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Current and Future Supply of RFS2 Qualifying and Non-Qualifying Oils and Fats for Biofuels

Report for:

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Research and analysis to inform your business decisions

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Part 1: The Supply of RFS-2 Qualifying Feedstocks

This report has been prepared in response to a request from NBB to examine the potential global supply of feedstocks for biodiesel production. The report is divided into three sections. The first part examines the supply of feedstocks that currently qualify for the Renewable Fuel Standard (RFS). The second part provides the same information for feedstocks that do not yet qualify. The final part provides a short summary of all of the surveyed feedstocks.

The US RFS2 mandates a fixed volume of biodiesel consumption each year. The biodiesel used to meet the mandate must have been produced using an approved feedstock pathway. The US Environmental Protection Agency (EPA) regulates these pathways to ensure biodiesel meets the 50% greenhouse gas (GHG) saving required under the RFS2. Feedstocks that have been approved by the EPA are:

- Soybean oil,
- Canola/rapeseed oil,
- Animal fats,
- Inedible corn oil from distillers dried grains,
- Waste greases,
- Camelina oil.

For each feedstock we examine current supply as well as the outlook to 2018 for the USA, Canada, other major producing countries, and the rest of the world.

It should be noted that our oil supply estimates are presented on an oil-in-seed basis. That is, our oil supply estimates represent the volume of oilseed produced in each country expressed in terms of its oil equivalent. Thus we do not take into account the location of oil extraction capacity or trade in seeds.

Conversion Factors and Units

Throughout this report, we express oil and fat volumes in metric tons as the report is global in scope and most data sources including the USDA report their production statistics in metric tons. Table 1.1 provides the conversion factors used to convert oils and fats into biodiesel.

We assume that 1 metric ton of biodiesel is equal to 299.2 gallons.

Table 1.1: Biodiesel yields from different oil and fat feedstocks

Feedstock	Metric Tons biodiesel
1 Metric Ton of Sunflower Oil	0.964
1 Metric Ton of Soy Oil	0.958
1 Metric Ton of Rapeseed Oil	0.945
1 Metric Ton of Palm Oil	0.956
1 Metric Ton of Yellow Grease	0.957
1 Metric Ton of Other	0.958

Summary of the world supply of oils and fats and their use for biodiesel

Total world production of oils and fats was 189 million metric tons in 2012. Of this total close to 12% or 23 million metric tons were used to produce biodiesel, yielding total biodiesel production of 6.7 billion gallons.

As Diagram 1.1 reveals, soybean oil is the most widely used feedstock for biodiesel. However, the percentage of world supply going to biodiesel still only equates to 18%. Rapeseed oil is the next largest category, with biodiesel accounting for around 24% of world production. Although palm oil represents the largest source of oil supply, its use for biodiesel is still just 7% of world supply.

Diagram 1.1: World Supply of Oils and Fats and their Use for Biodiesel, 2012

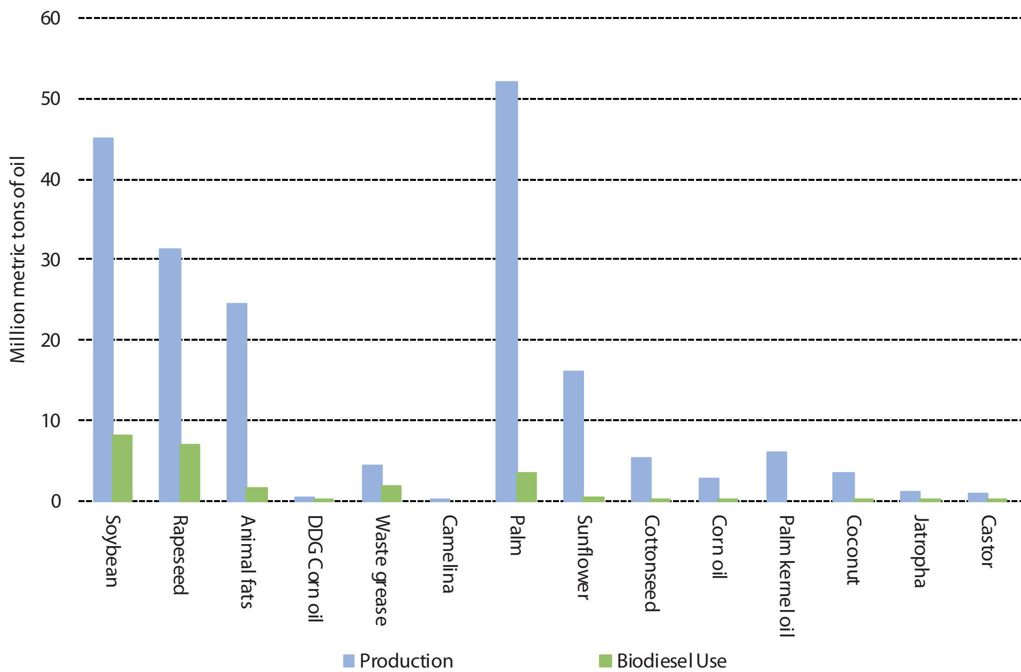
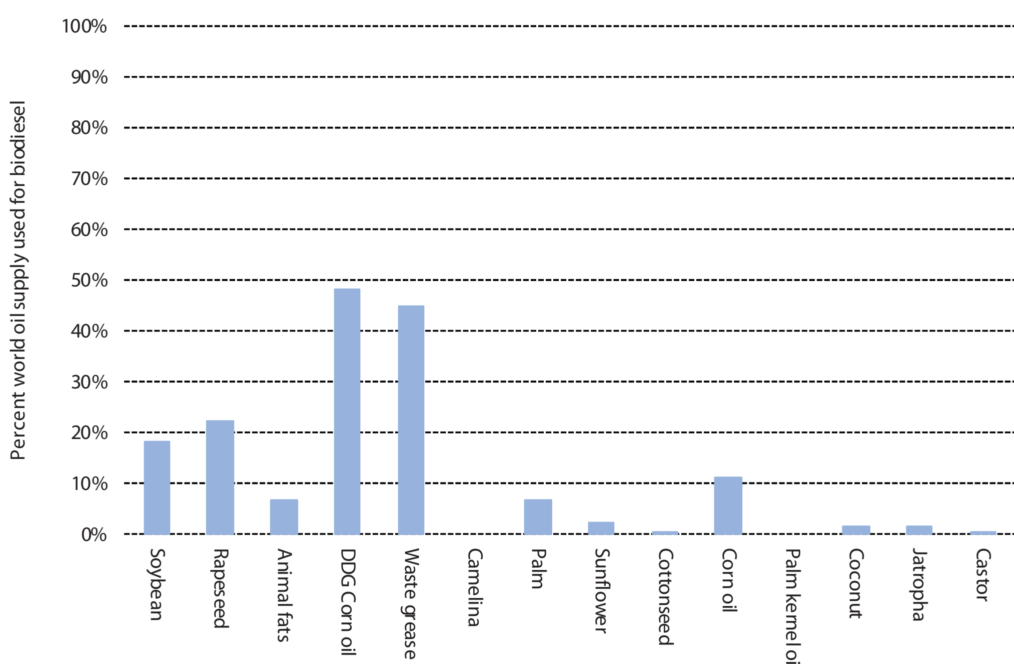


Diagram 1.2: The Percentage of World Oil and Fat Supply used for Biodiesel



Forecasting oil supplies to 2018

Our forecasting methodology draws upon competition between oilseeds and alternative crops planted in the major arable areas of the world. It is supplemented by an understanding of where undeveloped frontier lands are both available and suitable for oilseed development from an agronomic perspective. For tree crops, such as palm and coconut, we consider how plantings respond to prevailing profitability.

Within this broad framework, one beguiling question for the oilseed complex is how to reconcile output from the whole oilseed complex with the forecasts for demand of oilseed products. We forecast edible oil and meal demand in aggregate, rather than providing estimates for the individual oils and meals. This strategy is not for reasons of simplicity, but rather that we believe oils and meals represent, to a greater or lesser extent, close substitutes for one another.

This substitutability is particularly true in the vegetable oil complex and there is ample evidence provided by the market share captured by palm oil as its output has expanded. Extra supplies of palm oil have, within the constraints of its functional characteristics, created their own demand and consumers in many markets have demonstrated their willingness to switch between oils if the economics of doing so are persuasive. Therefore, we expect the aggregate supply of oils to match the aggregate demand over the medium term, with annual, as opposed to tree, crops bearing the brunt of the adjustment to supply-demand imbalances.

A methodology for forecasting vegetable oil supply to 2018

Our methodology for forecasting the output of oilseeds, oils and meal adopts the following key assumptions:

- ***Soybeans*** are planted to satisfy the growth in demand for the main non-ruminant livestock species, poultry and pigs. The animal numbers are adjusted to reflect the feed incorporation ratios in each country. Soybean oil supply is a co-product of meal production and forms an exogenously determined part of the aggregate vegetable oil supply.
- Oil palm (producing ***palm oil*** and ***palm kernel oil***) is planted in response to planting signals based on the prevailing profitability at the time of planting. However, as a tree crop with a 25 year economic lifespan and a minimum of three years before the first output appears, the supply of palm oil and palm kernel oil is not determined by the demand conditions of any particular year. Thus, palm oil and palm kernel oil — in common with soybean oil — form a part of the aggregate vegetable oil supply that is determined without reference to the prevailing level of oils demand or current prices.
- Coconut is another tree crop with an even longer productive life than the oil palm. New plantings are now scarce, and existing trees are rarely uprooted. Therefore, future ***coconut oil*** supply will continue to be determined primarily by the current stock of trees, and will again be unaffected by current demand or prices.
- Several other oils, notably ***corn oil*** and ***cottonseed oil***, are also produced without reference to the current state of the vegetable oil market. The supply of oil from these crops is a by-product of output decisions made in the cotton and corn wet milling markets.
- Relatively few oil crops are planted annually in response to prevailing market conditions for vegetable oils. In our analysis, ***rapeseed/canola*** and ***sunflower*** are the only major oils that can provide the annual short run supply flexibility to bring into balance aggregate world vegetable oil demand and supply. Therefore, rapeseed and sunflower balance the global vegetable oil market in our forecasts.

- Even so, we note that any temporary surpluses or deficits that emerge in the oil market can now be quickly absorbed by adjustments in the biodiesel sector to mop up gluts or contract to ration oil supplies. For example, this year Indonesian biodiesel output will be at peak levels as palm biodiesel is actually cheaper than diesel fuel in South East Asian markets. The experience this year demonstrates that large supply surpluses for vegetable oils can be absorbed with relatively little price effect.

- The expansion of the area planted to canola in Canada has been partly driven by the surge in US demand for canola oil. Short run supply has grown to meet the new demand for the oil. If supply overshoots demand for this oil, prices will fall to the point where discretionary biodiesel offtake absorbs the surplus.

- As rapeseed and sunflower expand to balance the vegetable oil market, the meal produced as a by-product of these crops will price its way into the aggregate compound feed market, at the expense of alternative oilseed meals or grains.

With this methodology in mind, we now provide estimates of current and future oil-in-seed supply for feedstocks that qualify for the RFS, starting with the most significant.

