product over its life.

² These terms are often used interchangeably in the scientific literature, although more often “embedded” is used to refer to the product level while “virtual” refers to overall trade flows between regions. The term “virtual water” was coined by Tony Allan in the mid-1990s (see, for example, Allan 1996).

³ One acre-foot is the amount of water that would fill one acre to a depth of one foot, or 325,851 gallons, or 1,233 cubic meters.

⁴ This figure differs from the one mentioned in the Executive Summary because it includes an additional measure of water pollution (called “grey water”) which is discussed in greater detail below.

will be geographically distributed according to the structure of its supply chain (Chapagain et al. 2006).

The water footprint is often reported as three components: green water, blue water, and grey water. “Green water” is the amount of precipitation and soil moisture that is directly consumed in an activity, such as in growing crops. “Blue water” is the amount of surface or groundwater that is applied and consumed in an activity, such as in growing crops or manufacturing an industrial good. Finally, “grey water⁵” is the amount of water needed to assimilate pollutants from a production process back into water bodies at levels that meet governing standards, regardless of whether those standards are actually met (Hoekstra et al. 2011). The green, blue and grey water metrics are calculated for individual processes and then aggregated based on the consumption patterns of the unit of interest.

Green, blue, and grey water footprints are often combined and reported as a single value in the literature. Each, however, has distinct ecological and social contexts. Green water pertains to rainwater and soil moisture occurring where crops are grown and thus may only be significant insofar as that water is unavailable for other land uses, alternative crops, or native vegetation. Blue water, by contrast, represents a deliberate abstraction and allocation of surface or groundwater resources, often using pumping and conveyance systems to extract and deliver water where it is needed.

Grey water is an indicator of water quality rather than a measure of consumptive water use. Even though the contamination of surface waters is by definition a consumptive use, contaminated water can often still serve multiple uses like navigation or cooling. Thus, in order to eliminate double counting of upstream grey water footprints by downstream blue water uses in this report, we present California’s grey water footprint separately. We feel that the grey water footprint is a useful quantitative indicator for water quality issues, but that methodologically it should be reported separately from the green and blue water footprints.

The quantitative measure of a green, blue, or grey water footprint, by itself, reveals little about the consequences or local impacts of that water use. Additional information (and often subjective evaluation) is required to estimate the impact of a water footprint. If the water consumed comes from areas where water is relatively abundant, the social and environmental impacts may be far less than the same consumption from a region where water is scarce. Such a contextualized analysis of the relative impacts of a water footprint is generally called a Water Footprint Sustainability Assessment in the literature (Hoekstra et al. 2011). Here, we present only the quantitative dimensions of California’s water footprint. Subsequent work, expanding on the results of this report, will address these broader issues.

Dimensions of California’s Water Footprint

Historically, water use in California has been measured and reported in terms of direct water withdrawals (and sometimes “consumption”) for agricultural and urban purposes. While water withdrawals increased rapidly in the middle part of the 20th century as California’s population and economy grew, for the past several decades California’s total water withdrawals have

⁵ Not to be confused with wastewater that is reused on a site, which often goes by the name “greywater.”

leveled off as overall water productivity has improved, both as a function of per capita use and economic output. Since 1975 total water withdrawals in California have remained more or less stable, even decreasing in the agricultural sector due to changes in cropping patterns and irrigation efficiencies (Figure 1). Yet, the state's population has nearly doubled, and the economy has more than tripled in constant dollar terms (CDF 2011, USDC-BEA 2012).

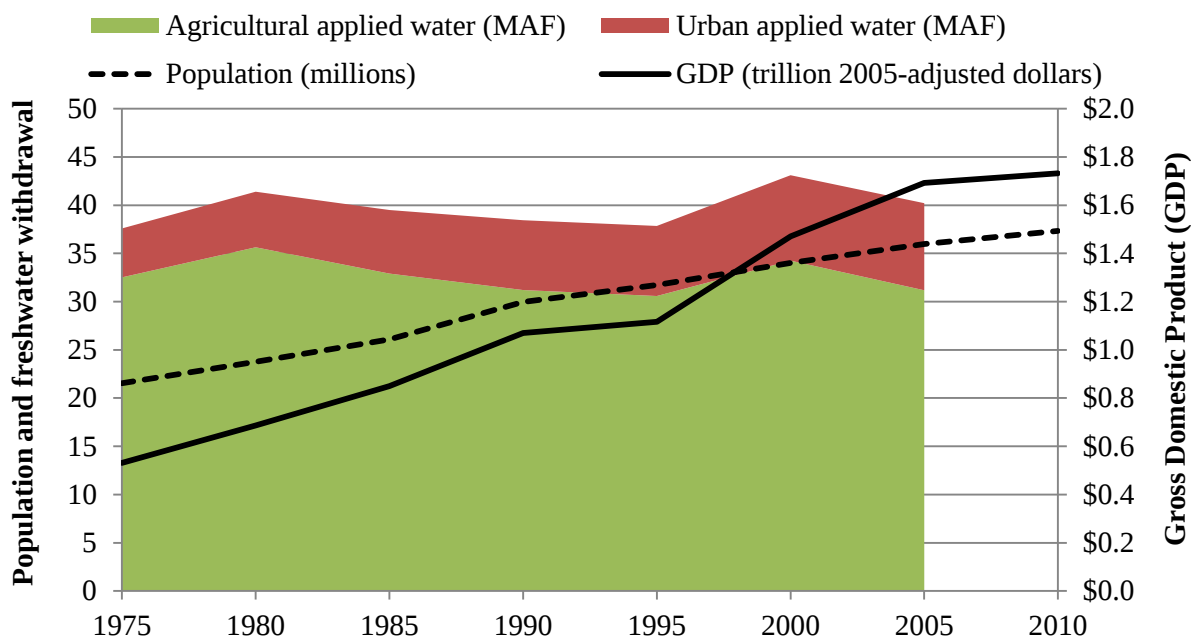


Figure 1. Trends in California's Population, Freshwater Withdrawals, and State-Level GDP

Note: MAF = million acre-feet

Sources: CDF 2011; USDC 2012

Individually, Californians use (withdraw) about 140 GPCD (CDWR 2009) to meet their basic household needs, which is considerably more than the national average of 98 GPCD (Kenny et al. 2009).⁶ When all other statewide water withdrawals are included, i.e., agriculture and the commercial, institutional, and industrial sectors, then per-capita water use in California is about 950 GPCD (CDWR 2009). This metric provides insight into how water is used in California. It does not, however, capture the amount of water required to support California's population because many of the goods produced in California are exported to other regions, and many of the goods consumed in California are produced outside of its borders.

Over the last fifty years, California has rapidly integrated into the global economy. The value of international imports is now more than fifteen times what it was in 1970, while domestic imports (i.e., goods imported into California from other U.S. states) have also grown substantially in real, price-adjusted terms (USDC-CB 2010). Exports have also grown, although to a lesser extent (see

⁶ Consumptive use at the household level is not generally estimated, however CDWR (2009) estimates that for all urban uses, consumptive use is 31% of withdrawal, which would make household consumptive use about 43 GPCD.

Figure 2).⁷ As Californians' consumption patterns have become more integrated with the global economy through trade, the water embedded in those trade flows plays an increasing role in California's water footprint. Thus, an important component of California's water footprint requires calculating the water intensity of imports and exports. Combining water use indicators with economic indicators can also shed additional light on how water is valued inside and outside of California.

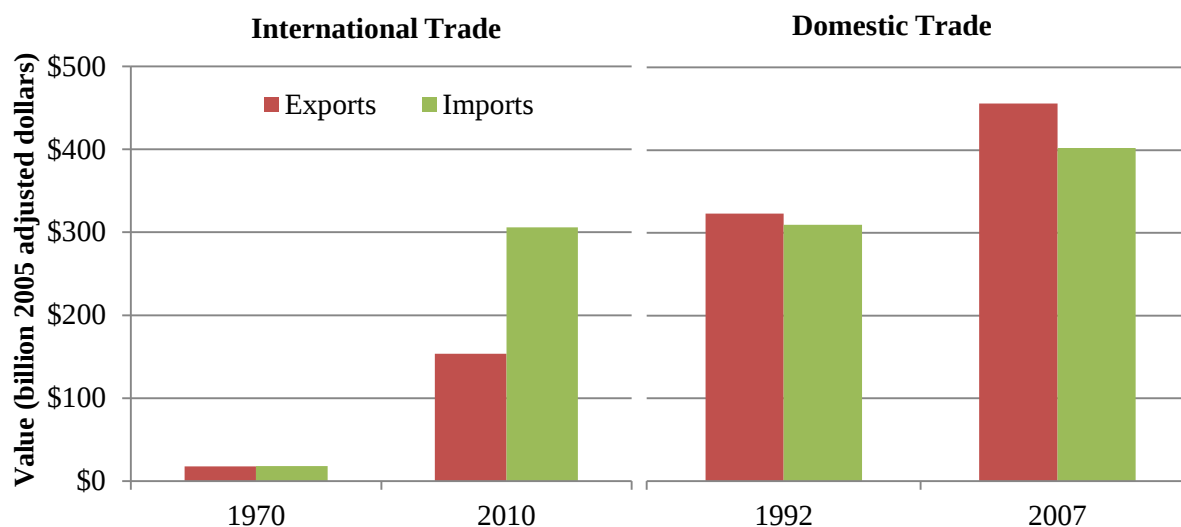


Figure 2. Trends in California's International and Domestic Trade

Source: U.S. Department of Commerce, Census Bureau

Previous work has sought to quantify the embedded water in various segments of the California economy. In the 1960s, the UC Berkeley Sanitary Engineering Research Laboratory began calculating water use in western states' economies using economic input-output tables, which show inter-industry flows of embedded water (McGauhey et al. 1960). In 1991, the Water Education Foundation commissioned a study estimating embedded water in several of California's agricultural goods, although the embedded water in traded goods was not considered (Kreith 1991). The purpose of the current report is to apply the water footprint concept and method to California. Our analysis represents the first comprehensive calculation of California's water footprint that incorporates embedded water associated with national and international trade flows.

Understanding the water footprint of California is important for a variety of reasons. First, California's water resources are becoming increasingly stretched to accommodate continued population and economic growth and to restore environmental flows. Allocation of water among competing uses has been a source of political tension throughout the state's history, and the water footprint sheds new light on questions such as the value of export crops and other goods with respect to their water use. Second, the water footprint provides specific information on the food systems and other systems that supply goods and services to Californians, which is relevant

⁷ Throughout the report the terms export and import are used to imply movement across California's border to both international and domestic trading partners.

to understanding the resource-related risks and vulnerabilities the state faces. This information is also useful to Californians wishing to know the impacts of their consumption habits and other activities, thus offering new opportunities to change or reduce their individual environmental footprint. Finally, a better understanding of how the state's constrained water resources are being used can help water managers make improved decisions about water policy.

Methods and Data Sources

The concept of embedded water has been used for some time, most notably in the study of trade as a mechanism for coping with water scarcity (Allan 1998). The basic approach in calculating a water footprint is to combine consumptive water use factors (gallons-per-unit of production) of blue, green, and grey water for individual goods and services with statistics on production, trade, and consumption of those goods and services. The Water Footprint Network (WFN) advanced the methodology, which has been applied at global, national, and industry levels (see www.waterfootprint.org). This analysis uses methods developed by the WFN and described in the *Water Footprint Assessment Manual* (herein “manual”)(Hoekstra et al. 2011).

We calculated California's water footprint using a top-down balancing approach as shown in Figure 3. The total water footprint of goods and services consumed in California has an internal component and an external component (top row). The internal water footprint is calculated as the water footprint of goods and services produced within California minus the water footprint of goods produced in California and exported out of the state. The external water footprint is calculated as the water footprint of goods which are imported into and consumed within California. The water footprint of traded services is not considered in this analysis for reasons discussed below.

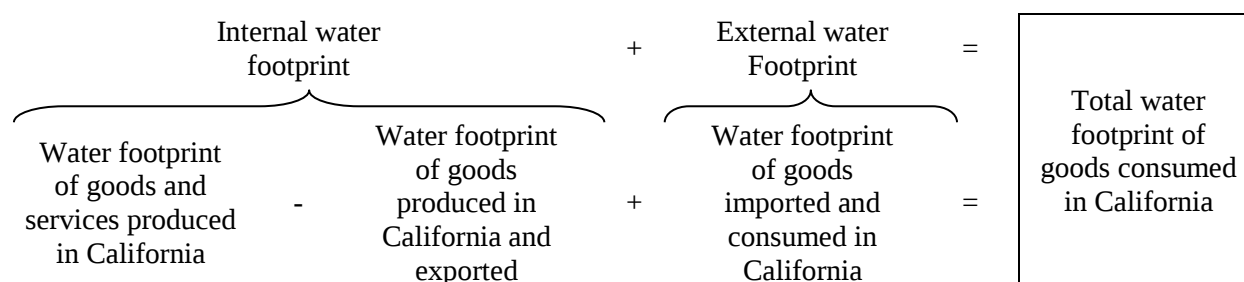


Figure 3. California's Water Footprint Accounting Framework

Note: Modified from Hoekstra et al. (2011)

The following sections describe the data and calculations that were used for each component of California's water footprint. First, we describe how the water footprint of goods and services produced in California was calculated using locally relevant data and methods described in the WFN manual. Second we describe available data that relates to the water footprint of goods produced outside of California. Finally, we discuss how trade data were applied to provide a geographical picture of California's internal and external water footprints.

The Water Footprint of Goods and Services Produced in California

For this analysis, we use California-specific data to estimate the water footprint of goods and services produced inside of California. The California Department of Water Resources (DWR) regularly estimates annual evapotranspiration rates of applied water (ETAW) and of precipitation (EP) for 20 crop categories (see Appendix 1 for category definitions).⁸ These data are reported on a per-acre basis in DWR's Land and Water Use Survey (LWUS), which we compiled for the years 1998-2005. As 2007 data were not yet available, we used average ETAW and EP factors from this time period (1998-2005) to represent blue and green water consumptive use factors, respectively, for 20 crop categories.⁹

For land area in agricultural production in California, the LWUS also reports irrigated crop area (ICA) for each crop category. However, as DWR does not survey non-irrigated crop area, i.e., purely rainfed agriculture, we also used County Agricultural Commissioner's (CAC) Data provided by the U.S. Department of Agriculture (USDA), which reports "harvested acres" for 281 distinct commodities on an annual basis. We related each CAC commodity to one of DWR's 20 crop categories according to Appendix 1 in order to check the difference between harvested acreage (according to CAC) and irrigated crop area (according to DWR) for the years 1998-2005. In most cases the difference was less than 10%, indicating that purely rainfed, non-irrigated agriculture is uncommon in California. However, pasture and grains had substantial acreage that was not irrigated, so blue water consumptive use factors were only applied to the acreage of those crops that was irrigated (ICA).