Soybean oil

Soybean oil is the most common oil produced in the USA making up over 80% of total US vegetable oil production in 2013 (not including animal fats or waste greases). The production of soybeans depends primarily on the demand for soybean meal. Soybean meal is crucial to the global animal feed industry as the key provider of protein, notably in diets for non-ruminant, livestock, such as pigs and poultry. The meal represents roughly 80% by weight of the products derived from the crushing of soybeans.

Methodology

Soybeans are planted to satisfy the growth in demand for meal in the production of poultry and pig meat. Soybean oil supply follows the growth in meal demand.

Soybeans face constraints on their production, notably the competition that it faces from grain crops for scarce land in many countries. Only Argentina and Brazil, among large soybean producers, have the potential to continue to record strong growth in their soybean areas, and even in Argentina there are many observers who believe future expansion is now constrained by the lack of further suitable land.

For other soybean producers, such as the USA, China and India, the limits of available arable areas mean that any future growth is confined largely to the switching of land out of grains and into oilseed crops. Under this constraint, swings in oilseed production are likely to occur as grain prices rise intermittently to claim back any lost land.

For many soybean producers, particularly in the USA, soybean plantings are inextricably bound to the fate of corn plantings. For most arable farmers, the choice of what to plant presents a range of possibilities and this pivotal decision commands a great deal of attention in the oilseed world. The relative prices (and hence the relative profitability) of alternative crops are key to this decision, but what is less clear is which specific prices we should consider. Diagram 1.3 sheds some light on this issue in the case of US soybean plantings.

Diagram 1.3: US area of soybeans vs. corn and their relative prices in January

Diagram 1.3 focuses on the planting decision of US farmers when choosing between maize (corn) or soybeans each year. In our analysis, we have contrasted movements in the US export price ratio (as a global benchmark) of soybeans to maize along with movements in the ratio of the areas planted to these crops. We have identified January as the key month for relative prices. This choice tries to capture the point when a farmer becomes largely committed to a crop mix in terms of seed and input purchases. From this time onward, the flexibility inherent in planting is rapidly reduced.

The correlations displayed in the diagrams are revealing and they provide a valuable tool for short term crop forecasting. In the US, the acreage split between corn and soybeans has reflected the price ratio in January very closely in recent years.

Other factors considered in our forecasting model include the longer term trends of corn versus soybean planting, competition for soybean meal from DDG in the meal market as a source of protein, and the outlook for yields.

Current and future supply

Table 1.2 presents our forecasts of soybean oil supply. **We project that world production of soybean oil will reach 59 million metric tons in 2018 (crop year 2017/18) up from 45 million metric tons in 2012 (crop year 2011/12).**

It should be noted that not all soybeans will be crushed; some beans are used for direct feed and food consumption. Therefore, our product forecasts are presented on an oil-in-seed basis rather than as actual oil output. Local crushing can also be affected by a range of factors such as tariff policy, national supply/demand balances and international trade agreements. The volume of world output of soybean oil will be the same, irrespective of where crushing takes place.

Expansion in the US is constrained by competition with corn for acreage. Nonetheless, yield growth will underpin US output growth and some new areas will be developed as robust strains of soybeans are developed for a broader US regional coverage. This will allow soybean oil production (contained in beans, and not necessarily crushed locally) in the US to grow over the next five years to nearly 19 million metric tons. Production of the oil in soybeans grown in Canada will remain low at between 0.8 and 0.9 million metric tons per year.

Table 1.2: Soybean oil supply ('000 metric tons of oil in bean output)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
USA	17,061	17,309	15,695	15,366	17,609	17,919	18,231	18,546	18,863
Canada	753	868	818	907	855	863	864	871	878
Argentina	10,342	9,355	7,675	9,623	9,329	9,551	9,834	10,318	10,792
Brazil	14,504	14,701	12,891	15,014	14,735	15,259	15,925	17,068	18,184
Paraguay	1,228	1,353	824	1,559	1,370	1,406	1,443	1,481	1,520
China	2,677	2,702	2,275	1,827	2,197	2,214	2,231	2,249	2,267
India	1,730	1,746	1,972	2,063	2,521	2,705	2,816	2,840	2,864
Rest of World	1,695	2,325	2,918	3,138	2,987	3,052	3,117	3,181	3,246
World	49,990	50,358	45,069	49,497	51,602	52,969	54,462	56,554	58,613

Notes: 1. Years are shown as annual but reflect crop years (2010 = crop year 2009/10 etc.).
2. Forecasts begin in 2014 (crop year 2013/14).

Source: 1. USDA (for historical data).

Canola oil

Canola is a type of rapeseed developed in Canada with low levels of erucic acid. The EPA published a final rule to approve canola oil as a feedstock for biodiesel in December 2010, later amending the pathway to clarify that rapeseed is also covered by the rule. We examine canola and rapeseed oil production in this section.

Current and future supply

Canola/rapeseed oil and sunflower oil provide the most important sources of flexibility in the world's supplies of oil from one year to the next. This is due to the high proportion by value of the oil to meal and the short lead time from planting to harvest, unlike tree crops such as palm.

Because of this flexibility, canola/rapeseed oil helps to balance aggregate world supply of vegetable oils to demand in the long term. This causes its supply to fluctuate over our forecast period. This is because the output of other oils, notably the tree crops and soybeans (which are planted primarily to satisfy meal demand), does not respond promptly to annual price signals in the oils market. Canola/rapeseed and sunflower areas, therefore, must bear the brunt of adjustments to prevailing conditions by declining when vegetable oil supplies are plentiful and oil prices are weak, and expanding when they are strong.

Table 1.3 presents our forecasts of canola/rapeseed oil in the US and Canada, as well as other major producing countries. **We estimate that the global supply of canola/rapeseed will reach 25.0 million metric tons in 2018 (crop year 2017/18), only slightly up on the 24.4 million metric tons produced in 2012 (crop year 2011/12).**

The majority of canola oil in North America will continue to come from Canada. Production in the US will expand in states such as Kansas. Supply undulates over the forecast period as a result of our assumption that rapeseed supply is flexible and can be used to balance oil and meal requirements. In our model of world canola/rapeseed production, Canada, as the dominant marginal supplier to the global rapeseed/canola export market, bears the brunt of the adjustment in rapeseed production. Growth in all other sources of canola/rapeseed is expected to remain low.

Table 1.3: Canola/rapeseed oil supply ('000 metric tons of oil in canola seed output)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
USA	293	447	295	460	476	489	502	515	529
Canada	5,676	5,603	6,527	6,254	7,666	8,685	8,233	7,759	6,763
Australia	763	864	1,274	1,236	1,099	1,163	1,226	1,290	1,356
China	4,848	4,675	4,774	4,801	4,630	4,728	4,803	4,878	4,953
EU	8,580	8,265	7,616	7,167	7,177	7,190	7,187	7,184	7,176
India	2,420	2,689	2,348	2,575	2,530	2,528	2,562	2,597	2,632
Rest of World	1,598	1,478	1,543	1,590	1,559	1,600	1,598	1,585	1,576
World	24,179	24,022	24,376	24,082	25,138	26,383	26,111	25,808	24,984

Notes: 1. Years are shown as annual but reflect crop years (2010 = crop year 2009/10 etc.).
2. Forecasts begin in 2014 (crop year 2013/14).

Source: 1. USDA (for historical data).

Note on US canola production:

The prospects for canola in rotation with wheat in areas of Kansas and Oklahoma are promising. Despite this, our forecasts to 2018 show only modest expansion. This is for several reasons, including:

- Increased US canola output is founded largely upon the substitution of canola oil for soybean oil in sectors where the trans-fat health issue occurs with partially hydrogenated soy oil. This substitution has driven the recent expansion of canola in Canada. However, we believe that as much as 80% or so of the potential substitution in the health-sensitive sectors has already occurred.

- Despite this, in our longer term forecasts to 2025, we see the US canola sector expanding more strongly, as US canola substitutes for Canadian canola in some US applications. The agronomic benefits of rotating canola with wheat in the US southern plains will underpin this expansion.

- The reason this expansion happens largely after 2018 is because of the global oil balance in the underlying model that generates the crop estimates presented here. This exercise begins with a comprehensive estimate for the growth in total world vegetable oil demand. From this total, we deduct the future oil crop estimates from the tree crops, minor oils such as corn/cottonseed/groundnut, and soybean oil. The remaining oil demand is then satisfied by sunflower and canola/rapeseed, as these provide the only annual flexibility in plantings. Even though some canola oil is sold in dedicated markets, like the trans fats sector, a great deal of canola is also sold as a commodity bulk oil into markets that substitute between oils, such as India and China. Up to 2020 or so, we envisage a great deal of palm oil coming onto the market (as explained elsewhere in the report), and the expansion of canola/rapeseed and sunflower will have to slow to accommodate these cheap oil supplies. After 2020 or so, the wave of palm oil will begin to slow, and, with demand continuing to expand in the background, there will be a requirement once more for more canola and sunflower. We see Canada and US canola both responding strongly in this future period. By 2018, however, in our view, canola and sunflower can only expand faster than our estimate if world oil demand grows faster than in our model, or palm expands more slowly than in our model. If that happens, there is a one-for-one trade off: one tonne less palm oil means one tonne more canola or sunflower oil (i.e. the total world supply of vegetable stays the same). If we were to increase our estimate for canola in the US (or Canada), while also leaving demand and the supply of other oils unchanged, the implications would be that vegetable oil prices would fall due to oversupply and in subsequent years grower would cut back on their supply. Overall, therefore, in our exercise, if US canola is to expand faster by 2018, we would to reduce the supply of another oil (such as Canadian canola or US soybean oil) to offset this.

High and low oleic canola/rapeseed varieties

Concerns over trans-fat health issues have led to increased interest in high oleic varieties of oilseeds. However, high oleic canola and rapeseed varieties have only spread slowly. As most research has been done on GM seeds, canola has seen the fastest adoption. Today around a fifth of the Canadian Canola harvest is high oleic. In 2012 this yielded 1.1 million metric tons of high oleic canola seeds. In Australia, the other large canola (as opposed to rapeseed) producer, high oleic varieties are still rare.

In the EU adoption has been much slower, and probably only a few percent of rapeseed varieties are high oleic. This is partially because of hostility towards GM seeds where most high oleic varieties have been created. It is also because of the large volumes of high oleic sunflower in the region, which meet the demand for high oleic oils. High oleic varieties of rapeseed are also uncommon in China.

Brassica juncea versus Brassica napus

Rapeseed (*Brassica napus*) is only one member of the Brassicaceae family. Other, closely related, varieties of Brassica are the mustard seeds. Mustard seeds have a short growing season and are particularly tolerant to drought.

Of the variety of different mustard seeds, we are interested in the cultivar *Brassica juncea* which encompasses the varieties of Brown and Indian/Oriental mustard. The other main type of mustard is yellow mustard (*Sinapis alba*).

In Europe and North America, *brassica juncea* is grown for the production of table mustard, oil and spices. Traditionally the North American market prefers the milder yellow mustard (*Sinapis alba*). Production of *brassica juncea*, however, has become increasingly popular for export to the EU and Japan. In Asia, the mustard from *Brassica juncae* is used as a condiment as well as a cooking oil. The leaves of *Brassica juncae* are used in Indian and African cooking. In west and southern Africa it is grown predominantly as a vegetable.