For the remainder of crops, blue and green water consumptive use factors were multiplied by the actual harvested acreage (2007) of 281 commodities (related to DWR crop categories as in Appendix 1). The total quantities of green and blue water for these 281 commodities were divided by commodity production statistics (also contained in the CAC dataset), resulting in a dataset of green water and blue water consumptive use factors in units of acre-feet-per-ton of produced product. The crops in the USDA dataset were then coded to a list of commodities that we generated (see Appendix 2), which could be related to traded goods. Because many goods are traded in a condition that is different from the "farm-weight" (as reported by CAC), standard conversions were applied using factors from M. Mekonnen and Hoekstra (2010b) and USDA (1992). Grey water factors for crop production in California were not calculated using state-level data, as this will be done in a future analysis. Instead, we used grey water factors provided by Mekonnen and Hoekstra (2010a) that were specified at the U.S. level for most goods, and otherwise at the global level.

Producing animal products, like meat and dairy, consumes a large volume of water, primarily due to growing the forage and fodder to feed the animals. Other water uses, e.g., for washing and hydrating animals and for the processing of animal products, are typically only around 1% of animal product water footprints (Mekonnen & Hoekstra 2010b) and are therefore not included in this initial analysis.¹⁰ The water footprints of feed and forage crops, calculated as described

⁸ All appendices can be found online at www.pacinst.org/reports/ca_water_footprint.

⁹ While we use the average factors here, we note that the actual amounts of green and blue water use in crop production vary widely from year to year depending on hydrologic conditions.

¹⁰ For a recent analysis including grey water-related impacts of animal production in California, particularly grey water issues, see Moore et al. (2011).

above, were allocated to animal products based on international biomass-to-product conversion rates published in Mekonnen and Hoekstra (2010b). Data on the production of animal products were obtained from the 2007 USDA Census of Agriculture. According to these sources, an estimated 63.2 million tons of biomass were needed for animal production in California in 2007. Data on animal feed in California is sparse, so the supply of biomass to the animal products industries was assumed to be composed of crops specified by CAC as feed or silage, as well as alfalfa, hay, and pasture.¹¹ The biomass demand from California's animal product industries exceeds the supply from in-state sources, thus imported feed crops also make a large contribution to the production of animal products. California does export some animal feed and forage crops, namely alfalfa, so those exports were treated as separate commodities and excluded as an input to animal products within California. Careful attention was paid to not double count the water footprints of animal feed and animal products.

The water footprint associated with producing industrial goods in California was calculated using the best available local data. The most comprehensive dataset for industrial water use comes from DWR's 1995 survey of commercial, industrial, and institutional water use. The dataset was not published but was analyzed by the Pacific Institute in Gleick et al. (2003). In the report, water withdrawal factors were developed for 20 manufacturing sectors on a per-employee basis. Subsequent work by the Sustainability Consortium transformed these factors into gallons-per-dollar metrics to support their "Open IO" life cycle assessment tool (Cox 2011). These factors represent total water use, i.e., consumptive and non-consumptive uses. The water footprint, however, is based on consumptive water use only. Using California-level data from USGS, we estimated that consumptive use represented 28% of water withdrawals in the industrial sector (Solley et al. 1998). A more detailed assessment should evaluate the differences in consumptive and non-consumptive uses by sector.

The industrial blue water factors were then applied to inflation-adjusted revenues per sector from the U.S. Census Bureau's Census of Manufacturers for the years 1997, 2002, and 2007. For comparative purposes, we also calculated consumptive use in the industrial sector based on changes in employment rather than inflation-adjusted revenues. It is important to note, however, that this approach assumes that the water-use factor (either per employee or revenue) has not changed and therefore does not account for efficiency improvements within industrial sectors that have occurred since 1995. We urge that new data on industrial water use be collected to assess these changes. The grey water footprint was calculated using the same methods as described above for industrial production in California, the U.S., and other countries.

The blue water footprints of residential indoor and outdoor use, as well as commercial and institutional uses (services) usually do not entail the production of actual goods, but nevertheless they are an important part of California's internal water footprint. Direct consumption in the residential, commercial, and institutional sectors were derived from data generated for the California Water Plan Update 2009 (CDWR 2009). These data show that average consumption rate for all urban uses from 1998-2005 was 31% of withdrawal, and this percentage was applied to withdrawal volumes in the residential, commercial, and institutional sectors to determine their average blue water consumption volumes.

¹¹ Pasturelands were assumed to contribute 1.5 tons of biomass per acre, which is consistent with George et al (2001).

Energy is also a fundamental piece of the California economy that relies on potentially water-intensive production systems. However in this report we have omitted a detailed analysis of California's energy-related water footprint for three reasons. The first is that we wanted our initial estimate of California's water footprint to be comparable with other studies in the footprinting literature, which do not typically include energy. Second, because a lot of energy is used in the production of goods, attributing the water footprint of energy to those various goods (i.e., embedded water in embedded energy) as they are produced all over the world presented enough complications to warrant a separate report. Third, California's energy system comes from a complex mix of renewables, fossil fuels, nuclear, in-state, out-of-state, freshwater, and saltwater systems. All of these factors also warrant a separate analysis.

Water Footprint of Goods Produced Outside of California

Many goods that are consumed in California are produced in other U.S. states and other countries. For agricultural goods, we used water footprint factors developed by WFN in a similar way to how we developed factors for goods made in California. Using country-level data from the United Nations Food and Agriculture Organization (FAO) and methods described in the manual, WFN has calculated blue, green, and grey water footprint factors for over 300 crops and crop-derived products in 225 countries (Mekonnen and Hoekstra 2010a). Factors have also been calculated for over 100 animal products in 202 countries (Mekonnen and Hoekstra 2010b). These factors are based on the weight of the product, i.e., cubic meters of water per kilogram of product, or acre-feet of water per ton of product. All goods are reported using codes from the Harmonized System (HS), which corresponds to trade data, as described below.

Industrial consumptive use factors are not differentiated by product in any global dataset. WFN has calculated average blue and grey water factors on a per-dollar basis for 230 countries. These factors are based on FAO-reported industrial withdrawal, and an assumption that blue water consumptive use is 5% of withdrawal. Green water is assumed to not factor into industrial production. Industrial grey water factors are calculated using FAO data showing country-level average percentage of wastewater that is treated. That percentage is multiplied by the amount of industrial water withdrawn but not consumed (95% of withdrawal) (Mekonnen and Hoekstra 2011a).

Other uses of water, including residential, commercial, and institutional uses, do not generally factor into the external water footprint calculations as they are not traded directly. Theoretically they could be, as many services like call and data centers and tourism outside of California that Californians "consume" are generally considered exports in those countries' national accounts, so the water use involved in those industries could also be included in California's external water footprint. However, these calculations are complicated, mostly excluded from current footprint analyses, and are likely to be a very small part of the overall water footprint. Future improvements in the footprint methodology could evaluate these factors.

Trade

Trade data are required to calculate California's internal and external water footprints. The U.S. Census Bureau collects California trade data with domestic and international trade partners.

Domestic trade data are collected in the Commodity Flow Survey (CFS), conducted every five years in coordination with the Bureau of Transportation Statistics (BTS). We used CFS data from 2007, the most recent data available, to calculate domestic shipments to and from California. State of origin, destination, shipment weights, and values are organized by both the North American Industrial Classification System (NAICS) and the Standard Classification of Transported Goods (SCTG). For industrial goods, the NAICS data provides the same level of resolution as the water footprint factors mentioned above, allowing us to map domestic virtual water flows on a per-dollar basis. For agricultural goods, however, the SCTG trade data is only disaggregated into nine categories, so blue, green, and grey water coefficients were generated as a weighted average over several agricultural industries (for example all fruits and vegetables are combined into one category) in order to estimate the virtual water flows inside the U.S. This is a major data limitation in our study and adds uncertainty to the domestic virtual water flow estimates.

International trade data are organized according to the Harmonized System (HS) and are available at a finer resolution of products than domestic data. State-level HS data are tracked annually by the U.S. Census Bureau and reported in its “USA Trade *Online*” system. Exports from California to global trading partners are available for 2007 on a value and weight basis. We included 285 exported products, which were aggregated into 75 product categories (see Appendix 3 for detail). Imports into California are available only for 2008, which we assume are similar to 2007 levels, and are reported on a “state of final destination” basis meaning that goods destined to other states that go through California ports are not counted. We included 389 imported products, with the additional products not included in Appendix 3 being categorized as “other” and listed in Appendix 4.

Data from USA Trade *Online* only reports weight values for commerce traded by sea and air, thus missing the weight of overland agricultural trade with Canada and Mexico. For these agricultural trade flows, we transformed the values of overland shipments to weights using value-to-weight ratios from BTS’ North American Transborder Freight Database, as well as aggregations of 10-digit value-to-weight ratios derived from USA Trade *Online*. For industrial trade flows, monetary values were sufficient to be applied to industrial water footprint factors from trading partner countries.

Limitations

Our results provide the first comprehensive water footprint for California, but the analysis has several limitations. Many challenges were faced in using California-specific data, both in incorporating these data into the water footprint methodology and in interpreting the results. We attempted to make our data selection and method transparent so that the analysis could be repeated by others. Nevertheless, uncertainties exist and more data would allow a clearer picture of California’s water footprint. For example, DWR’s Land and Water Use Survey (LWUS) is reported annually but actual data collection happens on average only every seven years, potentially missing some changes in cropping and irrigation systems that have recently occurred. Furthermore, if the sources of applied water per crop could be better distinguished between groundwater and surface water, better understanding of water footprint impacts could be formulated. Trade data, particularly on the domestic level, is also a limiting factor for developing

an accurate geographic picture of California's water footprint. We have also noted the need for higher resolution data on industrial water use, better separation of “withdrawals” versus “consumption” by sector, and reconciliation of import and export reporting categories among state, national, and international databases.

Results

In the following section, we report the results of our analysis. We present a general overview of California's water footprint, and then break it out to look in detail at California's internal and external water footprint. Results are reported separately for blue and green water and for gray water and are rounded to two significant figures.

California's Water Footprint

Our analysis finds that California's overall water footprint – the total amount of water (from California and elsewhere) consumptively used in the production of goods and services consumed within California – is 64 million acre-feet (MAF) per year (see Figure 4). This estimate represents the blue and green water associated with the consumption of agricultural and industrial goods, as well as residential, commercial, and institutional water consumption. Nearly 30% of the total water footprint (19 MAF) is associated with goods that are produced and consumed in California – referred to as California's internal water footprint. About 70% of California's water footprint (44 MAF) is associated with goods that are consumed in California but are produced outside of the state – referred to as California's external water footprint. The majority of California's external water footprint relates to goods imported from other U.S. states and to a lesser degree from California's major foreign trading partners.

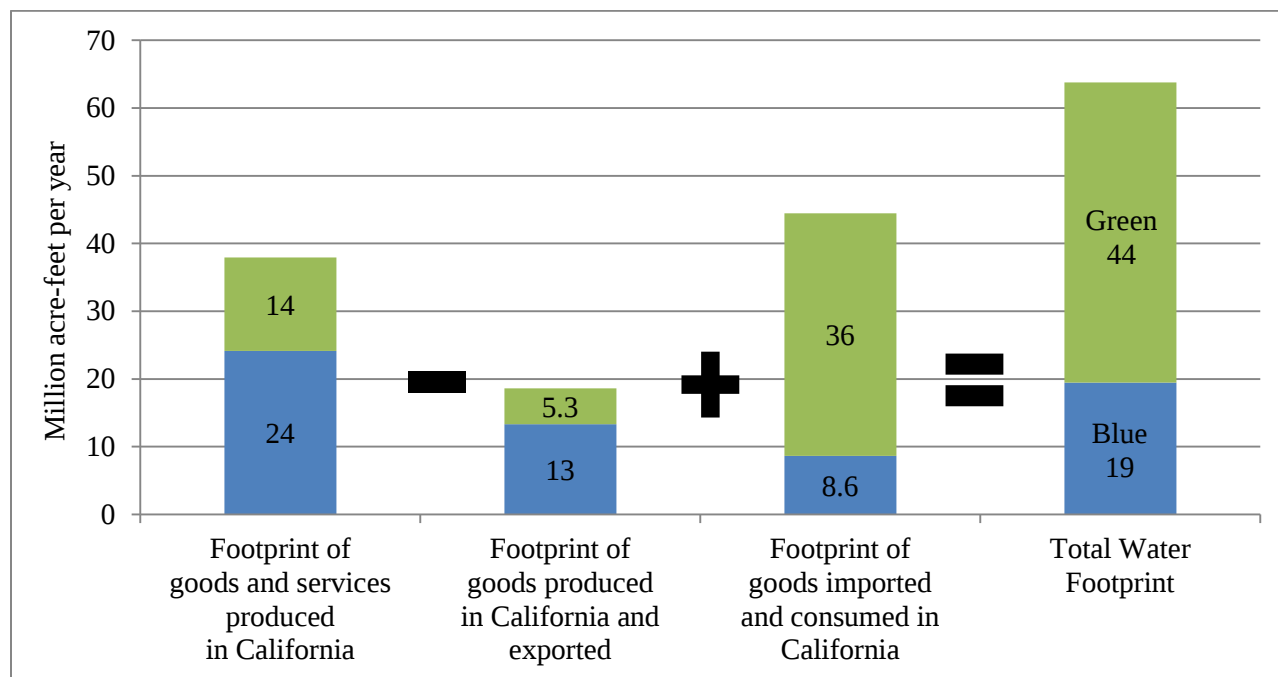


Figure 4. California's Blue and Green Water Footprint, by Component

On a per-capita basis, California's green and blue water footprint is about 1,500 gallons per capita per day (GPCD).¹² The average Californian's water footprint is slightly less than the average American's (Mekonnen and Hoekstra 2011a) but about 80% higher than the global average (Hoekstra and Mekonnen 2012) (Figure 5). Because of the large quantity of blue water used in California's production systems, however, blue water represents a much larger component of the average Californian's water footprint than that of the average American. Almost half (720 GPCD) of the average Californian's water footprint is associated with the consumption of meat and dairy products, which is less than for the average American but much more than the global average (Mekonnen and Hoekstra 2011b).

In the following sections we provide detailed results on each of the components of Figure 4, including discussion on notable products; water "types" (color); trade patterns; and the economic values of California's water footprint components. Finally, we present preliminary calculations for the grey water footprint for California and identify areas of future research on California's water footprint.