Worldwide the production of all mustard seeds is dwarfed by the production of rapeseed (*Brassica napus*). In many cases therefore, statistical offices do not differentiate between rapeseed and mustard. In those where the distinction is made, they are often unable to provide information on the production of *brassica juncea* as opposed to other varieties of mustard (such as *Sinapis alba).*

The FAO provides some indication of total worldwide production and area under mustard seeds in the main producing countries, which is shown in Diagram 1.4. However, the data does not include India. On the Indian subcontinent rapeseed and mustard seed are grown in blends and their statistics therefore do not distinguish between rapeseed and mustard seed. It also does not include any estimates of African production where, as we have seen, it is consumed as a vegetable. Diagram 1.5 presents world production over time (excluding India and Africa) and reveals that it exhibits significant annual fluctuations reaching lows of around 400,000 metric tons in 2001 and 2007.

Diagram 1.4: Average harvested area and production of mustard seed from 2009-2011

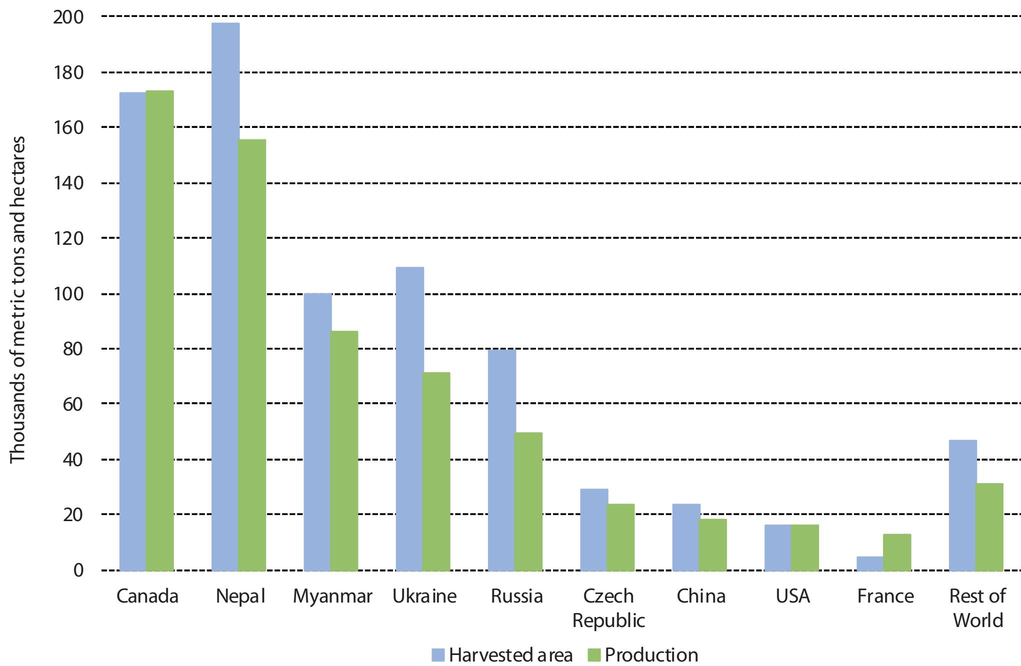
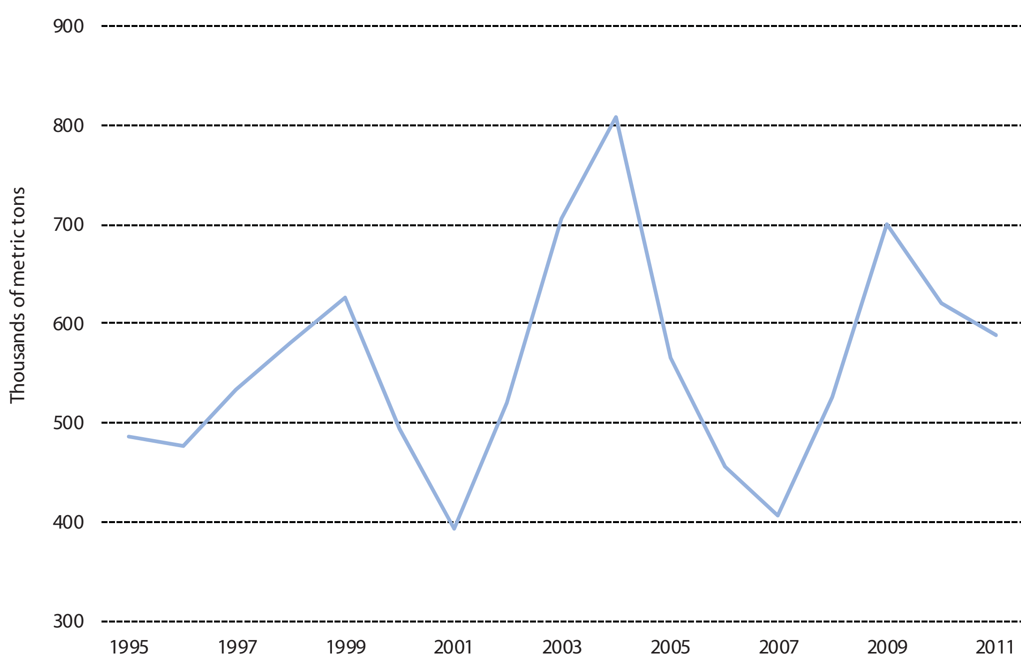
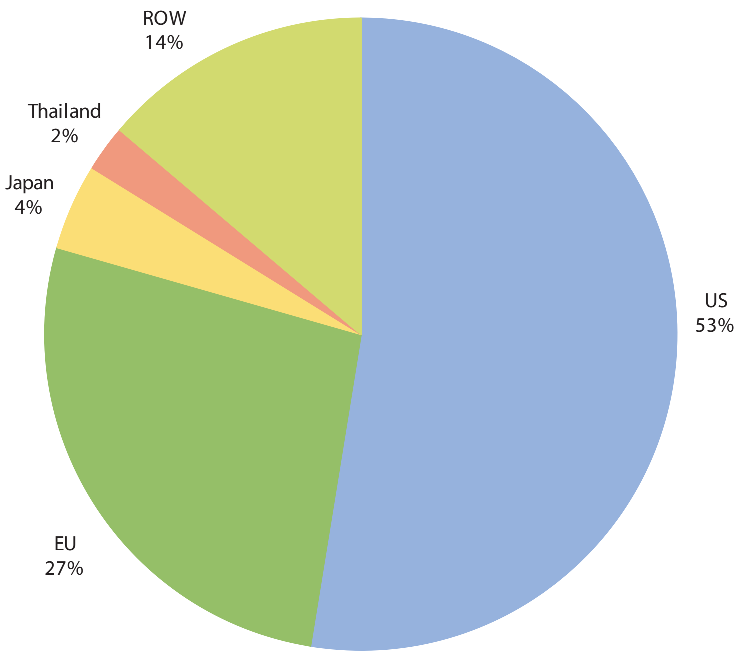


Diagram 1.5: World production of mustard seed (excluding India and Africa)



Canada is the world's largest producer of mustard seed, although Nepal has a larger harvested area. US production, by contrast, is modest with an average of 16,000 hectares planted from 2009-2011, almost all of which was for yellow mustard (*Sinapis alba*). Canada is also the world's largest exporter of mustards, exporting around 124,000 metric tons in 2011 of which over half went to the US and around a quarter to the EU, as illustrated in Diagram 1.6. Ukraine and Russia are the second and third largest exporters, respectively.

Diagram 1.6: Canadian exports of mustard seeds by destination



Recently Statistics Canada has provided some indication of the composition of mustard production, as brown and oriental mustard have grown in popularity. In 2011 and 2012 around half of all mustard production was of the *Brassica Juncae* variety.

Animal fats

Animal fat has become a valuable substitute for vegetable oils in several ways. Traditionally, it was used extensively for fatty acid production, but recently we have witnessed a surge in animal fat usage for biodiesel production. The forerunners in this regard were the US and Australia, but animal fat use in the EU biodiesel sector has been gaining ground rapidly as it enjoys, in some national markets, 'double counting' status under the RED. (A gallon of methyl ester derived from an animal fat counts for two gallons of biodiesel against the mandate.) As a result, EU tallow methyl ester prices have enjoyed a premium recently over methyl esters made from vegetable oils, such as palm.

Table 1.4: Animal fat supply by type ('000 metric tons)

		2010	2011	2012	2013	2014	2015	2016	2017	2018
USA	**Total**	**3,956**	**4,010**	**3,928**	**3,959**	**3,994**	**4,034**	**4,079**	**4,125**	**4,174**
	Poultry	471	475	475	480	486	492	499	507	515
	Pigs	1,145	1,161	1,188	1,201	1,215	1,231	1,248	1,266	1,285
	Beef	2,339	2,374	2,265	2,278	2,293	2,311	2,331	2,352	2,375
Canada	**Total**	**215**	**202**	**216**	**232**	**249**	**269**	**291**	**315**	**339**
	Poultry	26	27	31	36	41	47	54	60	68
	Pigs	35	35	37	40	42	45	48	51	54
	Beef	153	140	148	156	165	177	190	203	217
Brazil	**Total**	**1,110**	**1,122**	**1,145**	**1,174**	**1,203**	**1,233**	**1,262**	**1,292**	**1,320**
	Poultry	385	402	410	419	428	437	447	456	464
	Pigs	86	87	89	91	93	95	98	100	102
	Beef	638	632	647	664	682	700	718	736	754
China	**Total**	**1,402**	**1,383**	**1,434**	**1,490**	**1,547**	**1,605**	**1,664**	**1,721**	**1,775**
	Poultry	190	200	207	215	223	231	239	247	254
	Pigs	804	779	808	839	870	902	935	966	995
	Beef	407	404	419	436	454	472	490	508	527
EU	**Total**	**3,260**	**3,266**	**3,274**	**3,297**	**3,327**	**3,359**	**3,393**	**3,427**	**3,456**
	Poultry	329	335	337	340	344	348	353	357	361
	Pigs	631	636	638	644	651	659	667	675	681
	Beef	2,300	2,295	2,299	2,313	2,332	2,352	2,374	2,395	2,414
Rest of	**Total**	**2,740**	**2,696**	**2,871**	**2,962**	**3,053**	**3,144**	**3,235**	**3,327**	**3,421**
World	Poultry	488	506	522	537	552	566	581	596	610
	Pigs	-752	-766	-784	-786	-788	-792	-798	-805	-812
	Beef	3,005	2,956	3,133	3,210	3,289	3,370	3,452	3,536	3,622
World	**Total**	**12,682**	**12,680**	**12,868**	**13,113**	**13,371**	**13,643**	**13,924**	**14,208**	**14,485**
	Poultry	1,890	1,945	1,982	2,026	2,073	2,122	2,173	2,223	2,272
	Pigs	1,950	1,933	1,976	2,028	2,083	2,140	2,197	2,253	2,306
	Beef	8,842	8,801	8,911	9,058	9,215	9,381	9,554	9,731	9,908

Notes: 1. Years are calendar years.
2. Forecasts for countries outside of US begin in 2012.

Source: 1. For US data (2010-2012) is Render Magazine April 2013. Forecasts begin in 2013.