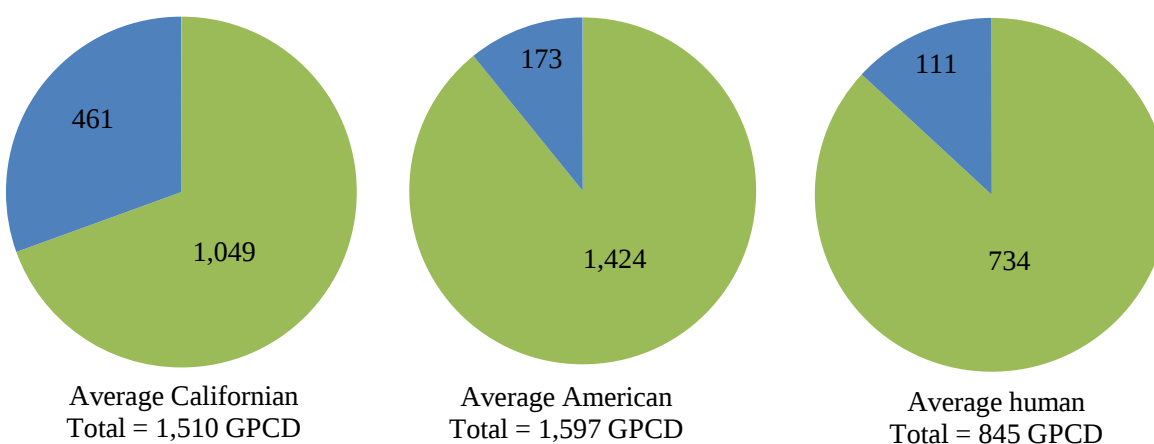


Figure 5. California's Blue and Green Water Footprint, by Water Type

¹² We assume a 2007 population of 37.6 million people.

California's Internal Water Footprint

Water Footprint of Goods and Services Produced in California

The production of all goods and services in California (including those goods and services that may be exported) consumes 38 MAF of water, of which about 64% is blue water and 36% is green water.¹³ California's agricultural sector accounts for 93% of this water consumption, with the remainder associated with the residential (5%), industrial (1%), and commercial/institutional (1%) sectors (See Figure 6).

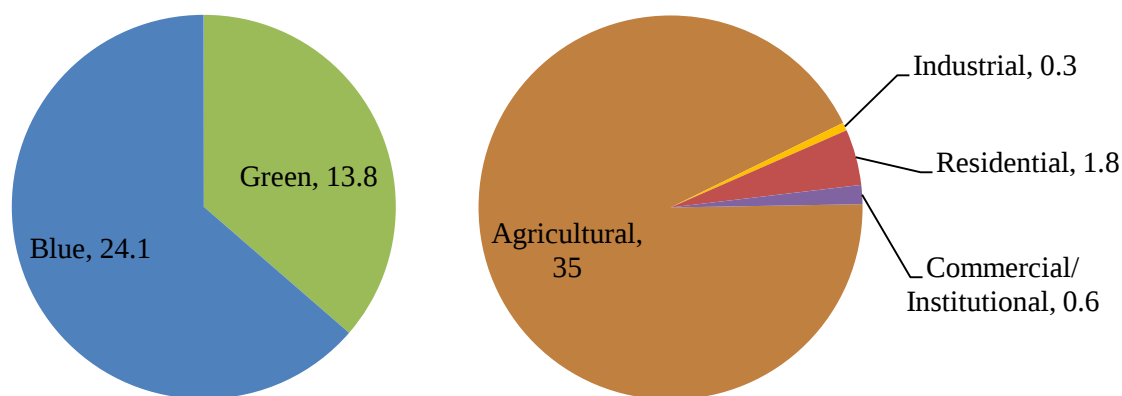


Figure 6. Blue and Green Water Footprints of Goods and Services Produced in California, in Million Acre-Feet per Year

Because these results deal only with the use of water resources in California, they can be compared to data reported by DWR. DWR (CDWR 2009) estimates that agricultural blue water consumption ranged from 17 to 23 MAF between 1998 and 2005, which is consistent with our estimate of 22 MAF. DWR estimates that agricultural green water consumption during this period averaged 2.4 MAF, significantly less than our green water estimate. DWR, however, only reports data for irrigated agriculture, whereas our estimate includes rainfed agriculture. DWR's estimate of the urban (industrial, residential, and commercial) blue water consumption was 2.5 MAF (averaged over 1998-2005), consistent with our estimate of 2.6 MAF (Technical Guide from CDWR 2009).

Figure 7 shows the green and blue water requirements of major agricultural products grown in California. Animal feed, which includes irrigated pasture, non-irrigated pasture, and other feed crops, has the greatest water requirements (15 MAF), followed by alfalfa, straw, and hay (5.5 MAF). Together, these crops provide the primary inputs to California's meat and dairy industry.¹⁴ Very few other products have a high green water footprint, while many products have

¹³ Note that grey water is reported separately.

¹⁴ As noted in the methods section, these industries rely heavily on imported animal feed, so the water footprint of meat and dairy products is reported separately after accounting for the import and export of animal feed.

significant blue water footprints as a result of California's extensive irrigation systems – primarily almonds, rice, grapes, and cotton.

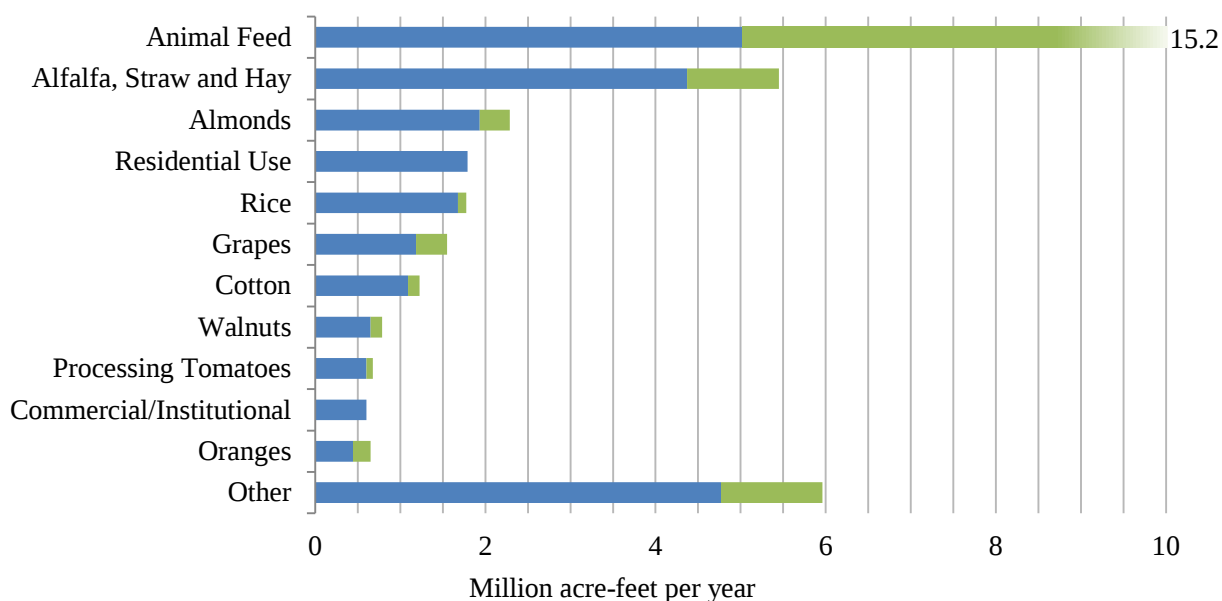


Figure 7. Blue and Green Water Footprints of Goods and Services Produced in California, by Product

Note the scale discontinuity for animal feed

Water Footprint of Goods Produced in California and Exported

Many of the goods produced in California are exported outside of the state's borders, so to calculate California's internal water footprint we must subtract the water footprint of those exported goods. We estimate that this "virtual water export" for California is 19 MAF, related to the export of goods outside of California's borders. Of this amount, about 30% (5.3 MAF) is green water and 70% (13.3 MAF) is blue water. These "green water exports" and "blue water exports" are almost entirely in the form of agricultural goods (Figure 8).

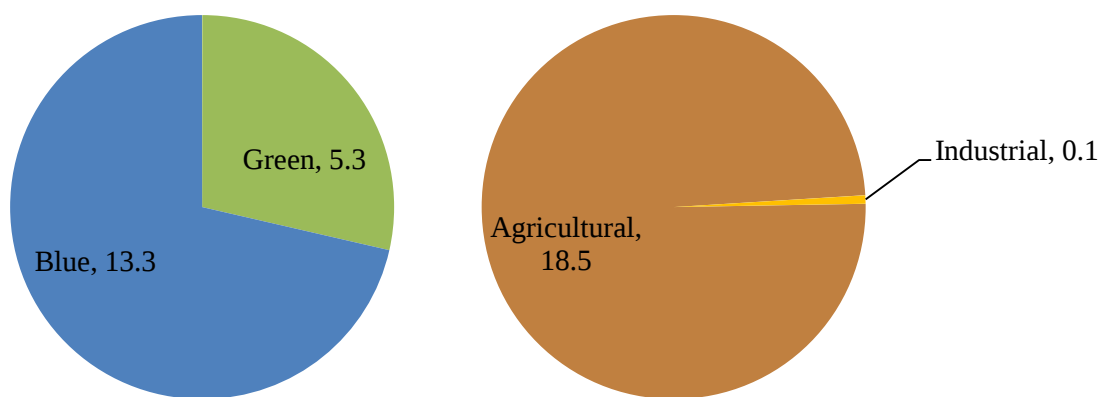


Figure 8. Blue and Green Water Footprints of Goods Produced in California and Exported, in Million Acre-Feet

On a geographical basis, most of California's blue and green water exports (11 MAF) go to other U.S. states (Figure 9). We were unable to estimate blue and green water exports to individual states due to limitations with trade data, although the data suggests that the largest exports of goods (by weight) were to Arizona, Texas, and Washington. Nearly 7.2 MAF of blue and green water is exported to other countries, including Japan (1.2 MAF), Mexico (0.8 MAF), Canada (0.6 MAF), and China (around 0.6 MAF).

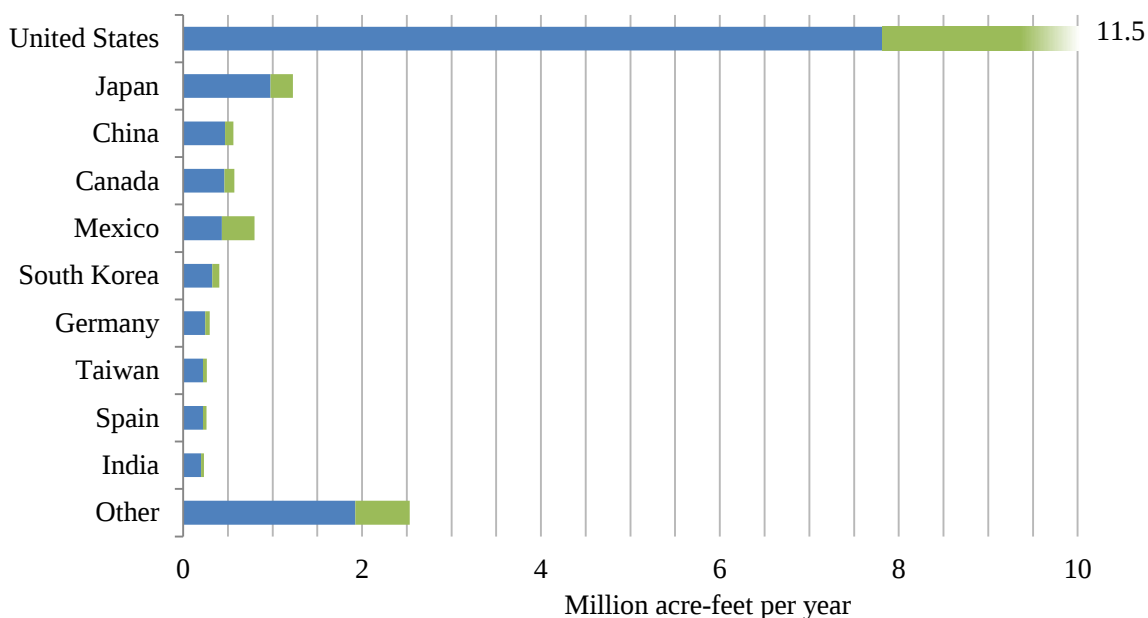


Figure 9. Blue and Green Water Footprints of Goods Produced in California and Exported, by Destination

Note the scale discontinuity for the United States

On a product basis, the categories used to report domestic and international trade are reported differently and therefore cannot be combined. We can, however, evaluate domestic and international trade data separately. Within the United States, the greatest volume of California's blue and green water resources is associated with the export of prepared foodstuffs, such as dairy products and processed fruits, nuts, and vegetables (Figure 10). Large amounts of blue water are also associated with the export of milled grain products (like baked goods) and other agricultural products (like fresh fruits and vegetables). Significant green water is associated with the export of meat products and alcoholic beverages, e.g., wine.

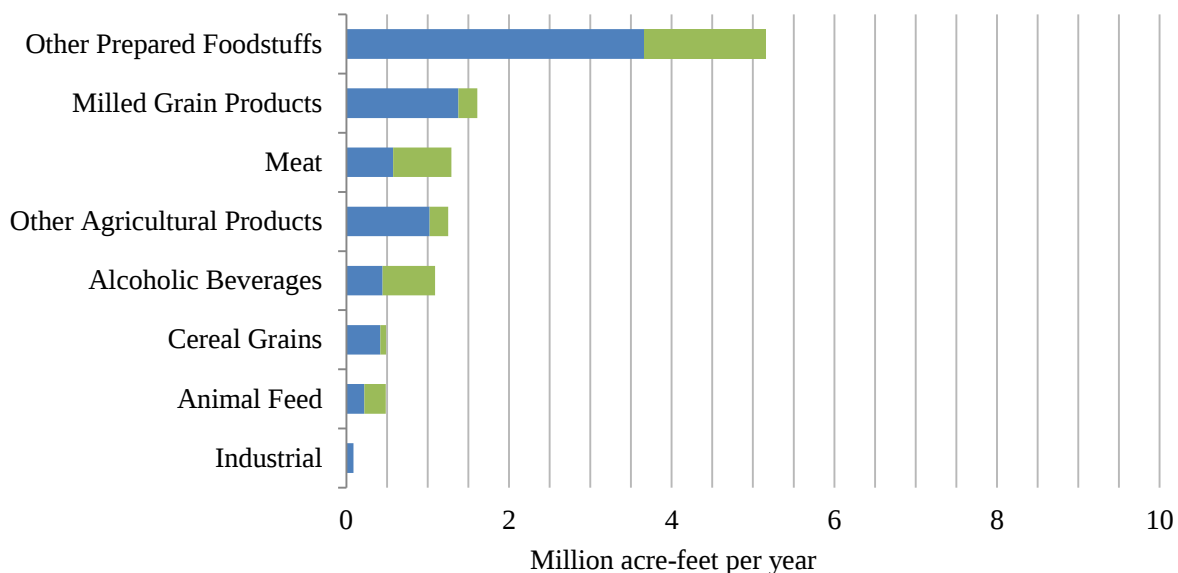


Figure 10. Blue and Green Water Footprints of Goods Produced in California and Exported Domestically

International trade data are available at a higher resolution, which allows for a more refined analysis of California's green and blue water exports (Figure 11). Meat and dairy products account for the largest export of blue and green water, at 1.3 MAF, most of which is green water. Almonds and cotton also represent large water exports, at more than 1.0 MAF, much of which is blue water. Other export crops with significant water requirements include alfalfa, grapes, and walnuts.

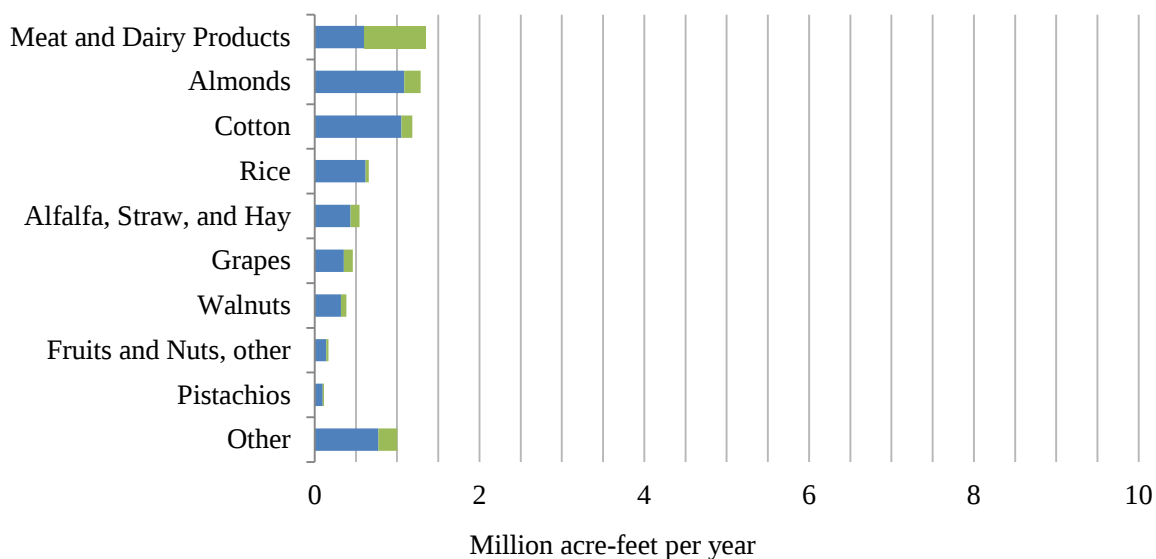


Figure 11. Blue and Green Water Footprints of Goods Produced in California and Exported Internationally

California's External Water Footprint

California's external water footprint is associated with goods that are produced outside of California but are imported and consumed within the state. At 44 MAF, it is more than double the water requirements of the state's exported goods (Figure 12). Of this amount, about 80% (36 MAF) is green water, while the remaining 20% (8.6 MAF) is blue water. Agricultural goods account for most of the external water footprint, with the remainder associated with industrial goods.

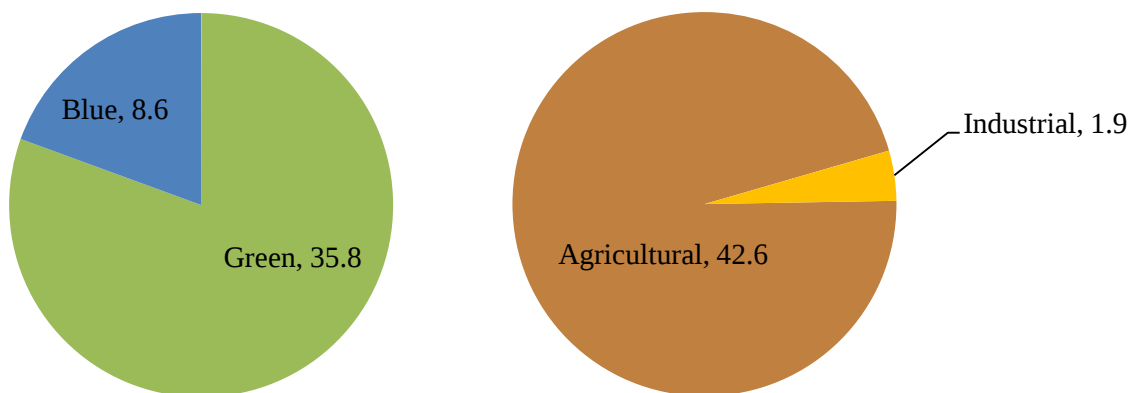


Figure 12. Blue and Green Water Footprints of Goods Produced Outside of California and Imported, in Million Acre-Feet per Year

On a geographical basis, nearly half of California's external water footprint is associated with goods produced in other parts of the U.S. (Figure 13). As with exports, it was difficult to estimate the water footprint attributed to individual states, but the largest imports of goods (by weight) in 2007 were from Nebraska, Iowa, and Washington. California's blue and green water imports also come from other countries. For example, California imports the equivalent of 1.9 MAF of water from Mexico, 1.6 MAF from Canada, and 1.3 MAF from China. Imports from China, mostly in the form of industrial goods, account for California's largest international blue water footprint (0.65 MAF). Most of the other international blue water imports are associated with agricultural goods. California's international green water import is entirely related to the import of agricultural goods.

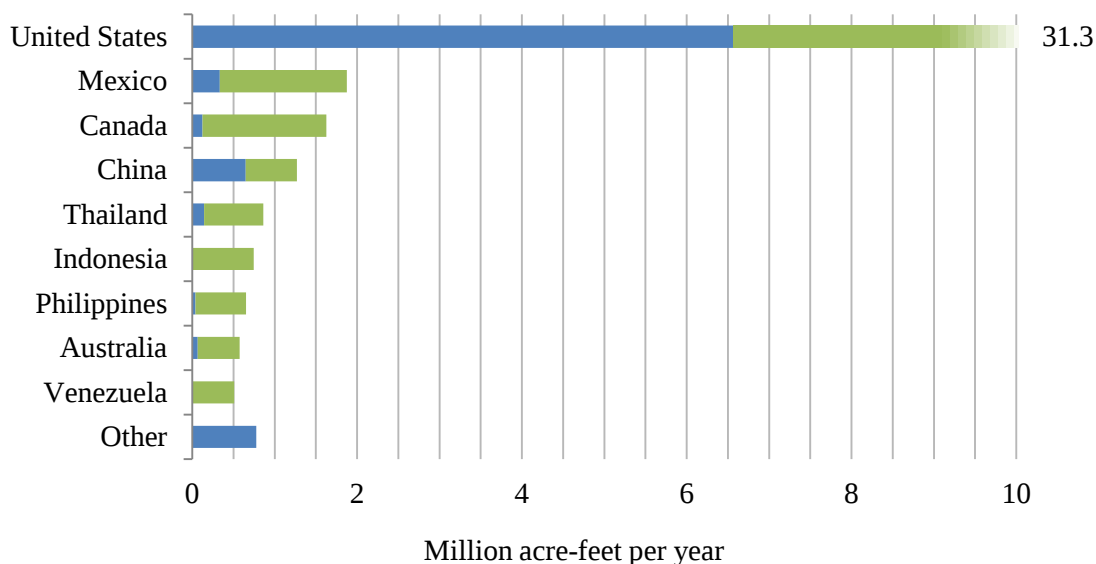


Figure 13. Blue and Green Water Footprints of Products Produced Outside of California and Imported, by Origin

Note the scale discontinuity with the United States

On a product basis, the categories used to report domestic and international trade in official statistics are different and not directly comparable. However, as mentioned with exports above, we can account for them separately. Most of the water required to produce goods imported from other U.S. states (Figure 14) is associated with meat products and cereal grains that in turn provide inputs to California's meat and dairy industry. Other significant sources of California's external water footprint are associated with milled grain products like baked goods and prepared foodstuffs like dairy and processed fruits and vegetables.

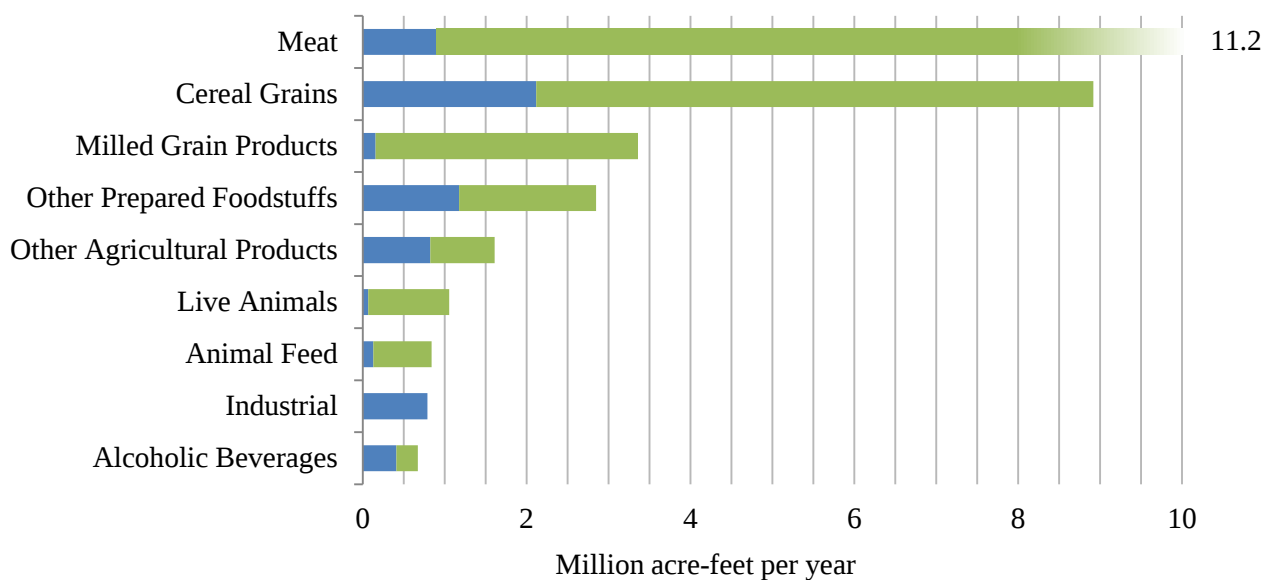


Figure 14. Blue and Green Water Footprints of Goods Produced in Other Parts of the U.S. and Imported

Note the scale discontinuity for meat

Exotic fruits (like bananas) and products like sugar, coffee, cocoa, and spices comprise the largest flows of blue and green water that are imported from international trade partners (Figure 15). Meat and dairy products, as well as rice, olive products, avocados, wheat, and grape products also make up large components of California's external water footprint from international trade partners.

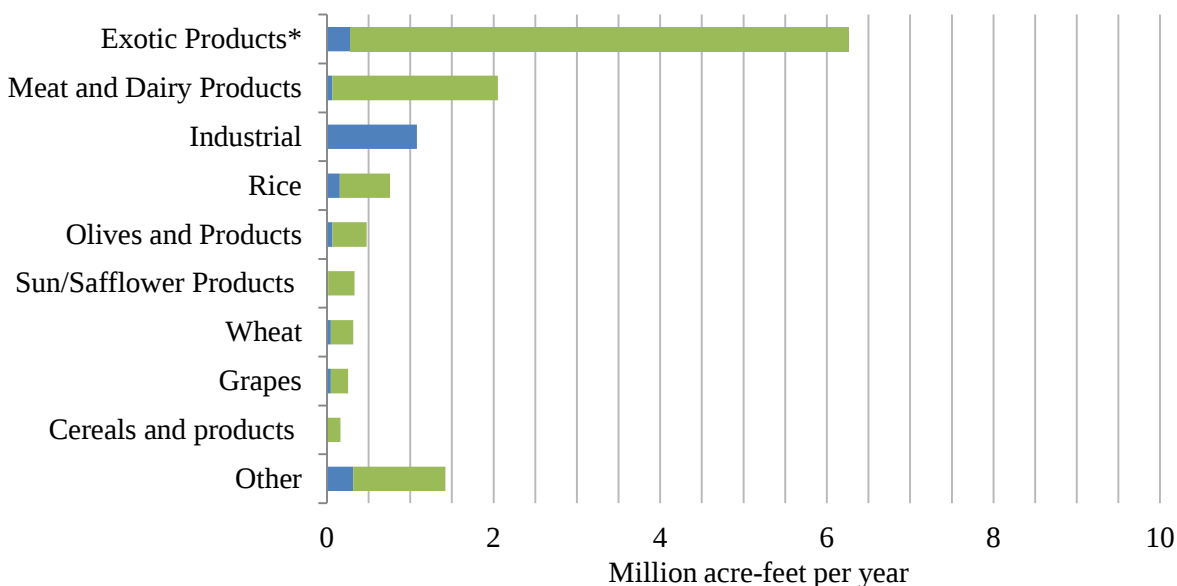


Figure 15. Blue and Green Water Footprints of Goods Produced Internationally and Imported

Note: * = exotic fruits, coffee, sugar, cocoa, and spices

Economic Values of Water Footprint Components

The water footprint, when combined with the monetary values of production and trade, highlights some of the connections between water use and California's economy (Figure 16). Overall, California's economy generates about \$3.1 trillion in gross revenue (sales) while using 38 million acre-feet (MAF) of in-state water resources, equivalent to \$0.25 per gallon of water. Exports generate \$0.6 trillion in revenue for California using 19 MAF, or \$0.10 per gallon. California imports \$0.8 trillion worth of goods that have a total water footprint of 44 million acre-feet; thus, we are paying the equivalent of about \$0.05 for every gallon of water imported into the state in the form of goods.