Methodology

Despite this growing use of tallow in biodiesel, the production of animal fats is still driven by demand for meat, with fat a "waste" by-product. Our forecast for animal fat production is therefore derived from projections of livestock output (beef, poultry and pig sectors) and rendering to 2018. The estimates of rendered animal fat production are estimated from the live weight of livestock at slaughter using conventional fat to carcass weight ratios.

There is a trend in the livestock sector of slower animal fat supply expansion than the growth in meal output because of rising feed incorporation ratios, i.e., more protein (meal) is being used over time to produce each ton of meat as livestock sectors modernize. This dynamic is particularly prevalent in developing countries where the meat industry has been adopting more intensive feeding practices over the past decade. The trend towards feedlots for livestock in South America is another excellent indicator of this practice.

Current and future supply

Table 1.4 summarizes our rendered fat production projections to 2018. **We project that global availability of animal fats will reach 14.5 million metric tons by 2018, up on the 12.9 million metric tons in 2012.** The table also highlights the faster growth of non-ruminant species, namely poultry and pigs, than of beef, globally. As health scares have hit the beef sector the hardest, consumer preferences have switched into white meats.

Inedible corn oil from defatting distillers' dried grains

The production of corn oil as a by-product of dry milling ethanol production is mainly a US phenomenon. For many years, only corn wet millers had the capacity to produce corn oil as a by-product of starch and ethanol operations. However, recent years have seen a surge in the installation of fractionation technology at dry mill plants, allowing the corn oil to be extracted from DDG. Dry millers with corn oil extraction typically enjoy higher processing margins than plants that do not have this technology installed, placing them at an economic advantage. In 2010, around 35% of dry mill plants were extracting corn oil. By 2011, the proportion had risen to over 40% and in 2012 comprised over half of industry capacity. In April 2013, about 70% of plants have extraction capacity. Over the same period, average oil yields from defatting have increased from less than 0.3 pounds of oil per bushel of corn crushed to over 0.6 pounds per bushel today.

The major end uses for corn oil from DDG are for biodiesel and feed production as its high free fatty acid (FFA) content means it is unsuitable for use as a food or in the oleochemical industry. Ethanol producers prefer to sell their oil for biodiesel production rather than feed as it usually commands a better price. Although the high FFA content makes it more difficult to process than other oils, demand from biodiesel producers has been strong as it trades at a discount to soybean oil.

Methodology

There are no published sources for the production of corn oil from the ethanol industry. Therefore we have estimated supply using reported ethanol production together with a number of key assumptions which we outline below. Table 1.5 provides a summary of how we have calculated monthly availability in the US in 2012. It should be noted that the corn oil produced at wet mills is food grade whereas the oil from DDG is inedible. The output of inedible oil is estimated at 538,000 metric tons in 2012.

Our estimates assume that wet mills account for 10-11% of fuel ethanol output and the remaining 89-90% is produced at dry mills. We have converted ethanol output into the volume of corn crushed by assuming that 2.302 metric tons of corn are required to produce 1,000 liters (1 cubic meter) of ethanol at both dry and wet mills. We assume that corn oil yields are fixed at 1.1 lbs per bushel of corn crushed for wet mills. However, for dry mills, we assume that yields have improved over time. In 2012 we assume that average corn oil yields are 0.55 lbs per bushel of corn crushed but that this figure eventually doubles to 1.0 lbs per bushel by 2020. This is because yields have improved dramatically over the last couple of years and the best performing factories are already generating 0.9 lbs of oil per bushel[1].

[1] "Corn oil adds significantly to profitability" Ethanol Producer Magazine, April (2013).

Table 1.5: Calculating monthly supply of inedible corn oil DDG, 2012 (metric tons)

	Ethanol Output			Corn Use			% Dry	Corn Oil Output		
	Wet Mill	Dry Mill	Total	Wet Mill	Dry Mill	Total	Mill Capacity	Wet Mill	Dry Mill	Total
	(mn gals)	(mn gals)	(mn gals)	('000 mt)	('000 mt)	('000 mt)	Extracting	('000 mt)	('000 mt)	('000 mt)
Jan-12	132	1,089	1,221	1,149	9,486	10,635	47%	23	38	61
Feb-12	121	999	1,119	1,053	8,700	9,753	48%	21	36	57
Mar-12	126	1,038	1,164	1,095	9,043	10,138	49%	22	38	59
Apr-12	120	988	1,107	1,042	8,607	9,649	50%	20	42	62
May-12	126	1,038	1,164	1,095	9,047	10,143	50%	22	45	66
Jun-12	121	997	1,118	1,052	8,686	9,738	51%	21	44	64
Jul-12	115	949	1,064	1,001	8,267	9,268	52%	20	46	66
Aug-12	119	981	1,100	1,035	8,550	9,585	53%	20	48	69
Sep-12	111	918	1,029	969	8,000	8,969	54%	19	46	65
Oct-12	115	950	1,065	1,002	8,275	9,277	55%	20	47	67
Nov-12	114	944	1,058	995	8,222	9,217	61%	20	52	71
Dec-12	118	973	1,091	1,026	8,477	9,503	63%	20	55	75
Total	**1,436**	**11,864**	**13,300**	**12,515**	**103,361**	**115,875**	**53%**	**246**	**538**	**783**

Sources: Fuel ethanol output data is from the EIA . % dry mill capacity extracting corn oil is from The Jacobson.

All wet mills are assumed to produce corn oil. For dry mills, we assume that a rising proportion of capacity can extract corn oil. In 2012 the proportion is assumed to be just over half of the industry, rising to around three quarters of capacity in 2013. By 2014 we anticipate that over 90% of dry mills will be extracting corn oil. Although it is economically desirable to extract corn oil at most plants, practical constraints such as location may mean that extraction rates fall somewhat short of 100%. We have therefore assumed that extraction rates are limited to a maximum of 93% of industry capacity.

Current and future supply

We estimate that the US ethanol industry produced 538,000 metric tons of inedible corn oil from DDG in 2012. According to the EIA, 259,000 metric tons of corn oil were used for biodiesel production in 2012. Assuming the remainder went to feed this would imply inedible corn oil feed use at 279,000 metric tons. Outside the US, the production of corn oil by ethanol producers is negligible as corn is less widely used as a feedstock. The ethanol industry in Canada is dwarfed by the US and uses both wheat and corn as a feedstock. We are not aware of any plants extracting corn oil in Canada at present. If Canada installed fractionation technology at its corn dry milling plants then it could in theory produce around 30,000 metric tons per annum, applying yields of 0.5 lbs per bushel corn. In the EU, wheat is the dominant feedstock with corn mainly used in Eastern Europe. One plant in Poland is known to be extracting corn oil, but its output is negligible in comparison with North American plants.

We anticipate that corn oil production by the US ethanol industry will continue to grow strongly in the period to 2018. This will be driven by the continued installation of extraction technology, together with improvements in the quality and quantity of corn oil produced. Growth will be especially rapid in 2013 and 2014 until the technology becomes widespread. Beyond 2014, output will continue to grow, albeit more slowly until 2018 as a result of continued improvements in yields. **By 2018, the output of inedible corn oil from DDG could exceed 1.7 million metric tons.**

Table 1.6: Inedible corn oil from DDG ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
USA	213	377	538	961	1,419	1,536	1,617	1,686	1,755
Canada	0	0	0	0	0	0	0	0	0
Rest of World	0	0	0	0	0	0	0	0	0
World	213	377	538	961	1,419	1,536	1,617	1,686	1,755

Notes: 1. Years are calendar years.
2. Forecasts begin in 2013.

Source: 1. LMC estimates (for historical data).

Waste greases

In this section we estimate current and future global collection volumes and potential availability of waste greases. Where possible, our figures include used cooking oil (UCO) and grease trap oil (GTO). UCO (or yellow grease in the US) is fryer oil obtained from restaurants. GTO (or brown grease in the US) is predominantly produced within the hotel, restaurant and catering sectors with some output from the food manufacturing industry. GTO is collected by grease traps which separate grease and oil from the water contained within wastewater. Its collection prevents sewer blockages.

Collection rates for waste greases are shaped by the incentives for collection in each country and therefore supply is inextricably linked to demand. As the major cost in procuring UCO/GTO is transport, sources of supply must be in close proximity to demand for supply to be economically viable. In practice this means that UCO/GTO is only collected in the major cities. Historically animal feed has been the key end use sector for UCO, but in recent years demand for biodiesel has prompted a sharp increase in collection rates, particularly in the EU and US. One difficulty in estimating supply is the lack of a precise definition of UCO. It is unclear how many times vegetable oil has to be used for frying before it is considered used.

Table 1.8 summarises potential waste grease collection volumes. **Globally waste grease collection is projected to rise only slightly from 4.3 million metric tons to 5.2 million metric tons in 2018.**

China

The Chinese biodiesel industry has around three million metric tons of capacity. However, output in 2012 was just 500,000. Of this, around 150,000 metric tons of biodiesel were produced from UCO. To date the majority of waste cooking oils have been directed towards the animal feed, industrial chemical and restaurant sectors.

There are significant potential volumes of grease trap oil (GTO) in China, especially following the recent crackdown on use of such oil in the food sector. In China, GTO or "gutter oil" is collected from restaurant fryers, drains, grease traps and slaughterhouse waste. It had been cleaned up and passed off as new cooking oil until a nationwide crackdown in August 2011. The government was responding to evidence which showed such oil to be highly toxic and in some instances carcinogenic.

There are significant constraints to GTO usage in biodiesel production. Around 70-80% of GTO content is water, while the free fatty acid content of GTO is up to 40% against a 7% average for UCO. Following interviews with Chinese biodiesel producers, we estimate that in 2012 there was around 1 million metric tons of retrievable oil from GTO in China. While historically the majority of UCO/GTO has not been used in biodiesel production an increasing volume is set to be directed towards the biodiesel sector. For example, ASB biodiesel is close to completion of its 100,000 metric ton waste biodiesel facility in Hong Kong. The plant will initially use around 40% palm fatty acid distillate (PFAD), with the remainder a mix of UCO and GTO. The proportion of UCO and GTO is set to increase to 90% by 2015.

EU

The collection of used cooking oil (UCO) has grown rapidly in the EU in recent years thanks to the double counting rule under the Renewable Energy Directive (RED) which allows biodiesel produced from UCO to count double towards mandates. This created a strong incentive to collect UCO and indeed some fryers we spoke with said that they now had an economic incentive to change their oil more frequently as a result of the double counting provisions.

The total UCO resource is estimated at 2.4 million metric tons in 2012, rising to 2.6 million by 2018, assuming that it grows in line with forecast economic growth. The collection of UCO for biodiesel production was 0.7 million metric tons in 2011 and is expected to reach 1.1 million in 2013. Previously, UCO was used in animal feed in the EU. However, under the EU's Animal By-products Regulation (2002) such use has been banned as a safeguard to animal health. In the past, UCO was also directed to the heating and non-food oleochemicals sectors. However, today the bulk of UCO is used to produce biodiesel.