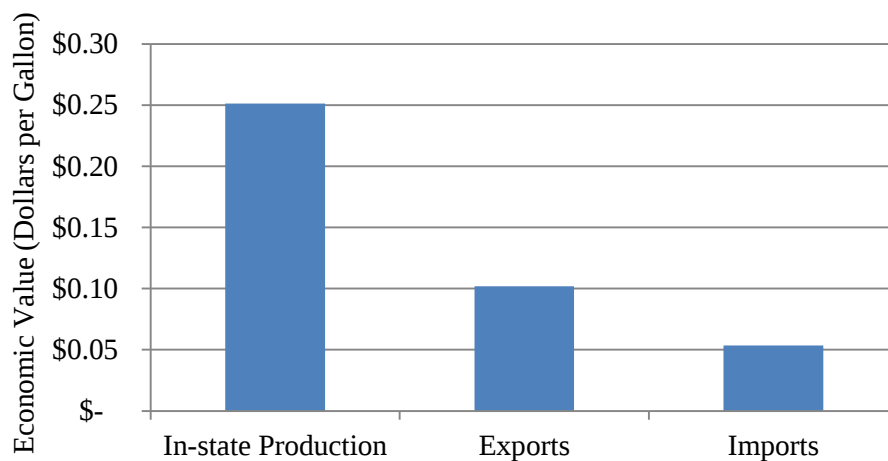


Figure 16. Dollar Value per Gallon of Production and Trade

These findings suggest that California exports relatively high-value products while importing more water-intensive, lower value products. In a water-scarce region like the western United States, this is a strategic advantage – California's economy is generating more revenue with less water. There are, however, hidden and typically unquantified costs of water use in the locations from where California imports products that support consumption within the state. Globally, water is generally underpriced and Californian consumers may be benefiting from overexploitation of water resources elsewhere.

The amount of water used to generate revenue from exports is also an important consideration for water managers in California. Exports have less than half the water productivity (dollars generated per gallon) of in-state production, which suggests that there may still be some potential for improving the economic productivity of water in California. California could realize an economic benefit if more of the available water were used for higher value goods. We note that these findings can inform state and national policies and decisions, but that maximizing the economic value per unit of water used is only one consideration in water policy and decision making. Environmental outcomes, social preferences, and equity issues are also important and must be taken into consideration.

Grey Water Footprint

Grey water represents the amount of water required to dilute pollutants discharged by an activity in order to meet local water quality standards. We estimate that California's grey water footprint associated with the consumption of agricultural and industrial goods is about 40 MAF per year (Figure 17). This amount is more than half of California's combined blue and green water footprint. The external component (grey water associated with goods produced outside of California but imported for consumption in the state) represents 80% (32 MAF) of California's grey water footprint. Thus, most of the water pollution associated with California's consumption of goods occurs outside of the state's borders. The external grey water footprint includes both goods imported from other U.S. states, as well as from major international trading partners. While most of California's grey water footprint is external, it is also important to note that 63% (14 MAF) of the grey water footprint of goods produced in California is associated with exports to its trading partners.

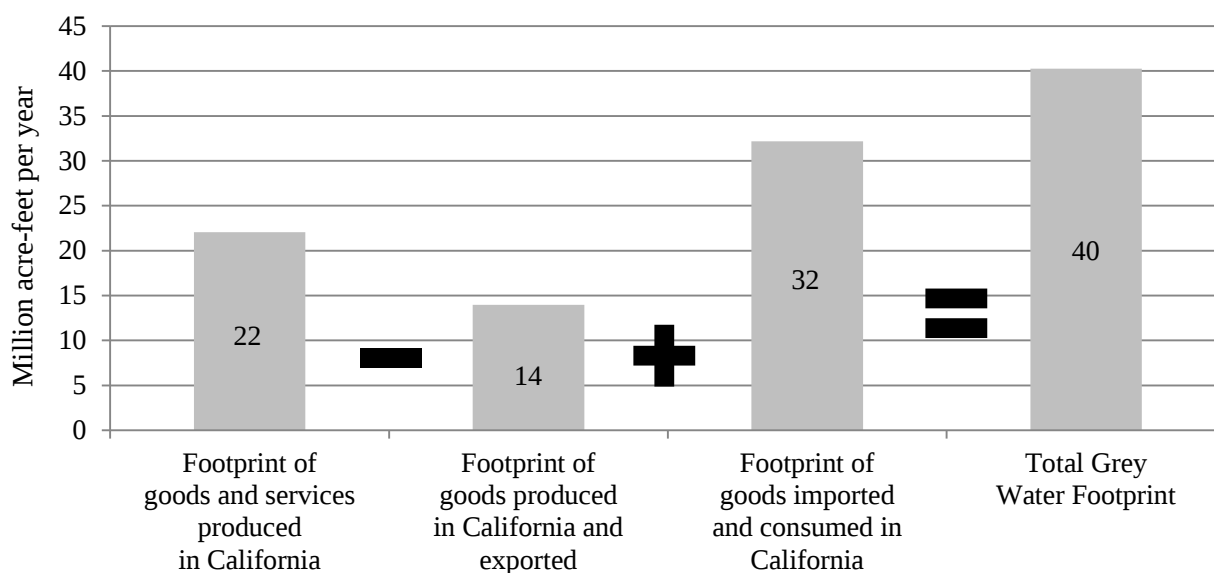


Figure 17. California's Grey Water Footprint, by Component

About 60% (25 MAF) of California's grey water footprint is associated with industrial goods, while 40% (16 MAF) is associated with agricultural goods (Figure 18). Because the industrial grey water footprint is calculated on a per-dollar basis, it is difficult to accurately determine which industrial goods consumed in California have the largest grey water footprint. However, computers and electronics comprise the largest dollar value of imports to California, so they are potentially significant contributors to California's grey water footprint. Geographically, most of California's grey water footprint is associated with goods imported from other U.S. states. Imports from China represent a larger grey water footprint (8.3 MAF) than goods produced and consumed in California (8.1 MAF).

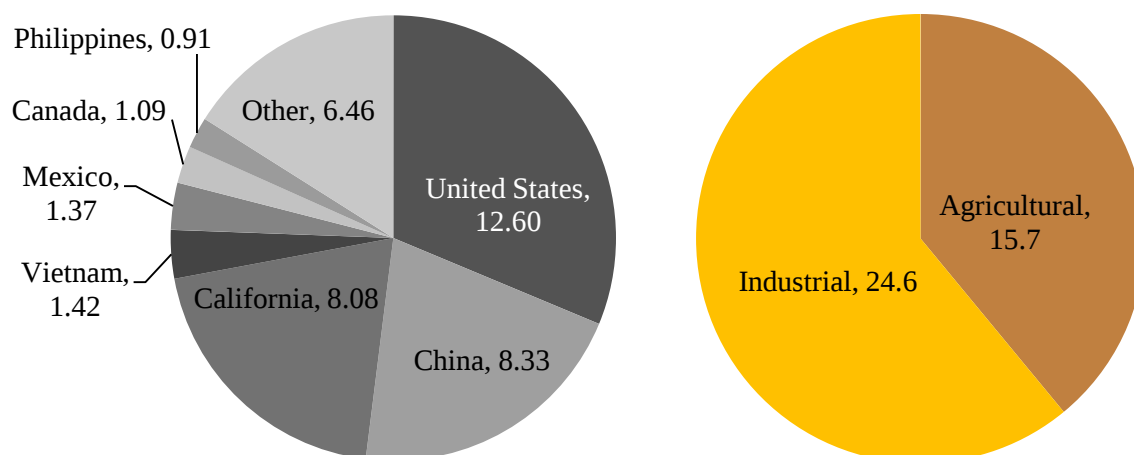


Figure 18. Grey Water Footprint of Products Consumed in California, by Location and Sector, in Million Acre-Feet per Year

Next Steps

This study provides an initial assessment of California's water footprint. In the near term, future work includes six steps. First, we will extend our water footprint analysis to other sectors like energy and mining, which can affect water systems in significant ways. Second, we will conduct a regional water footprint assessment in order to understand embedded water flows and regional differences within California. Third, we will study the temporal dynamics of California's water footprint in order to understand how factors like population growth, climate, water management strategies, and trade regimes might affect the water footprint over time. Fourth, we will refine our understanding of California's grey water footprint, both in term of data sources and calculation methods, as well as in terms of how the grey water footprinting should be interpreted in conjunction with the blue and green. Fifth, we will identify more carefully the uncertainties embedded in our calculations and report estimated variance in the results. Lastly we will be making a business case for more widespread use of the water footprint and deeper understanding of California businesses' relationship to water resources inside California and beyond.

Conclusions

California's total net water footprint is around 64 million acre-feet per year – the total water required to produce the goods and services consumed within the state. About 70% of this water is associated with the import of goods; California is thus a net virtual water importer. Much of this virtual water import is “green water,” from the direct use of precipitation in agricultural production (not irrigation) in other parts of the U.S. and world. This situation is likely a reflection of California's unique Mediterranean climate and a lack of precipitation during the summer growing months. Thus the import of virtual water is strategic in that California enjoys the benefits of being able to consume water-intensive products without having to impact scarce local water resources. Nevertheless, further research is needed to understand the water-related impacts in locations where the goods that Californians consume are produced.

Within California, the economy relies more heavily on surface and groundwater supplies, or “blue water.” Over 50% of California's blue water resources that are put into production are associated with goods that are exported outside of the state's borders and consumed elsewhere. This virtual water export is likely a reflection of the role California's agricultural industry plays in supplying a significant portion of the nation's fruits and vegetables. However, the economic productivity of exports (\$0.10 in export sales per gallon of water) is greater than of imports (\$0.05 per gallons) but far less than the productivity of California's entire economy (\$0.25 in sales per gallon). The reduced economic benefit of those exports suggests that California could realize an economic benefit if more of the available water were used for higher value products. We note that while these findings can inform state and national policies and decisions, maximizing the economic value per unit of water used is only one consideration in water policy and decision making. Environmental outcomes, social preferences, and equity issues are also important and must be taken into consideration.

On an individual basis, the average Californian's water footprint is about 1,500 gallons per day, which is about ten times larger than the average Californian's daily water use (withdrawal) for residential purposes. This amount is only slightly less in magnitude than the water footprint of the average American (1,600 gallons per day), although there are key differences. First, California's water footprint has a larger component of “blue water,” meaning that the state relies more on applied surface water (primarily in irrigation) that may have had tradeoffs with other uses, such as supporting ecosystems. Second, the external component (water required to produce goods and services imported into the state for consumption) makes up the majority of Californians' total water footprint, meaning that consumer impact on water resources from outside the state is significant. This information would be useful for consumers wishing to make informed choices or orient their purchasing around local production.

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Appendix 1: County Agricultural Commissioners' Production Data Commodities Categorized by CDWR Land and Water Use Survey Crop Categories

CDWR Code	USDA Commodity Description
Al Pist	Almond Hulls, Almonds All, Pistachios
Alfalfa	Hay Alfalfa, Seed Alfalfa, Sprouts Alfalfa & Bean
Corn	Corn Crazy, Corn Grain, Corn Popcorn, Corn Seed, Corn Silage, Corn Sweet All, Corn White
Cotton	Cotton Lint Pima, Cotton Lint Unspecified, Cotton Lint Upland, Cotton Seed Planting, Cottonseed
Cucurb	Cucumbers, Cucumbers Greenhouse, Melons Cantaloupe, Melons Casaba, Melons Honeydew, Melons Unspecified, Melons Watermelon, Pumpkins, Squash
DryBean	Beans Blackeye, Beans Dry Edible Unspecified, Beans Fava, Beans Fresh Unspecified, Beans Garbanzo, Beans Kidney Red, Beans Lima Baby Dry, Beans Lima Green, Beans Lima Lg. Dry, Beans Lima Unspecified, Beans Pink, Beans Seed, Soybeans,
Fr Tom	Tomatoes Cherry, Tomatoes Fresh Market, Tomatoes Greenhouse, Tomatoes Unspecified
Grain	Barley Feed, Barley Malting, Barley Seed, Barley Unspecified, Food Grains Misc., Hay Grain, Hay Green Chop, Hay Other Unspecified, Hay Wild, Oats Grain, Oats Seed, Rye Grain, Rye Seed, Silage, Straw, Wheat All, Wheat Seed
On Gar	Garlic All, Onions, Onions Green & Shallot
Oth Dec	Apples All, Apricots All, Cherries Sweet, Chestnuts, Figs Dried, Fruits & Nuts Unspecified, Nectarines, Peaches Clingstone, Peaches Freestone, Peaches Unspecified, Pears Asian, Pears Bartlett, Pears Prickly, Pears Unspecified, Pecans, Persimmons, Plumbcots, Plums, Plums Dried, Pomegranates, Pomelo, Quince, Walnuts Black, Walnuts English
Oth Fld	Field Crop By-Products, Field Crops Seed Misc., Field Crops Unspecified, Hay Sudan, Seed Other (No Flowers), Seed Sudan Grass, Sorghum Grain, Sorghum Silage, Sunflower Seed, Sunflower Seed Planting
Oth Trk	Anise (Fennel), Artichokes, Asparagus Fresh Market, Asparagus Processing, Asparagus Unspecified, Beans Snap Fresh Market, Beans Snap Processing, Beans Snap Unspecified, Beets Garden, Berries Blackberries, Berries Boysenberries, Berries Bushberries Unspec., Berries Loganberries, Berries Olallieberries, Berries Raspberries, Berries Strawberries F Mkt, Berries Strawberries Proc., Berries Strawberries Unspec, Biomass Orchard, Broccoli Food Service, Broccoli Fresh Market, Broccoli Processing, Broccoli Unspecified, Brussels Sprouts, Cabbage Ch. & Specialty, Cabbage Head, Cabbage Red, Cardoon, Carrots Food Service, Carrots Fresh Market, Carrots Processing, Carrots Unspecified, Cauliflower Food Service, Cauliflower Fresh Market, Cauliflower Processing, Cauliflower Unspecified, Celery Food Service, Celery Fresh Market, Celery Processing, Celery Unspecified, Chayotes, Cherimoyas, Chives, Christmas Trees & Cut Greens, Cilantro, Collard Greens, Endive All, Escarole All, <i>(continued on next page)</i>

	Flowers Anthuriums Cut, Flowers Asters Cut, Flowers Cacti Succulents, Flowers Carnation Cut Min., Flowers Carnation Cut Std., Flowers Carnation Unspec., Flowers Chrysanth. Cut Pom., Flowers Chrysanth. Cut Std., Flowers Chrysanth. Unspec., Flowers Cut Unspecified, Flowers Decorative Dried, Flowers Foliage Cut All, Flowers Foliage Plants, Flowers Gardenias Cut, Flowers Irises Cut, Flowers Lilacs Cut, Flowers Mums Potted, Flowers Orchids Cut All, Flowers Poinsettia Potted, Flowers Roses Cut Min., Flowers Roses Cut Standard, Flowers Roses Unspecified, Greens Turnip & Mustard, Horseradish, Kale, Kohlrabi, Leeks, Lettuce Bulk Salad Prods., Lettuce Head, Lettuce Leaf, Lettuce Romaine, Lettuce Unspecified, Mint, Mustard, Nursery Flower Seeds, Nursery Herbaceous, Nursery Plants Strawberry, Nursery Plants Veg. Bedding, Okra, Parsley, Parsnips, Peanuts All, Peas Dry Edible, Peas Edible Pod (Snow), Peas Green Fresh Market, Peas Green Processing, Peas Green Unspecified, Peas Seed, Peppers Bell, Peppers Chili Hot, Radicchio, Radishes, Rappini, Rhubarb, Rutabagas, Salad Greens Misc., Salad Greens Nec., Seed Veg & Vinecrop, Spices And Herbs, Spinach Food Service, Spinach Fresh Market, Spinach Processing, Spinach Unspecified, Swiss Chard, Tomatillo, Turnips All, Vegetables Baby, Vegetables Greenhouse, Vegetables Oriental All, Vegetables Unspecified, Watercress
Pasture	Nursery Turf, Pasture Forage Misc., Pasture Irrigated, Pasture Range, Seed Bermuda Grass, Seed Clover Unspecified, Seed Grass Unspecified, Seed Ladino Clover
Potato	Potatoes Irish All, Potatoes Seed, Potatoes Sweet
Pro Tom	Tomatoes Processing
Rice	Rice Milling, Rice Seed, Rice Sweet, Rice Wild
Safflower	Safflower, Safflower Seed Planting
Sugarbeet	Sugarbeet
Subtrop	Avocados All, Citrus By-Products Misc., Citrus Unspecified, Dates, Eggplant All, Feijoa, Grapefruit All, Guavas, Jojoba, Kiwifruit, Kumquats, Lemons All, Limes All, Macadamia Nuts, Olives, Oranges Navel, Oranges Unspecified, Oranges Valencia, Tangelos, Tangerines & Mandarins
Vine	Grapes Raisin, Grapes Table, Grapes Unspecified, Grapes Wine
Not Categorized	Apiary Products Bees Nuclei, Apiary Products Bees Pkg., Apiary Products Bees Queen, Apiary Products Bees Unspec, Apiary Products Beeswax, Apiary Products Honey, Apiary Products Pollen, Biomass For Energy, Cattle & Calves Unspecified, Cattle Beef Bulls Breeding, Cattle Beef Cow Breeding, Cattle Beef Cows Cull, Cattle Bulls, Cattle Calves Only, Cattle Calves Veal, Cattle Cows, Cattle Dairy Cows Breeding, Cattle Dairy Heifers Repl., Cattle Heifers, Cattle Heifers & Steers Fed, Cattle Heifers Fed Steers, Cattle Milk Cows, Cattle Milk Cows Cull, Cattle Steers, Cattle Stockers Feeders, Chickens Broilers, Chickens Chicks, Chickens Chicks Broiler, Chickens Hens Spent, Chickens Pullets Laying, Chickens Unspecified, Eggs Chicken Hatching, Eggs Chicken Market, Eggs Chicken Unspecified, Eggs Duck All, Eggs Turkey Hatching, Eggs Unspecified, Filberts, Fish, Forest Products Firewood, Forest Products Unspecified, Game Birds, Game Birds Ducks, Game Birds Geese, Game Birds Ostrich & Emu, Game Birds Pheasants, Game Birds Pigeons & Squabs, Game Birds Quail, Goat Cheese, Goats & Kids Unspecified, Goats Milk, Hogs & Pigs Unspecified, (cont.)

	Livestock Products Misc., Livestock Unspecified, Manure, Milk Cow'S Unspecified, Milk Manufacturing, Milk Market Fluid, Mohair, Mushrooms, Nursery Bulbs Lily, Nursery Fl Blbs./Crms./Rhiz., Nursery Fl. Propg. Mtrls, Nursery Frt/Vine/Nut N-Bear, Nursery Geraniums, Nursery Hort. Specmn. Misc., Nursery Plants Bedding, Nursery Plants Orchid, Nursery Plants Pot'D Unsp, Nursery Plants Rose, Nursery Products Misc., Nursery Woody Ornamntals, Poultry Unspecified, Rabbits, Seed Vetch, Sheep, Sheep & Lambs Unspecified, Sheep Breeding Stock, Sheep Ewes Cull, Sheep Lambs, Sheep Lambs Feedlot Fat, Turkeys Poult, Turkeys Toms & Hens, Turkeys Unspecified, Wool
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Appendix 2: County Agricultural Commissioners' Production Data Commodity Descriptions Related to PI Codes

PI Code	CAC Commodity Description
Alfalfa, Straw and Other Hay	Straw, Seed Alfalfa, Hay Wild, Hay Sudan, Hay Other Unspecified, Hay Green Chop, Hay Grain, Hay Alfalfa
Almonds	Almonds All
Animal Feed	Sprouts Alfalfa & Bean, Sorghum Silage, Silage, Seed Vetch, Seed Sudan Grass, Seed Ladino Clover, Seed Clover Unspecified, Seed Bermuda Grass, Pasture Range, Pasture Irrigated, Pasture Forage Misc., Corn Silage, Barley Feed, Almond Hulls
Apples & Products	Apples All
Apricot	Apricots All
Artichokes	Artichokes
Asparagus	Asparagus Unspecified, Asparagus Processing, Asparagus Fresh Market
Avocado	Avocados All
Barley	Barley Unspecified, Barley Seed, Barley Malting
Beans Dry	Beans Seed, Beans Pink, Beans Lima Unspecified, Beans Lima Lg. Dry, Beans Lima Large Dry, Beans Lima Baby Dry, Beans Kidney Red, Beans Garbanzo, Beans Dry Edible Unspecified, Beans Dry Edible Unspec., Beans Blackeye,
Beans Fresh/ Frozen/Canned	Beans Snap Unspecified, Beans Snap Processing, Beans Snap Fresh Market, Beans Lima Green, Beans Fresh Unspecified, Beans Fava
Beets and Radishes	Radishes, Parsnips, Horseradish, Beets Garden
Brussels Sprouts	Brussels Sprouts
Cabbage and Brassicas	Rappini, Mustard, Kohlrabi, Kale, Collard Greens, Cabbage Red, Cabbage Head, Cabbage Chinese & Specialty, Cabbage Ch. & Specialty
Carrots and Turnips	Turnips All, Carrots Unspecified, Carrots Processing, Carrots Fresh Market, Carrots Food Service
Cauliflower and Broccoli	Cauliflower Unspecified, Cauliflower Processing, Cauliflower Fresh Market, Cauliflower Food Service, Broccoli Unspecified, Broccoli Processing, Broccoli Fresh Market, Broccoli Food Service
Celery	Celery Unspecified, Celery Processing, Celery Fresh Market, Celery Food Service
Cereals and products	Rice Wild, Food Grains Misc., Field Crops Unspecified, Field Crops Seed Misc., Field Crop By-Products
Cherries	Cherries Sweet
Chestnuts	Chestnuts
Citrus Other	Pomelo, Kumquats, Citrus Unspecified
Citrus Peels	Citrus By-Products Misc.
Corn other	Corn White, Corn Popcorn, Corn Grain, Corn Crazy
Corn Seed	Corn Seed
Corn sweet	Corn Sweet All

Cotton	Cottonseed, Cotton Seed Planting, Cotton Lint Upland, Cotton Lint Unspecified, Cotton Lint Pima (<i>continued on next page</i>)
Cucumbers	Cucumbers Greenhouse, Cucumbers
Dates	Dates
Eggplant	Eggplant All
Figs	Figs Dried
Fruits & Nuts Nesoi	Pomegranates, Persimmons, Pecans, Jojoba, Guavas, Fruits & Nuts Unspecified, Cherimoyas
Garlic	Garlic All
Grapefruit	Grapefruit All
Grapes	Grapes Wine, Grapes Unspecified, Grapes Table, Grapes Raisin
Kiwis	Kiwifruit
Leeks	Leeks
Lemons and Limes	Limes All, Lemons All
Lettuce	Salad Greens Nec., Salad Greens Misc., Radicchio, Lettuce Unspecified, Lettuce Romaine, Lettuce Leaf, Lettuce Head, Lettuce Bulk Salad Products, Lettuce Bulk Salad Prods., Escarole All, Endive All
Macadamia Nuts	Macadamia Nuts
Meat and Dairy Products	Wool, Turkeys Unspecified, Turkeys Toms & Hens, Turkeys Poults, Sheep Lambs Feedlot Fat, Sheep Lambs, Sheep Ewes Cull, Sheep Breeding Stock, Sheep & Lambs Unspecified, Sheep, Rabbits, Poultry Unspecified, Pigeons & Squabs, Pheasants, Ostrich & Emu, Mohair, Milk Market Fluid, Milk Manufacturing, Milk Cow'S Unspecified, Manure, Livestock Unspecified, Livestock Products Misc., Hogs & Pigs Unspecified, Goats Milk, Goats & Kids Unspecified, Goat Cheese, Geese, Game Birds Unspec, Game Birds Quail, Game Birds Pigeons & Squabs, Game Birds Pheasants, Game Birds Ostrich & Emu, Game Birds Geese, Game Birds Ducks, Game Birds, Fish, Eggs Unspecified, Eggs Turkey Hatching, Eggs Duck All, Eggs Chicken Unspecified, Eggs Chicken Market, Eggs Chicken Hatching, Ducks, Chickens Unspecified, Chickens Pullets Laying, Chickens Hens Spent, Chickens Chicks Broiler, Chickens Chicks, Chickens Broilers, Cattle Stockers Feeders, Cattle Steers, Cattle Milk Cows Cull, Cattle Milk Cows, Cattle Heifers Fed Steers, Cattle Heifers & Steers Fed, Cattle Heifers, Cattle Dairy Heifers Replacement, Cattle Dairy Heifers Repl., Cattle Dairy Cows Breeding, Cattle Cows, Cattle Calves Veal, Cattle Calves Only, Cattle Calves Excluded Unspecified, Cattle Calves Excl. Unspec., Cattle Bulls, Cattle Beef Cows Cull, Cattle Beef Cow Breeding, Cattle Beef Bulls Breeding, Cattle & Calves Unspecified
Melons	Melons Watermelon, Melons Unspecified, Melons Honeydew, Melons Casaba, Melons Cantaloupe
Mushrooms	Mushrooms
Nursery/flowers	Seed Other (No Flowers), Seed Grass Unspecified, Nursery Woody Ornamentals, Nursery Turf, Nursery Products Misc., Nursery Plants Vegetable Bedding, Nursery Plants Veg. Bedding, Nursery Plants Rose,

	Nursery Plants Potted Unspecified, Nursery Plants Pot'D Unsp, Nursery Plants Orchid, Nursery Plants Bedding, (cont.) Nursery Hort. Specmn. Misc., Nursery Herbacious Perennials, Nursery Herbac. Prnls, Nursery Geraniums, Nursery Fruit/Vine/Nut Non-Bearing, Nursery Flower Seeds, Nursery Flower Propagative Materials, Nursery Flower Bulbs/Corms/Rhizomes, Nursery Fl. Propg. Mtrls, Nursery Fl Blbs./Crms./Rhiz., Nursery Bulbs Lily, Flowers Roses Unspecified, Flowers Roses Cut Standard, Flowers Roses Cut Min., Flowers Poinsettia Potted, Flowers Orchids Cut All, Flowers Mums Potted, Flowers Lilacs Cut, Flowers Irises Cut, Flowers Gardenias Cut, Flowers Foliage Plants, Flowers Foliage Cut All, Flowers Decorative Dried, Flowers Cut Unspecified, Flowers Chrysanth. Unspec., Flowers Chrysanth. Cut Std., Flowers Chrysanth. Cut Pom., Flowers Chrysanthemum Unspecified, Flowers Carnation Unspecified, Flowers Carnation Unspec., Flowers Carnation Cut Std., Flowers Carnation Cut Miniature, Flowers Carnation Cut Min., Flowers Cacti Succulents, Flowers Asters Cut, Flowers Anthuriums Cut, Christmas Trees & Cut Greens
Oats	Oats Seed, Oats Grain
Olives & Products	Olives
Onions & shallots	Onions Green & Shallot, Onions
Oranges	Oranges Valencia, Oranges Unspecified, Oranges Navel
Other	Pears Prickly, Forest Products Unspecified, Forest Products Firewood, Filberts, Feijoa, Apiary Products Pollination Fees, Apiary Products Pollin. Bees, Apiary Products Honey, Apiary Products Beeswax, Apiary Products Bees Unspecified, Apiary Products Bees Unspec, Apiary Products Bees Queen, Apiary Products Bees Pckg., Apiary Products Bees Packaged, Apiary Products Bees Nuclei
Other Tubers	Rutabagas
Peaches and Nectarines	Peaches Unspecified, Peaches Freestone, Peaches Clingstone, Nectarines
Peanuts	Peanuts All
Pears and Quince	Quince, Pears Unspecified, Pears Bartlett, Pears Asian
Peas Dry	Peas Seed, Peas Dry Edible
Peas Fresh/Frozen/Canned	Peas Green Unspecified, Peas Green Processing, Peas Green Fresh Market, Peas Edible Pod (Snow)
Peppers	Peppers Chili Hot, Peppers Bell
Pistachio	Pistachios
Plants Other	Nursery Frt/Vine/Nut N-Bear
Plum	Plums Dried, Plums, Plumcots
Potatoes Irish	Potatoes Irish All, Potatoes All
Potatoes Seed	Potatoes Seed
Potatoes Sweet	Potatoes Sweet
Raspberries and	Berries Raspberries, Berries Olallieberries, Berries Loganberries,

other berries	Berries Bushberries Unspecified, Berries Bushberries Unspec., Berries, Boysenberries, Berries Blueberries, Berries Blackberries (<i>cont.</i>)
Rice	Rice Sweet, Rice Seed, Rice Milling
Rye	Rye Seed, Rye Grain
Safflower, Sunflower and Products	Sunflower Seed Planting, Sunflower Seed, Safflower Seed Planting, Safflower
Seeds Veg and Nesoi	Seed Vegetable & Vinecrop, Seed Veg & Vinecrop
Sgr Beet	Sugar Beets
Sorghum	Sorghum Grain
Soybeans	Soybeans
Spinach & Products	Spinach Unspecified, Spinach Processing, Spinach Fresh Market, Spinach Food Service
Strawberries Fresh	Nursery Plants Strawberry, Berries Strawberries Fresh Market, Berries Strawberries F Mkt
Strawberries Nesoi	Berries Strawberries Unspecified, Berries Strawberries Unspec
Strawberries Processed	Berries Strawberries Processing, Berries Strawberries Proc.
Tangerines and Mandarins	Tangerines & Mandarins, Tangelos
Tomatoes Fresh	Tomatoes Unspecified, Tomatoes Greenhouse, Tomatoes Fresh Market, Tomatoes Cherry
Tomatoes Processed	Tomatoes Processing
Vegetables Other	Watercress, Vegetables Unspecified, Vegetables Oriental All, Vegetables Greenhouse, Vegetables Baby, Tomatillo, Swiss Chard, Squash, Spices And Herbs, Rhubarb, Pumpkins, Parsley, Okra, Mint, Greens Turnip & Mustard, Cilantro, Chives, Chayotes, Anise (Fennel)
Walnuts	Walnuts English, Walnuts Black
Wheat	Wheat Seed, Wheat All, Triticale