Certain member states have interpreted double counting rules in ways which will restrict the role of UCOME in coming years. France for example has limited the role of double counting biodiesel to 0.35% of diesel sales. Germany requires that UCO contain no animal fat and has extended certification requirements along the supply chain down to collectors. The onerous nature of these requirements will limit supply by raising collection costs. We estimate that double counting biodiesel production will rise to 2.0 million metric tons by 2018. The majority of this will be UCOME. In turn we estimate that UCOME production will grow in line with demand, reaching 1.8 million metric tons by 2018.

The majority of European GTO is currently processed into biogas. UCO traders have indicated that increasing volumes of GTO are being used in biodiesel production in the UK through an acid-esterification process. However, this trend does not appear to be widespread, owing to the contamination levels of GTO and the subsequently high costs of pre-treatment. No figures are available on GTO availability.

US

Yellow grease comprises mainly used cooking oil collected from restaurant fryers but can also include some lower grades of tallow (cow or sheep fat) from the rendering industry. Demand for cooking oil has typically grown in line with population in recent years, at a rate of 3-4% per annum. However, the collection of used oil has fallen since 2008, as collection rates have failed to keep pace with cooking oil demand. In recent years, the theft of used cooking oil has been a major problem for the industry and this may have contributed to declining collection rates.

Obtaining reliable statistics on the production of yellow grease is difficult. Production and consumption data for the rendering industry was traditionally reported in the US Census Bureau's report. However, the report was discontinued in July 2011. The data reproduced in Table 1.7 for the years 2007-2012 comes from the April 2013 edition of Render Magazine which estimated yellow grease output for 2011 and 2012 based on historical data for used cooking oil demand.

We have used the same methodology to provide forecasts of yellow grease production between 2013 and 2018. We allow for growth in cooking oil consumption in line with population but assume that collection rates continue to decline in line with historical trends. This approach implies that yellow grease production will continue to fall reaching 853,000 metric tons by 2018.

Nonetheless, there are several reasons why these projections may understate future production of yellow grease. Firstly, used cooking oil theft is in decline, thanks to better security measures by the industry and greater efforts by police to reduce the crime. Secondly, there is a widespread expectation that demand for biodiesel will continue to grow, prompted by a rise in the biomass based diesel category of the RFS as well as California's Low Carbon Fuel Standard. If this allows biodiesel prices to be sustained at a higher level than in the past, this will increase the price that biodiesel producers can pay for yellow grease, increasing the volume that is economically viable for collection.

Table 1.7: Yellow grease production in the US

	US Population (Millions)	Cooking oil Consumption ('000 metric tons)	% Oil Collected	Yellow Grease Production ('000 metric tons)
2007	302	6,876	13.2%	910
2008	305	7,470	12.3%	920
2009	307	7,117	12.3%	873
2010	310	7,526	11.5%	869
2011	312	7,909	11.5%	906
2012	314	8,192	10.8%	885
2013	317	8,475	10.3%	877
2014	319	8,758	10.0%	872
2015	321	9,041	9.6%	867
2016	323	9,324	9.2%	862
2017	326	9,608	8.9%	857
2018	328	9,891	8.6%	853

Sources: 1. Population (2007-2018) from USDA based on last US Census published June 2012.
2. Cooking oil consumption (2007-2010) from USDA.
3. Yellow grease production (2007-2012) from Render Magazine April 2013. Forecasts by LMC.

Table 1.8: Potential waste grease collection volumes ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
USA	869	906	885	877	872	867	862	857	853
Canada	40	45	61	66	68	69	71	73	74
EU	2,321	2,360	2,359	2,369	2,409	2,461	2,518	2,577	2,638
China	812	907	1,000	1,080	1,169	1,269	1,377	1,494	1,621
Rest of World	0	0	0	0	0	0	0	0	0
World	4,042	4,218	4,305	4,392	4,518	4,666	4,828	5,001	5,186

Notes: 1. EU represents "total UCO resource" from Greenea data for 2011. Excludes GTO. Forecasts begin in 2012.
2. US yellow grease production (2010-2012) from Render Magazine April 2013. Forecasts begin in 2013.
3. China estimate for 2012 based on potential GTO and UCO supply. Forecasts begin in 2013.
4. Canada based on waste grease collected for biodiesel only. Forecasts begin in 2013.

Yellow and brown grease

Yellow grease is derived from used cooking oil (UCO) from the fast-food industry where it is collected from deep fryers. Yellow grease can also refer to lower-quality grades of tallow (cow or sheep fat) from animal rendering plants.

By contrast, brown grease or grease trap oil (GTO) is sourced from grease interceptors. Grease interceptors or grease traps as they are sometimes known, are plumbing devices designed to intercept most greases and solids before they enter a wastewater disposal system.

Camelina oil

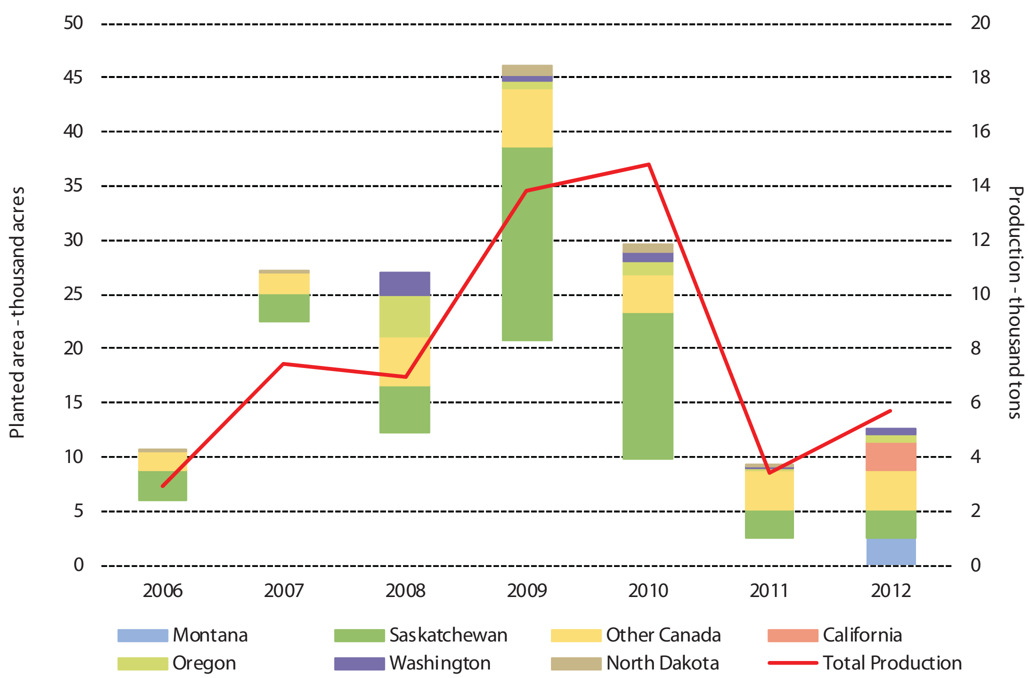
Our projections of Camelina oil production are given in Table 1.9. **World Camelina production is projected to reach a maximum of 846,000 metric tons in 2018, mainly from the USA.**

Current production

Although an ancient crop, camelina is a minor oilseed that has been grown on no more than 100,000 acres worldwide in the last fifty years. In recent years, however, there has been renewed interest in the crop for the healthy properties of its oil and the beneficial impact it has upon meat and eggs when fed as a meal. However, the biggest boost to camelina production has come in North America, where it has attracted the attention of green diesel producers driven to meet a renewable fuel mandate and growers looking to produce a low-risk/low-input crop on marginal acres, a protocol for which camelina is well suited. On average, over the last five years, roughly half of the world's production has taken place in North America, specifically the Northern Plains of the US and Canada's Prairie Provinces. The balance of production is scattered throughout Eastern and Central Europe, namely in Germany, France, Austria, Poland, Slovenia, Finland, Russia and the Ukraine. The majority of the camelina crop is likely to become GM in the future.

Although biofuels mandates paved the way for camelina expansions in North America, where acreage peaked in 2009, the fickle and political nature of this market has been less welcoming of camelina in recent years. For example, upwards of 600,000 gallons of green diesel produced from camelina were supplied to the US military between 2009 and 2011. However, the US Congress terminated a military green diesel procurement program in early 2012. A number of other hurdles have also emerged for camelina in recent years, including one of two major buyers reneging on contracts in 2010 and series of obstacles associated with camelina being a new and minor crop in the US and Canada. Collectively, these challenges have pushed North American acreage to roughly 11,500 acres in 2012, down from nearly 50,000 in 2009 (Diagram 1.7).

Diagram 1.7: North American camelina plantings and production 2006-2012



With camelina's role in biofuels on temporary hiatus, the largest end-users of camelina oil in North America were in the cosmetics industry, with L'Oreal and Estee Lauder being major end users of so-called "sativa" oil.

After three years of petitioning the EPA, underwritten primarily by the largest marketer of camelina seed globally, Sustainable Oils, biofuel pathways for camelina were approved both as an advanced biofuel and biomass based diesel. With a biofuel pathway in place, the market for camelina is set to improve. This, coupled with the Biomass Crop Assistance Program (BCAP) and a pilot program for insuring a grower's camelina crop, should lead to sizable increases in camelina acreage in North America in the coming years.

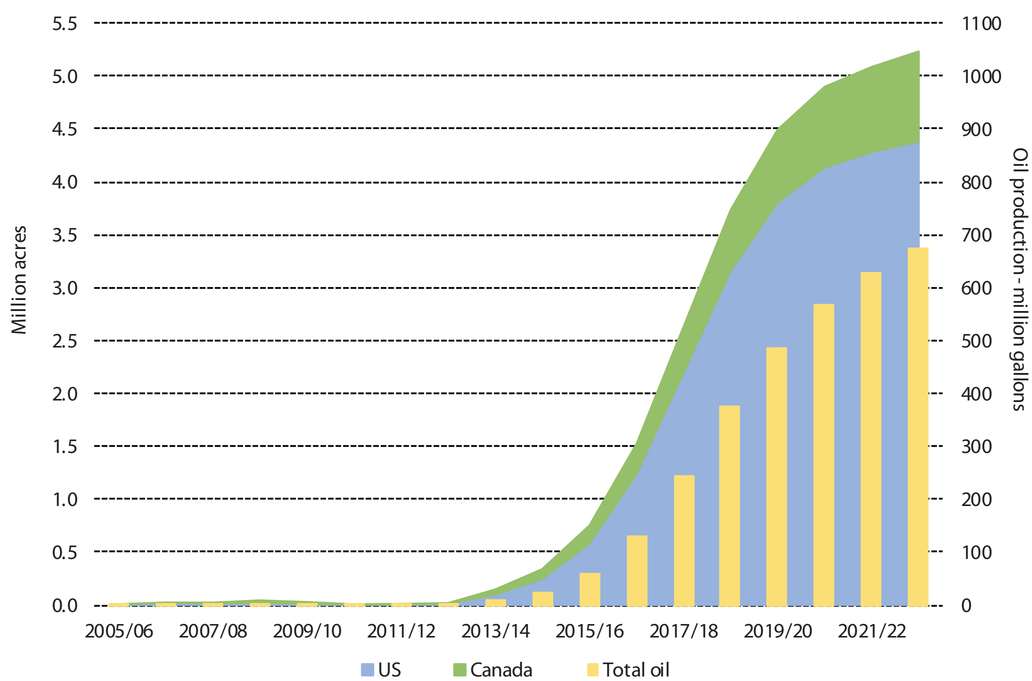
The potential for camelina production in North America

Because camelina is a niche crop, grown on relatively few acres in only isolated parts of North America it would be difficult to forecast production with much certainty going forward. This task is made impossible however by the fact that the few years of large scale production that have taken place in North America have been plagued by hot and cold market dynamics preventing an accurate assessment of the relative attractiveness of camelina against competing crops.