Appendix 3: HS Traded Commodities Categorized by PI Code

PI Code	Harmonized system codes and descriptions
Alfalfa, Straw and Other Hay	120921 Alfalfa (lucerne) Seed For Sowing; 121140 Poppy Straw, Fresh/ Dried, Whtr/ Nt Cut, Crush,pwd; 121300 Cereal Straw & Husks Unprep W/n Chop Etc Or Pellet; 121410 Alfalfa (lucerne) Meal And Pellets; 121490 Forage Products Nesoi (hay, Clover, Vetches, Etc)
Almonds	080211 Almonds, Fresh Or Dried, In Shell; 080212 Almonds, Fresh Or Dried, Shelled
Apples & Products	080810 Apples, Fresh; 081330 Apples, Dried; 200971 Apple Juice Of A Birx Value <=20,nt Fort W Vitamin; 200979 Apple Juice, Nesoi,nt Fortified W Vitamins, Unferm
Apricot	080910 Apricots, Fresh; 081310 Apricots, Dried; 200850 Apricots, Prepared Or Preserved, Nesoi
Artichokes	070910 Globe Artichokes, Fresh Or Chilled
Asparagus	070920 Asparagus, Fresh Or Chilled; 200560 Asparagus, Prepared Or Preserved Nesoi, Not Frozen
Avocado	080440 Avocados, Fresh Or Dried
Barley	100300 Barley
Beans Dry	071320 Chickpeas (garbanzos), Dried Shelled, Include Seed; 071331 Beans (vigna Mungo (l.) Hepper Etc), Dried Shelled; 071332 Beans, Small Red (adzuki), Dried Shelled, Inc Seed; 071333 Kidney Beans & White Pea Beans, Dri Shel, Inc Seed; 071339 Beans Nesoi, Dried Shelled, Including Seed; 071350 Broad Beans & Horse Beans, Dried Shelled, Inc Seed
Beans Fresh/Frozen/Canned	070820 Beans (vigna Spp., Phaseolus Spp.) Fresh Or Chilled; 071022 Beans, Raw Cooked In Boiling Water, Frozen; 200551 Beans, Shelled, Prep Etc., No Vinegar Etc, Not Frz; 200559 Beans, Not Shelled, Prep/pres Nesoi, Not Frozen
Beets and Radishes	070690 Salad Beets, Radishes, Etc Nesoi, Fresh Or Chilled
Brussels Sprouts	070420 Brussels Sprouts, Fresh Or Chilled
Cabbage and Brassicas	070490 Edible Brassicas (cabbages Etc) Nesoi, Fr Or Chill
Carrots and Turnips	070610 Carrots And Turnips, Fresh Or Chilled
Cauliflower and Broccoli	070410 Cauliflower And Headed Broccoli, Fresh Or Chilled
Celery	070940 Celery Other Than Celeriac, Fresh Or Chilled
Cereals and products	100890 Cereals Nesoi, Including Wild Rice; 110290 Cereal Flours, Nesoi; 110319 Groats And Meal Of Cereal, Nesoi; 110419 Grains Rolld/flakd Of Cereals, Nesoi; 110429 Grains Worked Etc, Of Cereal, Nesoi; 110430 Germ Of Cereals, Whole, Rolled, Flaked Or Ground; 190410 Prep Food, Swelling/roasting Cereal/cereal Product; 190420 Prep Food From Unroasted Cereal Flakes/mixtures; 190490 Cereals (not Corn) In Grain Form, Prepared, Nesoi
Cherries	080920 Cherries, Sweet Or Tart, Fresh; <i>(continued on next page)</i>

	081210 Cherries, Provisionally Preserved, Inedible; 200860 Cherries, Prepared Or Preserved, Nesoi
Chestnuts	080240 Chestnuts, Frsh Or Dried, W/nt Shelled Or Peeled
Citrus Other	080590 Citrus Fruits, Inc Kumquats, Nesoi, Fresh Or Dried; 200791 Citrus Fruit Jams, Jellies, Marmalades, Pastes Etc; 200830 Citrus Fruit (including Mixtures), Prep Etc Nesoi; 200931 Juice Of 1 Citrus Fruit, Brix Value <=20, Nt Fortf
Citrus Peels	081400 Peel, Citrus Or Melon, Frsh/frzn/dried/provsl Pres
Corn nesoi	100590 Corn (maize), Other Than Seed Corn; 110220 Corn (maize) Flour; 110313 Groats And Meal Of Corn (maize); 110423 Grains Worked (hulld Pearld Sliced Kibbld) Of Corn; 110812 Starch, Corn (maize); 151521 Corn (maize) Oil, Crude, Not Chemically Modified; 151529 Corn (maize) Oil, Refined, & Fractions, Not Modif
Corn Seed	100510 Corn (maize) Seed, Certified, Excluding Sweet Corn
Corn sweet	071040 Sweet Corn Raw/cooked By Steam/boiling In Water Fz; 200580 Sweet Corn, Prepared/preserved Nesoi, Not Frozen
Cotton	120720 Cotton Seeds, Whether Or Not Broken; 140420 Cotton Linters; 151221 Cottonseed Oil Crude W/nt Gossypol Has Been Removd; 151229 Cottonseed Oil, Refined, And Fractions, Not Modif; 520100 Cotton, Not Carded Or Combed
Cucumbers	070700 Cucumbers And Gherkins, Fresh Or Chilled; 071140 Cucumbers/gherkins Provisionally Pres, Inedible; 200110 Cucumbers, Gherkins, Prep/pres Vinegar/acetic Acid
Dates	080410 Dates, Fresh Or Dried
Eggplant	070930 Eggplants (aubergines), Fresh Or Chilled
Figs	080420 Figs, Fresh Or Dried
Fruits & Nuts Nesoi	080290 Nuts Nesoi, Fresh Or Dried, Shelled Or Not; 081090 Fruit Nesoi, Fresh; 081190 Fruit Nesoi & Nuts, Sweetened Etc Or Not, Frozen; 081290 Fruit & Nuts Provisionally Preserved Inedible Neso; 081340 Fruit, Dried, Nesoi, Ex That Of Heading 0801-0806; 081350 Mixtures Of Dried Fruits, Nuts, Or Fruits And Nuts; 200190 Vegt/fruit/nuts Etc Nesoi Prep/pres By Vinegar Etc; 200600 Veg/fruit/nuts/fruit-peel Etc, Preserved By Sugar; 200819 Nuts (exc Peanuts) And Seeds, Prepared Etc. Nesoi; 200892 Fruit Mixtures, Prepared Or Preserved Nesoi
Garlic	070320 Garlic, Fresh Or Chilled
Grapefruit	080540 Grapefruit, Fresh Or Dried; 200921 Grapefruit Juice,brix Value <=20,nt Fort W Vitamin; 200929 Grapefruit Juice,nesoi,nt Fortorified W Vitamins
Grapes	080610 Grapes, Fresh; 080620 Grapes, Dried (including Raisins); 200961 Grape Juice Of A Brix Value <= 20, Nt Fort W/vitam; 200969 Grape Juice, Nesoi,nt Fortified With Vitamins/min; 220410 Sparkling Wine Of Fresh Grapes; 220421 Wine, Fr Grape Nesoi & Gr Must W Alc, Nov 2 Liters; 220429 Wine, Fr Grape Nesoi & Gr Must With Alc, Nesoi; 220430 Grape Must Partly Ferment, Ov .5% Alcohol, Nesoi; 220590 Vermouth/grape Wine Flavored Wth Plants Etc Ov 2ls; (cont.)

	220820 Grape Brandy
Kiwis	081050 Kiwi Fruit (chinese Gooseberries) Fresh
Leeks	070390 Leeks & Other Alliaceous Vegetables, Fresh, Chlld
Lemons and Limes	080550 Lemons And Limes, Fresh Or Dried
Lettuce	070511 Head Lettuce (cabbage Lettuce), Fresh Or Chilled; 070519 Lettuce, Except Head Lettuce, Fresh Or Chilled
Macadamia Nuts	080260 Macadamia Nuts, Fresh Or Dried
Meat and Dairy Products	010110 Purebred Breeding Animal; 010190 Mules And Hinnies, Live; 010210 Bovine Animals, Live, Purebred Breeding; 010290 Bovine Animals, Live, Nesoi; 010310 Swine, Live, Purebred Breeding Animals; 010391 Swine, Live, Nesoi, Weighing Less Than 50 Kg Each; 010392 Swine, Live, Nesoi, Weighing 50 Kg Or More Each; 010410 Sheep, Live; 010420 Goats, Live; 010511 Chickens, Live, Weighing Not Over 185 G Each; 010519 Ducks, Geese, Turkeys & Guineas, Live, Nov 185 G; 010599 Turkeys, Ducks, Geese, Guinea Fowls, Live, Ov 185g; 020110 Carcasses/half-carcasses Of Bovine Anmls Frsh/chld; 020120 Meat, Bovine Cuts With Bone In, Fresh Or Chilled; 020130 Meat Of Bovine Animals, Boneless, Fresh Or Chilled; 020210 Carcasses/half-carcasses Of Bovine Animals, Frozen; 020220 Meat, Bovine Cuts With Bone In, Frozen; 020230 Meat Of Bovine Animals, Boneless, Frozen; 020311 Carcasses & Half-carcasses Of Swine Fresh, Chilled; 020312 Meat, Swine, Hams, Shldrs, Bone In, Frsh Or Chlld; 020319 Meat Of Swine, Nesoi, Fresh Or Chilled; 020321 Carcasses And Half-carcasses Of Swine, Frozen; 020322 Meat, Swine, Hams, Shoulders Etc, Bone In, Frozen; 020329 Meat Of Swine, Nesoi, Frozen; 020410 Carcasses And Half-carcasses Of Lamb Fresh/chilled; 020421 Carcasses & Half-carcasses Of Sheep, Fresh/chilled; 020422 Meat Of Sheep, Cuts, Bone In Nesoi, Fresh, Chilled; 020423 Meat Of Sheep, Boneless, Fresh Or Chilled; 020430 Carcasses And Half-carcasses Of Lamb, Frozen; 020441 Carcasses And Half-carcasses Of Sheep, Frozen; 020442 Meat Of Sheep, Cuts With Bone In, Nesoi, Frozen; 020443 Meat Of Sheep, Boneless, Frozen; 020450 Meat Of Goats, Fresh, Chilled Or Frozen; 020500 Meat Of Horses, Asses, Mules, Hinnies Fr, Chld, Fz; 020610 Offal Of Bovine Animals, Edible, Fresh Or Chilled; 020621 Tongues Of Bovine Animals, Edible, Frozen; 020622 Livers Of Bovine Animals, Edible, Frozen; 020629 Offal Of Bovine Animals, Edible, Nesoi, Frozen; 020630 Offal Of Swine, Edible, Fresh Or Chilled; 020641 Livers Of Swine, Edible, Frozen; 020649 Offal Of Swine Except Livers, Edible, Frozen; 020680 Offal Sheep,goat,horse,ass, Mule/hinny Edble Fr/ch; 020690 Offal Of Sheep, Goats, Horses Etc, Edible, Frozen; 020900 Pig & Poultry Fat Frsh Chld Frzn Salted Dried Smkd; 021011 Hams, Shoulders & Cuts, Bone In, Salted, Drd, Smkd; 021012 Meat Of Swine, Bellies (bacon Etc), Cured Etc; 021019 Meat Of Swine Nesoi, Salted, In Brine, Dried, Smkd; 021020 Meat, Bovine Animals, Salted, In Brine, Drd, Smokd; 040110 Milk And Cream, Nt Concndrd, Nt Sweetd, Nov 1% Fat; 040120 Milk/cream Nt Cnctrd/swt, Fat Content Ov 1% Nov-6%; (cont.)

	040130 Milk & Cream, Not Concndr/swtn, Fat Content Ov 6%; 040210 Mlk & Crm,cntd,swt,powdr,gran/solids,nov 1.5% Fat; 040221 Mlk/cream Cncdrt Nt Swtn Pwd/oth Solids Ov 1.5% Fa; 040229 Mlk & Crm,cntd,swtnd,powdr/solids, Over 1.5% Fat; 040291 Milk And Cream, Concentrated, Not Sweetened, Nesoi; 040299 Milk And Cream, Sweetened, Concen Or Not Nesoi; 040310 Yogurt, W/n Sweetened, Flavored Or Cntg Fruit/coco; 040390 Buttermilk/kephir/curdled Fermntd Acidfd Mlk & Crm; 040410 Whey & Modfd Whey Whet/nt Cncntrtd Cntg Add Sweetn; 040490 Products Of Natural Milk Constituents, Nesoi; 040510 Butter; 040610 Cheese (unrpd/uncurd) Frsh Incl Whey Cheese Curd; 040620 Cheese Of All Kinds, Grated Or Powdered; 040630 Cheese, Processed, Not Grated Or Powdered; 040640 Cheese, Blue-veined, Nesoi; 040690 Cheese, Nesoi, Including Cheddar And Colby; 040700 Birds' Eggs, In The Shell, Fresh, Preserv Or Cookd; 040811 Egg Yolks, Dried, Whether Or Not Sweetened; 040819 Egg Yolks, Frsh, Frzn, Cooked By Water, Molded Etc; 040891 Birds' Eggs Not In Shell, Dried, W/n Sweetened; 040899 Birds' Eggs Nt In Shell, Frsh Frzn Cookd Water Etc; 050210 Pigs, Hogs, Boars Bristles & Hair & Waste Thereof; 050300 Horsehair And Horsehair Waste; 051110 Bovine Semen
Melons	080711 Watermelons, Fresh; 080719 Melons(except Watermelons) And Papayas, Fresh
Oats	100400 Oats; 110412 Grains, Rolled Or Flaked, Of Oats; 110422 Grains Worked (hulld Pearld Sliced Kibbld) Of Oats
Olives & Products	071120 Olives, Provisionally Preserved, Inedible; 150910 Olive Oil/fractions, Virgin, Not Chem Modified; 150990 Olive Oil/fractions, Refined But Not Chem Modified; 151000 Olive-residue Oil & Blends (1509&1510) Nt Chem Mod; 200570 Olives Prep/pres Ex Vinegar/acetic Acid Not Frozen
Onions & shallots	070310 Onions And Shallots, Fresh Or Chilled; 071220 Onions, Dried (powder Etc), Not Further Prepared
Oranges	080510 Oranges, Fresh; 200911 Orange Juice, Frozen, Sweetened Or Not; 200912 Orange Juice, Not Frozen,of A Brix Value Not Ov 20; 200919 Orange Juice, Other Than Frozen, Sweetened Or Not
Other Tubers	071490 Roots & Tubers Neso, Fresh Or Dried; Sago Pitch
Peaches and Nectarines	080930 Peaches, Including Nectarines, Fresh; 200870 Peaches, Prepared Or Preserved, Nesoi
Peanuts	120210 Peanuts (ground-nuts) Raw, In Shell; 120220 Peanuts (ground-nuts), Raw, Shelled, Broken Or Not; 150810 Peanut (ground-nut) Oil, Crude, Nt Chem Modified; 150890 Peanut (ground-nut) Oil, Refined, Nt Chem Modified; 200811 Peanuts, Prepared Or Preserved, Nesoi
Pears and Quince	080820 Pears And Quinces, Fresh; 200840 Pears, Prepared Or Preserved, Nesoi
Peas Dry	071310 Peas, Dried Shelled, Including Seed
Peas Fresh/Frozen/ Canned	070810 Peas (pisum Sativum), Fresh Or Chilled; 071021 Peas, Raw Cooked In Boiling Water, Frozen; 200540 Peas (pisum Sativum) Prep/pres Nesoi, Not Frozen (cont.)

Peppers	070960 Fruits Of Genus Capsicum Or Pimenta, Fresh/chilled
Pistachio	080250 Pistachios, Fresh Or Dried, Shelled Or Not
Plum	080940 Plums, Prune Plums And Sloes, Fresh; 081320 Prunes, Dried
Potatoes Irish	070190 Potatoes, Except Seed, Fresh Or Chilled, Nesoi; 071010 Potatoes Uncookd/cooked By Boiling In Water, Frozn; 110510 Flour And Meal Of Potatoes; 110520 Flakes, Granules And Pellets Of Potatoes; 110813 Starch, Potato; 200410 Potatoes, Prepared Etc., No Vinegar Etc., Frozen; 200520 Potatoes, Prepared Etc. No Vinegar Etc, Not Frozen
Potatoes Seed	070110 Potatoes, Seed, Fresh Or Chilled
Potatoes Sweet	071420 Sweet Potatoes, Fresh Or Dried, Whether/nt Pellets
Raspberries and other berries	081020 Raspberries/blckberries/mulberries/loganberrrs Frsh; 081120 Raspberries/blckberries/etc Uncookd/cookd Water Fz
Rice	100610 Rice In The Husk (paddy Or Rough); 100620 Rice, Husked (brown); 100630 Rice, Semi- Or Wholly Milled, Polished Etc Or Not; 100640 Rice, Broken; 110230 Rice Flour
Rye	100200 Rye In The Grain; 110210 Rye Flour; 120925 Rye Grass Seed For Sowing
Safflower, Sunflower and Products	120600 Sunflower Seeds, Whether Or Not Broken; 120760 Safflower Seeds, Whether Or Not Broken; 151211 Sunflower-seed Or Safflower Oil, Crude, Fract, Etc; 151219 Sunflower-seed Or Safflower Oil, Refine, Fract Etc
Seeds Veg and Nesoi	120991 Vegetable Seeds For Sowing
Sgr Beet	120910 Sugar Beet Seed Of A Kind Used For Sowing; 121291 Sugar Beet, Fresh Or Dried, Whether Or Not Ground; 170112 Beet Sugar, Raw, Solid Form, W/o Added Flav/color; 170191 Cane/beet Sugar, Refined, Solid, Added Flav/color; 170199 Cane/beet Sug Chem Pure Sucrose Refind Nesoi
Sorghum	100700 Grain Sorghum
Soybeans	120100 Soybeans, Whether Or Not Broken; 150710 Soybean Oil & Fractions, Crude, Wheth/not Degummed; 150790 Soybean Oil, Refined, And Fractions, Not Modified
Spinach & Products	070970 Spinach, New Zealand & Orache (garden), Frsh/chld; 071030 Spinach Raw/cooked By Steaming/boiling In Water Fz
Strawberries Fresh	081010 Strawberries, Fresh
Strawberries Nesoi	200880 Strawberries, Prepared Or Preserved Nesoi
Strawberries Processed	081110 Strawberries, Uncooked/cooked By Water, Frozen
Tangerines and Mandarins	080520 Mandarins (inc Tanger Etc) & Citrus Hybr Fr Or Dri
Tomatoes Fresh	070200 Tomatoes, Fresh Or Chilled
Tomatoes Processed	200210 Tomatoes Whole/pieces Prep/pres Ex Vinegar Etc; 200290 Tomato Paste Etc, Not Prepared With Vinegar Etc.; 200950 Tomato Juice (dry Weight Content Less Than 7%); 210320 Tomato Ketchup And Other Tomato Sauces (cont.)

Vegetables Other	070990 Vegetables, Nesoi, Fresh Or Chilled; 071080 Vegetables, Nesoi Raw/cooked By Boiling, Frozen; 071090 Vegetables Mixtures, Raw/cooked By Boiling, Frozen; 071190 Veg Nesoi, Veg Mix, Provisionally Pres, Inedible; 071290 Vegetables Nesoi & Mixtures, Dried, No Furth Prep; 121299 Vegetable Prodcnts (inc Unrt Chicory Rt) Edible Neso; 200490 Vegetables Nesoi, Prep Etc., No Vinegar Etc, Frozn; 200510 Homogenized Vegetables (baby Food Etc), Not Frozen; 200599 Veg & Mix Prpd/prsvd Exc Vinegar/acetic Acid/sugar
Walnuts	080231 Walnuts, Fresh Or Dried, In Shell; 080232 Walnuts, Fresh Or Dried, Shelled
Water	220110 Water, Mineral & Aerated Natrl/artfcl Nt Swtn/flav; 220190 Waters Not Sweetnd Or Flavored Nesoi; Ice And Snow; 220210 Waters, Incl Mineral & Aerated, Sweetnd Or Flavord
Wheat	100110 Durum Wheat; 100190 Wheat (other Than Durum Wheat), And Meslin; 100810 Buckwheat; 110100 Wheat Or Meslin Flour; 110311 Groats And Meal Of Wheat; 110320 Pellets Of Wheat And Of Other Cereals; 110811 Starch, Wheat; 110900 Wheat Gluten, Whether Or Not Dried; 190120 Mixes & Doughs For Prep Of Bakers Wares Hdg 1905; 190211 Pasta, Uncooked, Not Stuffed Etc., Containing Eggs; 190219 Pasta, Uncooked, Not Stuffed Etc., Nesoi; 190220 Pasta, Stuffed, Whether Or Not Cooked, Etc.; 190230 Pasta, Prepared Nesoi; 190430 Bulgur Wheat, Pre-cooked Or Otherwise Prepared; 190590 Bread, Pastry, Cakes, Etc Nesoi & Puddings

Appendix 4: Imported Products by HS Code Listed as “Other”

071340 Lentils, Dried Shelled, Including Seed
 071410 Cassava (manioc) Fresh Or Dried, W/nt Pellet
 080119 Coconuts, Other Than Dessicated
 080121 Brazil Nuts, Fresh Or Dried, In Shell
 080221 Hazelnuts Or Filberts, Fresh Or Dried, In Shell
 080222 Hazelnuts Or Filberts, Fresh Or Dried, Shelled
 080300 Bananas And Plantains, Fresh Or Dried
 080430 Pineapples, Fresh Or Dried
 080450 Guavas, Mangoes And Mangosteens, Fresh Or Dried
 080720 Papayas (papaws), Fresh
 081040 Cranberries, Blueberries, Etc, Fresh
 090111 Coffee, Not Roasted, Not Decaffeinated
 090112 Coffee, Not Roasted, Decaffeinated
 090121 Coffee, Roasted, Not Decaffeinated
 090122 Coffee, Roasted, Decaffeinated
 090210 Green Tea Nt Fermted In Immed Packg Content Nov 3kg
 090220 Green Tea (not Fermented) Nesoi
 090230 Black Tea Fermted & Partly Fermted Tea,packg Nov 3kg
 090240 Black Tea Fermted & Other Partly Fermentd Tea Nesoi
 090411 Pepper Of Genus Piper, Neither Crushed Nor Ground
 090412 Pepper Of The Genus Piper, Crushed Or Ground
 090420 Fruits Of Genus Capsicum Or Pimenta, Drd/crsh/grnd
 090500 Vanilla Beans
 090611 Cinnamon, Neither Crushed Nor Ground
 090619 Cinnamon-tree Flowers, Neither Crushed Nor Ground
 090620 Cinnamon & Cinnamon-tree Flowers, Crushd Or Ground
 090700 Cloves (whole Fruit, Cloves And Stems)
 090910 Seeds Of Anise Or Badian
 090920 Seeds Of Coriander
 091010 Ginger
 091030 Tumeric (curcuma)
 091091 Mixtures Of Spices Provided For In Diff Headings
 091099 Spices, Nesoi
 100820 Millet
 100830 Canary Seed
 110610 Flour & Meal Of Dried Leguminous Vegetbles Of 0713
 110620 Flour & Meal Of Sago, Roots/tubers Of Heading 0714
 110710 Malt, Not Roasted
 110720 Malt, Roasted
 110814 Starch, Cassava (manioc)
 120300 Copra
 120400 Flaxseed (linseed), Whether Or Not Broken
 120740 Sesame Seeds, Whether Or Not Broken
 120750 Mustard Seeds, Whether Or Not Broken
 120791 Poppy Seeds, Whether Or Not Broken
 120799 Oil Seeds & Oleaginous Fruits W/nt Broken, Nesoi
 120810 Flours And Meals Of Soybeans
 120890 Flour & Meal Oil Seed/oleaginous Frt Ex Mstd Nesoi *(continued on next page)*

120922 Clover (trifolium Spp.) Seed For Sowing
 121010 Hop Cones Frsh/dried, Not Ground Powdrd Or Pellets
 121020 Hop Cones, Ground, Powdered Or In Pellets; Lupulin
 130213 Vegetable Saps And Extracts Of Hops
 151110 Palm Oil, Crude, Not Chemically Modified
 151190 Palm Oil, Refined But Not Chemically Modified
 151311 Coconut (copra) Oil, Crude, Not Chemically Modified
 151319 Coconut (copra) Oil, Refined, Not Chemically Modified
 151321 Palm Kernel Or Babassu Oil, Crude Not Chemically Modified
 151329 Palm Kernel Or Babassu Oil, Refined, Not Chemically Modified
 151511 Linseed Oil, Crude, Not Chemically Modified
 151519 Linseed Oil, Refined, Not Chemically Modified
 151530 Castor Oil, Whether/not Refined, Not Chemically Modified
 151550 Sesame Oil Whether/not Refined Not Chemically Modified
 170111 Cane Sugar, Raw, Solid Form, W/o Added Flav/color
 170220 Maple Sugar And Maple Syrup
 170230 Glucose (dextrose), Under 20% Fructose In Dry Form
 170240 Glucose & Glucose Syrup Containing 20-49% Fructose
 170250 Chemically Pure Fructose In Solid Form
 170260 Fructose, Nesoi & Syrup, Over 50% Fructose In Dry Form
 170290 Sugar, Nesoi, Including Invert Sugar & Syrup
 170310 Cane Molasses From Extraction Or Refining Of Sugar
 170390 Molasses From Extraction/refining Sugar, Nesoi
 170490 Sugar Confection (incl Wh Choc), No Cocoa, Nesoi
 180100 Cocoa Beans, Whole Or Broken, Raw Or Roasted
 180200 Cocoa Shells, Husks, Skins And Other Cocoa Waste
 180310 Cocoa Paste, Not Defatted
 180320 Cocoa Paste, Wholly Or Partly Defatted
 180400 Cocoa Butter, Fat And Oil
 180500 Cocoa Powder, Not Sweetened
 180610 Cocoa Powder Cont Added Sugar Or Other Sweetening
 180620 Chocolate Prep Nesoi, In Blocks Etc. Over 2 Kg
 180631 Chocolate & Other Cocoa Preps, Not Bulk, Filled
 180632 Chocolate & Other Cocoa Preps, Not Bulk, Not Filled
 180690 Cocoa Preparations, Not In Bulk Form, Nesoi
 190190 Malt Extract; Flour, Meal, Milk Etc Prod Etc Nesoi
 190300 Tapioca And Substitutes From Starch In Flakes, Etc
 190510 Crispbread
 190520 Gingerbread And The Like
 190531 Cookies (sweet Biscuits)
 190532 Waffles And Wafers
 190540 Rusks, Toasted Bread And Similar Toasted Products
 200899 Fruit & Edible Plant Parts Nesoi, Prep Etc. Nesoi
 200939 Juice Of Other Single Citrus Fruit, not Fermented, nesoi
 200980 Juice Of Any Single Fruit/vegetable Unfermented Nesoi
 200990 Mixtures Of Fruit And/or Vegetable Juices
 220290 Nonalcoholic Beverages, Nesoi
 220300 Beer Made From Malt
 220510 Vermouth/grape Wine Flavored With Plants Etc Ctr 2l<
 220600 Fermented Beverages Nesoi (cider, Perry, Mead Etc)
 230400 Soybean Oilcake & Other Solid Residue, Wh/not Ground (cont.)

230500 Peanut Oilcake & Oth Solid Residue, Wh/not Ground
230620 Linseed Oilcake And Oth Solid Residues W/nt Ground
240110 Tobacco, Not Stemmed/stripped
400110 Natural Rubber Latex, Whether Or Not Pre vulcanized
520210 Cotton Yarn Waste (including Thread Waste)
520299 Cotton Waste, Nesoi
520300 Cotton, Carded Or Combed
530290 True Hemp Processed Not Spun, Tow & Yarn Waste
530310 Jute Other Textile Bast Fib Ex Flx Hem Raw Retted
530390 Jute Other Tex Bast Fib Tow Wast Proc Nt Sp Other