Therefore, rather than forecasting camelina production going forward we have projected the maximum acreage the crop could feasibly capture over the next 10-15 years.

Camelina has been most competitive on marginal acres and this will be true going forward. Specifically, it is thought that where camelina will be best able to compete is in the fallow share of a dryland wheat/fallow rotation and even then, camelina's ability to claim acreage will be limited by competing crops and the use of broadleaf herbicides on cereals in the rotation. There may also be reluctance from some growers to adopt a GM crop due to yield drag.

Diagram 1.8: Maximum potential for camelina production in North America



- There are currently 49 million acres of wheat harvested in the US annually. Of this total, roughly 35 million acres are in dryland.

- Of these 35 million acres, it is estimated that only two thirds are grown in rotation with fallow with no alternative to fallow that would be more profitable.

- However, of these 23 million acres where camelina could potentially compete, nearly half are treated with sulfonyl urea herbicide to control broadleaf weeds. Brassicae crops, like camelina, are particularly sensitive to this herbicide class, leaving only 11.5 million available acres for camelina.

- The majority of camelina seed grown in North America uses licensed genetic material. In speaking with seed companies and camelina industry stakeholders it has become apparent that "tech penetration" of greater than 50% is atypical, thus leaving 5.8 million acres where camelina could feasibly be planted in 2011/12.

- Lastly, wheat acreage in North America has been falling and is projected to fall further over the next 10 years. By 2022/23 USDA projects US wheat acreage to fall 8%. Thus, maximum potential acres for camelina are also expected to fall to a projected 4.4 million acres in 2022/23 (Diagram 1.8).

- In Canada, the logic behind determining the maximum acreage for camelina is similar and like the US their wheat acreage is expected to fall in the coming years. In Addition, Canadian wheat acreage is just 40% of wheat acreage in the United States. By 2022/23 the theoretical maximum camelina area in Canada would be 850,000 acres. Collectively this would add up to a theoretical maximum camelina acreage of 5.2 million acres in 2022/23 across North America (Diagram 1.7).

- Commercial camelina yields in recent years have ranged between 500 and 1000 pounds of seed per acre. The crop has the potential to yield much higher however, and as growers become more accustomed to its cultivation it is expected that yields could average 2,300-2,500 pounds per acre in ten years' time.

- If these yields are achieved, there is potential for 675 million gallons of camelina oil production in the next 10-15 years (Diagram 1.7).

The potential for camelina production outside North America

Camelina is grown in small pockets throughout Europe and central Asia, where it is confined to niche uses, primarily as a salad oil or in cosmetic applications. The prospects for future growth in edible applications for camelina are limited, however, because of the presence of Erucic acid in the oil.

While camelina can be bred to achieve Erucic acids levels below 2% (the maximum allowed for canola), there is little motivation to do so given the ample quantities of canola grown globally. Instead, future growth for camelina globally, like in North America, is tethered to its demand as a biofuel and other industrial applications.

Groups like Sustainable Oils which have experience in contracting and marketing camelina production only speak of a small group of countries when identifying growth opportunities outside of America. Of the countries that are most seriously discussed, two, Turkey and the Ukraine have been explored, but with caution as a result of concern that the intellectual property behind camelina genetics will not be respected.

Commercializing camelina production has been pursued more vigorously in Australia, because of its history of respecting intellectual property and because it presents the agronomic conditions where camelina is most likely to be competitive. Within Australia, camelina has the best chance for success in the arid conditions of South and Western Australia, where wheat is grown in rotation with pasture for Australia's expansive livestock sector. That said, drought frequently occurs in these areas and is severe enough that not all areas planted to camelina will yield an economically viable crop every year. Proponents of camelina argue that in these years, camelina could be valuable as a high protein hay and, while not as valuable as the seed itself, some value could still be recovered from camelina during drought years.

Ultimately camelina is thought to be most useful as a break crop between pasture and wheat, giving the grower a chance to clear volunteer grasses from fields prior to planting a higher value crop like wheat. There has been less testing of camelina in Australia relative to North America, but industry stakeholders have suggested a maximum potential acreage for camelina in Australia of around 1 million acres, with yields comparable to those in North America.

Table 1.9: Maximum potential camelina oil supply ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
USA	2	0	1	2	22	60	157	365	707
Canada	3	1	1	2	11	23	46	85	139
Rest of World	0	0	0	0	0	0	0	0	0
World	5	1	2	4	32	83	202	449	846

Notes: 1. Years are calendar years.
2. Forecasts begin in 2012.

Source: 1. USDA (for historical data).

Part 2: The Supply of RFS-2 Non-Qualifying Feedstocks

This chapter examines the current and future supply to 2018 of biodiesel feedstocks which have not been approved for the RFS2. As in Part 1, our supply estimates represent oil-in-seed rather than the quantity of oil actually produced in each country. We include the following oil crops.

- Palm oil,
- Sunflower seed oil,
- Cottonseed oil,
- Edible corn oil (not from DDG),
- Palm kernel oil,
- Coconut oil,
- Jatropha oil,
- Castor oil.

Palm oil

As a tree crop, oil palm dances to a different tune from annual oilseed crops. In order to project oil palm supply out to 2018, we have developed a complex methodology which we outline below before presenting our forecasts.

Palm oil has become more and more important to global vegetable oil supplies since 2000. Its role has been especially important because biofuels have boosted demand for oils without lifting it for meals. Thus the world appreciates a source of oil, such as oil palm, that does not add much to the supply of meal. (Please note that, even if not much palm oil is used as a biofuel, it helps to fill the gap when other oils are diverted from food to biofuel uses.)

Methodology

Palm oil demand (and therefore output) has expanded rapidly in the past decade or so, but can oil palm continue such impressive rates of growth?

Our methodology for answering this question hinges upon the supply response of oil palm plantings. As with any agricultural crop, the most important determinant of plantings is price. However, analysis of the feedback loop connecting prices to palm oil output is more difficult than that for annual oilseeds, such as rapeseed or soybeans. New plantings take years to emerge as new additions to palm supply. Moreover, data for the largest producer, Indonesia, which is where most of the growth in planted areas is occurring, are notoriously unreliable.

Our methodology in forecasting palm oil output is designed to capture the following supply responses of major actual and potential oil palm producers around the world:

- We concentrate first on the response of plantings in ***Malaysia*** (where data are superb). In Malaysia, the rate of plantings has been slowing for some time. This mostly reflects the lack of suitable remaining land, with only Sarawak in Borneo offering the potential for any notable future expansion.
- Next, we turn to ***Indonesia*** which offers the greatest potential for oil palm area expansion in the next decade. The constraints on Indonesian growth are less to do with land availability than with internal and external pressures. The environmental lobby, led by powerful and vocal NGOs, has exerted sufficient pressure via end-use companies and governments for Indonesia's government to have agreed to tighten the acceptable parameters of land development for oil palm.

- Inside Indonesia, labor costs are rising as economic development takes place and raises the key price at which there exists an incentive to expand area. These twin pressures alone should be sufficient to slow the pace of area expansion in Indonesia. However, if Indonesia slows its expansion, demand for vegetable oils will ensure that oil palm developments are simply pushed to less environmentally sensitive regions and/or those with lower labor costs.
- This brings us to ***West Africa***. This region has extensive agro-climatic zones meeting the conditions required for successful oil palm cultivation. Several South East Asian palm oil companies and outside investors are evaluating projects in West Africa and some are already under way. In part, this is a reaction to the constraints described above in Malaysia and Indonesia. The net impact upon total future palm oil output, therefore, of environmental pressures may be negligible (though some may argue that there would be a net environmental gain by re-locating to less sensitive regions). Our analysis considers the potential rate of development in West Africa as a result of the relocation of some investment that would previously have gone to South East Asia.
- ***Latin America*** is in a somewhat similar position to West Africa, although labor costs are generally much higher. Nonetheless, some tropical regions of Central and South America have available land and suitable climates. In some cases, such as Brazil and Colombia, these benefits are supported by domestic biodiesel programmes and, in Brazil, developers (notably Vale, the mining and rail giant) are introducing palm plantations for their own dedicated use after the palm oil is converted to biodiesel.

Current and future supply

Our forecasts for world palm oil output, under the assumption that the petroleum price follows our low "realistic" (low price) projection and that a combination of pressures slow the rate of expansion, are summarised in Table 2.1.

Our forecasts for palm oil output yield the following main conclusions:

- Even under bearish price forecasts, palm oil will expand its output at over 6% per annum to 2018, driven by its inherent profitability and the worldwide demand for vegetable oil as incomes and populations rise. As oil palm provides very little meal relative to its oil yield, and oil yields per hectare are high, low cost palm oil is extremely well-placed to feed the burgeoning demand for oils in food, replacing other oils diverted to biofuels.
- In addition, oil palm's low meal content means that high oil prices feed almost directly into a producer response in oil palm plantings. For other oilseeds, the price signal to the grower is diffused by the feedback from revenues from the co-product, oilseed meal.

Table 2.1: Palm oil supply ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
USA	0	0	0	0	0	0	0	0	0
Canada	0	0	0	0	0	0	0	0	0
Indonesia	22,258	25,197	27,588	30,449	31,450	34,268	37,361	40,592	43,689
Malaysia	16,994	18,912	18,943	19,912	20,008	21,003	22,022	23,058	24,048
Thailand	1,276	1,490	1,846	2,011	1,889	2,042	2,227	2,422	2,626
Rest of World	5,367	2,976	3,577	5,033	5,477	5,753	6,047	6,382	6,771
World	45,895	48,574	51,955	57,406	58,824	63,066	67,657	72,454	77,135

Notes: 1. Years are shown as annual but reflect crop years i.e., 2012 refers to crop year 2011/12.
2. Forecasts begin in 2014 (crop year 2013/14).

Source: 1. USDA (for historical data).

Sunflowerseed oil

Along with rapeseed, sunflowerseed provides a vehicle to allow annual adjustments in oilseed supplies to match changes in global demand for vegetable oils (with soybean supplies adjusting to match changes in meal demand). In fact, sunflowerseed is subject to many of the same disciplines as its fellow softseed, canola/rapeseed.

Current and future supply

We present our forecasts for sunflowerseed production to 2018 in Table 2.2. The sunflower forecast displays similar characteristics to rapeseed, with output fluctuating due to the competition with grains and imbalances between aggregate demand and output in the overall vegetable oil complex. The large increases in palm oil expected over the next five years should limit the space for sunflower oil sales, which is why we have a period of negative growth after 2015. The greatest burden of adjustment is felt by Ukraine, the leading global exporter of sunflower products. However, Argentina and Russia share some of the pain. Over the past decade, the centre of world sunflower supply has experienced a significant shift towards the Black Sea region.

Table 2.2: Sunflower oil supply ('000metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
USA	564	508	379	517	574	574	574	575	575
Canada	42	28	8	36	31	29	26	26	30
Argentina	941	1,502	1,367	1,310	1,441	1,490	1,520	1,468	1,454
EU	2,829	2,832	3,362	2,955	3,179	3,197	3,216	3,234	3,253
Russia	2,630	2,190	3,940	3,258	3,295	3,363	3,349	3,332	3,287
Ukraine	3,111	3,438	4,298	3,684	3,400	3,935	3,728	3,595	3,078
Rest of World	3,059	3,126	2,641	3,326	3,542	3,554	3,582	3,599	3,701
World	13,176	13,624	15,996	15,086	15,462	16,143	15,994	15,829	15,378

Notes: 1. Years are shown as annual but reflect crop years i.e., 2012 = crop year 2011/12.
2. Forecasts begin in 2014 (crop year 2013/14).

Source: 1. USDA (for historical data).

Cottonseed oil

Historically, cottonseed, a by-product of lint output for textiles, was the world's second largest oilseed by volume, following soybeans closely. Its importance remains high in Asia, and the US. Almost all cottonseed, oil and meal are consumed in the country where they are produced. Although exports are relatively small, cottonseed oil has gained some popularity in snack food production.

Cotton is grown in warmer climates and succeeds in low to moderate rainfall zones, allowing it to perform well in the drier parts of Asia and the southern US. Cottonseed production is dominated by four major producers: China, USA, India and Pakistan. Their share of world output has risen from around 50% in the mid-1970s to over 70% today. Cottonseed oil is produced as a by-product of output decisions made with reference to the cotton fiber market.

Methodology

The decision to plant cotton is driven by the economics of the production of the fiber. In the past, supply increases have been reliant on improvements in cotton yields with cottonseed areas stalling in recent years and some countries even declining, such as China and the US.

World cotton plantings do demonstrate an ability to respond to market signals by increasing during high cotton price periods and decreasing when prices are relatively weak. The effectiveness of market signals gives us some confidence in the ability of cotton output to continue to progress, on average, at its trend rate out to 2018. Cottonseed will be competing to maintain its area, rather than expanding, and relying on yield developments to increase production.

Current and future supply

Table 2.3 presents our forecasts of cottonseed oil supply to 2018. China and India are the largest producers of cottonseed oil making up around half of total global production. These countries are also driving growth in supply whereas US production is expected decrease over the forecast period.

Table 2.3: Cottonseed oil supply ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
USA	280	379	342	363	327	322	318	313	309
Canada	0	0	0	0	0	0	0	0	0
China	1,466	1,411	1,476	1,566	1,541	1,606	1,643	1,677	1,711
India	1,045	1,150	1,210	1,220	1,253	1,099	1,105	1,131	1,157
Rest of World	1,805	2,026	2,232	2,133	2,133	2,429	2,465	2,485	2,505
World	4,596	4,966	5,260	5,282	5,254	5,456	5,531	5,606	5,681

Notes: 1. Years are shown as annual but reflect crop years i.e., 2012 = crop year 2011/12.
2. Forecasts begin in 2014 (crop year 2013/14).

Source: 1. USDA (for historical data).

Edible corn oil

Milling of corn for starch and the production of ethanol from a wet milling process generates a range of by-products, such as edible corn oil, corn gluten feed and corn gluten meal. As a result, the supply of these products grows at a rate entirely dictated by the growth in the milling process from which they are derived.

Methodology

Modelling future corn oil and gluten feed and meal supply is complicated as they are not simply a function of corn crop dynamics. Animal feed is the major outlet for corn; much of the rest is absorbed by the process of starch and ethanol production. The complication is that ethanol or starch producers have the option to use either wet or dry milling and different by-products are derived as a result. At present, food-grade corn oil can only be obtained from the wet milling route.

Corn gluten feed is considered as a carbohydrate cattle feed rather than protein feed due to its low protein content of 21% (against 60% for corn gluten meal). Thus, it is not seen as a direct competitor for protein meal.

Our forecasts of corn oil and gluten feed and meal output to 2018 draw upon LMC's forecasts of world starch processing and wet milled ethanol production, and are adjusted for use of grains other than corn in the EU and elsewhere. This allows us to estimate the volume of corn being processed for starch with some confidence. From that, we estimate the volume of corn oil output using conventional ratios.

Current and future supply

Table 2.4 lists our forecasts of edible corn oil production in the major producing countries and globally to 2018. Total edible corn oil supply is expected to grow steadily over the next five years to reach nearly 3.2 million metric tons worldwide by 2018. This is predominantly the result of growing demand for starch products with growth in corn oil a by-product of that supply. Growth over the forecast period is driven by China. In 2013 corn oil output in China is expected to account for nearly 27% of total world output. This share should increase to over 30% by 2018.

Table 2.4: Edible corn oil supply ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
USA	919	968	962	947	953	962	965	964	966
Canada	69	68	69	68	68	69	70	72	73
China	652	708	737	778	822	868	917	970	1,017
EU	332	342	337	339	342	346	350	356	359

Notes: 1. Years are calendar years.
2. Forecasts begin in 2012.

Source: 1. LMC estimates (for historical data).

Palm kernel oil

Current and future supply

Palm kernel is produced as a direct by-product of the production of palm oil. Thus, its output volumes are a direct consequence of the factors that determine palm oil output. We summarise below our forecasts of palm kernel oil and meal output to 2018. Growth in supply follows the same trend as our palm oil forecasts, growing on average, at 6% per year from 2014 to 2018.

Table 2.5: Palm kernel oil supply ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
USA	0	0	0	0	0	0	0	0	0
Canada	0	0	0	0	0	0	0	0	0
Indonesia	2,605	2,794	3,102	3,375	3,563	3,882	4,233	4,599	4,950
Malaysia	2,097	2,073	2,102	2,194	2,288	2,401	2,518	2,637	2,750
Rest of World	799	799	818	869	902	937	982	1,037	1,101
World	5,501	5,666	6,022	6,438	6,753	7,221	7,733	8,272	8,800

Notes: 1. Years are shown as annual but reflect crop years i.e., 2012 = crop year 2011/12.
2. Forecasts begin in 2014 (crop year 2013/14).

Source: 1. USDA (for historical data).

Coconut oil

The world's largest producer of coconut oil is the Philippines, who alone accounts for around 40% of the world production. The Philippines, India and Indonesia dominate the sector and supply over 80% of global output.

The expansion of coconut oil production has been subdued as a result of a lack of profitability among major producers. The typical yield of coconut palm is at the lowest end of all oil-bearing crops/palms, with 0.25 metric tons of coconut oil per acre, which compares unfavorably with 1.75 metric tons of palm oil in modern estates. Yield is also extremely volatile due to the exposure to intermittent typhoons and drought in major producing countries.

Apart from its low yield, productivity is further disadvantaged by its production model since smallholders account for nearly all the world's output. Typical plot sizes are 4-5 acres and operate with family labor. Consequently, economies of scale are hard to attain. A further problem for coconut is that, in the Philippines and Indonesia, these small plantations are scattered around hundreds of islands which makes the physical consolidation of production a considerable challenge.

Finally, one must not forget the long gestation period of coconut palms, where the tree only starts yielding after 7 years — considerably longer than the three years a farmer must wait for an oil palm planting to begin to produce a crop or the five years for rubber. This long delay means replanting occurs very slowly on smallholder plots and so one can routinely find trees that are over 100 years old. If smallholders face cash flow problems, they may be tempted simply to sell the trees for timber and to replant to another, faster-growing, cash crop. In the Philippines, for example, one-off revenues from sales of the timber when coconut palms are felled equal about five years' earnings from coconut farming.

The net effect of the sector's structural weaknesses has been that average worldwide yields for coconut have fallen over the past decade or so. In the same period, the global coconut palm area has stabilized but, without further plantings, the area is expected to decline.

Copra output has, therefore, been hindered by poor economics. As coconut oil is a very close substitute for its partner lauric oil, palm kernel oil, and PKO supplies are growing rapidly in the wake of oil palm development, there seems little reason to believe that coconut production should expand to a significant degree in the foreseeable future, especially since few new plantings of coconut are taking place. In the next table, we present our estimates for output of coconut oil to 2018.

Current and future supply

Table 2.6 shows our production forecasts of coconut oil to 2018. Production is expected to remain stable over the next five years with little change in the structure of the industry.

Table 2.6: Coconut oil supply ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
USA	0	0	0	0	0	0	0	0	0
Canada	0	0	0	0	0	0	0	0	0
Indonesia	968	943	911	975	974	937	946	955	964
Philippines	1,630	1,824	1,555	1,736	1,725	1,592	1,588	1,598	1,608
Rest of World	1,031	1,039	1,030	1,036	1,036	1,150	1,172	1,188	1,205
World	3,629	3,806	3,496	3,747	3,735	3,679	3,707	3,741	3,777

Notes: 1. Years are shown as annual but reflect crop years i.e., 2012 = crop year 2011/12.
2. Forecasts begin in 2014 (crop year 2013/14).

Source: 1. USDA (for historical data).

Jatropha oil

Jatropha oil is a non-food oil which has attracted interest as a biofuel because of its potentially good sustainability credentials. Jatropha can be grown on marginal land that is not well suited to growing food crops, thereby reducing the conflict between food and fuel. In addition, it offers the promise of employment for a large number of poor subsistence workers in parts of Africa and Asia where the opportunity cost of labor is low.

A few years ago there was an influx of investment into jatropha to exploit its potential as a feedstock for biodiesel. One of the largest of these was the joint venture between BP and D1 Oils established to promote jatropha production world-wide. The entity was responsible for the planting of 500,000 acres, around 25% of the world's supply at that time. However, BP pulled out of the joint venture in 2009. Other companies established to produce jatropha oil have left the sector. These events cast doubt on the future of jatropha. For this reason we present estimates of maximum future supply based on current area rather than a forecast of future output per se.

Methodology

Jatropha curcas grows in a number of climatic zones in tropical and sub-tropical regions of the world. Jatropha is able to grow almost anywhere, even on gravel, sandy and saline soils. It can thrive on the poorest stony soil. Its water requirement is extremely low and it can withstand long periods of drought by shedding most of its leaves to reduce transpiration loss.

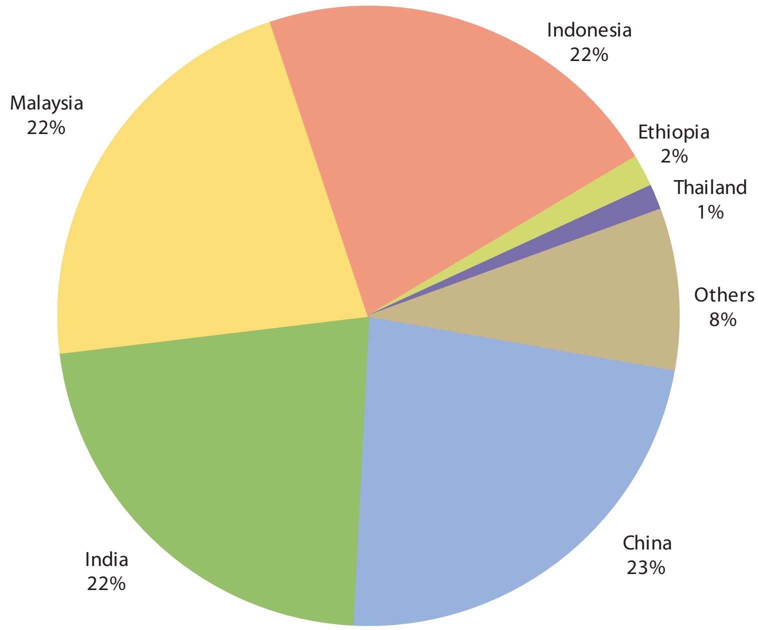
Although it can withstand drought, the plant does not prosper with precipitation of less than 25 inches of rainfall per year. The plant cannot tolerate significant frost, ruling out cultivation in temperate regions. The tree will survive a very light frost, but it loses all its leaves, with the result that the production of seeds declines sharply. The challenge for commercial producers is to identify a location with good rainfall but not under pressure to grow alternative food crops.

It takes 3-4 years for jatropha to reach its full yield potential. The productive life of the tree is reportedly up to 30 years but there is no data on how yields evolve beyond the plants' maturity.

A recent survey by Leuphana University found that there are currently 111 jatropha projects worldwide engaged in seed production covering an area of 3 million acres. Most of the area is located in Asia, with China, India, Malaysia and Indonesia the main countries engaged in jatropha cultivation. Outside Asia, most of the remaining area is to be found in Africa.

Over 70% of the operational sites in the survey started operations between 2007 and 2009. Cultivation site establishments peaked in 2008 and thereafter dropped considerably as a result of the global financial crisis. Very few projects have been in existence for more than five years.

Diagram 2.1: Distribution of World Jatropha Area, 2011 (Total = 3 million acres)



Source: Leuphana University, December 2012.

Current and Future Production

Current world production of jatropha oil is very small and estimated at around 25,000 metric tons. As the crop is still under development, it is difficult to know how supply will evolve in the future. We have calculated the maximum potential future supply of jatropha oil using the area and seed yield estimates in the Leuphana survey. The survey also provides the age of each plantation which allows us to model its future output, given what is known about the trajectory of yields to date. We have assumed that the oil content of the seed is 30-35%, of which 80% can be extracted. We assume that no new plantations are established after 2012, reflecting the waning of interest in jatropha. The projections represent the maximum potential supply that could be available in the future if all plantations are harvested and 100% of the seed is processed into oil. Output could be lower than this if as we understand from recent field visits to Asia, some projects are abandoned as a result of a lack of finance. On the basis of these assumptions, we project that in the period to 2018, an annual total of 1.0-1.3 million metric tons of jatropha oil could be produced worldwide.

Table 2.7: Future maximum Jatropha oil production ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Africa	28	44	55	61	63	63	62	60	56
Asia	922	978	1,177	1,204	1,200	1,189	1,165	1,085	974
Latin America & Caribbean	2	5	11	14	16	18	20	20	19
USA	0	0	0	0	0	0	0	0	0
Canada	0	0	0	0	0	0	0	0	0
Rest of World	0	0	0	0	0	0	0	0	0
World	952	1,027	1,243	1,279	1,278	1,270	1,246	1,164	1,049

Note: Years are calendar years. Figures represent maximum possible output in each year rather than actual production.

Source: Leuphana University (for historical data).

In the absence of subsidies, jatropha production will only be viable in the longer term if it can be produced profitability at an f.o.b. value of $1,135 per metric ton. If we assume annualised yields of 0.8-1.0 metric tons of seed per acre then jatropha oil could be produced for this price in countries where wage rates are around $4.0-4.5 per day.

China, India, and the Philippines all have daily wage rates in excess of $4.50 per day. Consequently, jatropha plantations are unlikely to be economically sustainable in these countries in the long term, unless much higher yields can be achieved. This casts some doubt over the sustainability of jatropha in these countries.

Countries which are climatically suited to growing jatropha and which have wage rates below $4.50/day are almost entirely found in Africa. Production in Africa is characterised by the small-holder model of production which is generally less efficient and higher in cost than a large scale plantation. Most of the jatropha oil currently produced is consumed locally as a substitute for diesel oil. Despite a large number of projects underway, it is impossible to know whether any surplus oil will be available for export in the future.

The future price of jatropha oil will be driven by its value as a feedstock for biodiesel production. This implies that it is likely to trade at levels close to soybean oil. If jatropha is to avoid conflict with food crops, it must be grown on sub-optimal soil with lower rainfall. This will inevitably lower yields and raise production costs.

Castor oil

The castor oil plant is a perennial shrub grown in tropical zones producing seeds known as castor beans which are crushed to produce castor oil. On a global basis, area planted to castor has remained relatively steady during the past twenty years at around 1.4 million hectares, while yield and production have increased. The price of castor oil has also moved steadily upward. India has a large and growing share of global area making up nearly 65% of area in 2011 and almost 85% of global production. There is very little trade in castor seed but both Brazil and China import seed as well as being major producers.

Current and Future Production

Our current production figures for castor oil are based on the production of castor beans published by the Food and Agriculture Organisation of the United Nations (FAO). We assume oil content of 50.3% to calculate oil production. Our forecasts are based on the trend in bean production over the past twenty years.

Table 2.8: Castor oil supply ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Canada	0	0	0	0	0	0	0	0	0
USA	0	0	0	0	0	0	0	0	0
Brazil	48	60	58	59	60	61	62	63	64
China	91	91	88	86	83	80	78	75	73
India	679	1,177	664	682	700	719	737	756	774
Other	67	65	56	56	55	55	55	55	55
World	884	1,392	865	882	899	916	932	949	966

Note: Years are calendar years.

Source: FAO (for historical data).

The latest data from the FAO is for 2011 which saw a large spike in production. Our forecasts assume that this spike is not evidence of rapid growth in production but the product of an exceptional year when high prices encouraged production. The surplus supply in 2011then led to lower prices, causing farmers to switch production away from castor beans. We forecast castor oil production increasing steadily over the next five years. However if prices are attractive potential supply could be much higher.

Total oil supplies

Parts 1 and 2 of this study have discussed in detail our estimates of current and future supply of oils and fats to 2018. Diagram 3.1 presents our total global supply forecasts by type of oil over the forecast period. Our forecasts show supplies of oil growing by an average of nearly 4% per year between 2013 and 2018 reaching 217 million metric tons in 2018.

The composition of the oil market is expected to remain fairly stable. The only major shift is that palm oil is expected to make up a growing proportion of the total market, increasing from 29% in 2012 to 34% in 2018.

Diagram 3.1: Current (2010-2012) and projected (2013-2018) world oil and fat supplies by type

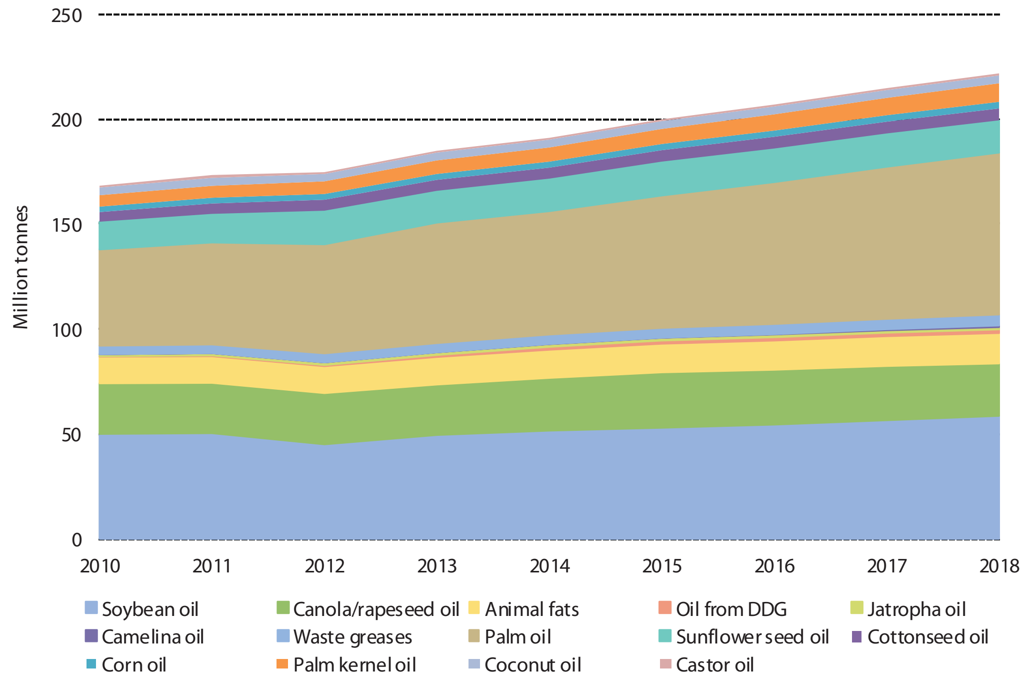


Table 3.1: Current (2010-2012) and projected (2013-2018) world oil and fat supplies ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Soybean oil	49,990	50,358	45,069	49,497	51,602	52,969	54,462	56,554	58,613
Canola/rapeseed oil	24,179	24,022	24,376	24,082	25,138	26,383	26,111	25,808	24,984
Animal fats	12,682	12,680	12,868	13,113	13,371	13,643	13,924	14,208	14,485
Oil from DDG	213	377	538	961	1,419	1,536	1,617	1,686	1,755
Jatropha oil	952	1,027	1,243	1,279	1,278	1,270	1,246	1,164	1,049
Camelina oil	5	1	2	4	32	83	202	449	846
Waste greases	4,042	4,218	4,305	4,392	4,518	4,666	4,828	5,001	5,186
Palm oil	45,895	48,574	51,955	57,406	58,824	63,066	67,657	72,454	77,135
Sunflower seed oil	13,176	13,624	15,996	15,086	15,462	16,143	15,994	15,829	15,378
Cottonseed oil	4,596	4,966	5,260	5,282	5,254	5,456	5,531	5,606	5,681
Corn oil	2,561	2,698	2,727	2,773	2,844	2,922	2,997	3,086	3,160
Palm kernel oil	5,501	5,666	6,022	6,438	6,753	7,221	7,733	8,272	8,800
Coconut oil	3,629	3,806	3,496	3,747	3,735	3,679	3,707	3,741	3,777
Castor oil	884	1,392	865	882	899	916	932	949	966
Total	170,315	175,421	176,734	186,954	193,143	201,968	208,958	216,825	223,832

Note: All oils except oil from DDG, jatropha, camelina, waste greases and corn oil are presented on a crop year basis (i.e. 2010 represents the 2009/10 crop year). The figures for jatropha represent maximum theoretical supply.

Diagram 3.2 presents total oil and fat supply split by EPA approved and non-EPA approved feedstocks. This reveals that the majority of the growth in total supplies is from the non-approved feedstocks. In 2018 we expect around 52% of total oil and fat supplies to be made up of currently non-EPA approved feedstocks. The percentage of total oil and fat supplies from the US and Canada fluctuates between 18% and 21% over the forecast period remaining fairly stable.

Diagram 3.2: World supply of oils and fats split by RFS-approved and non-approved supply

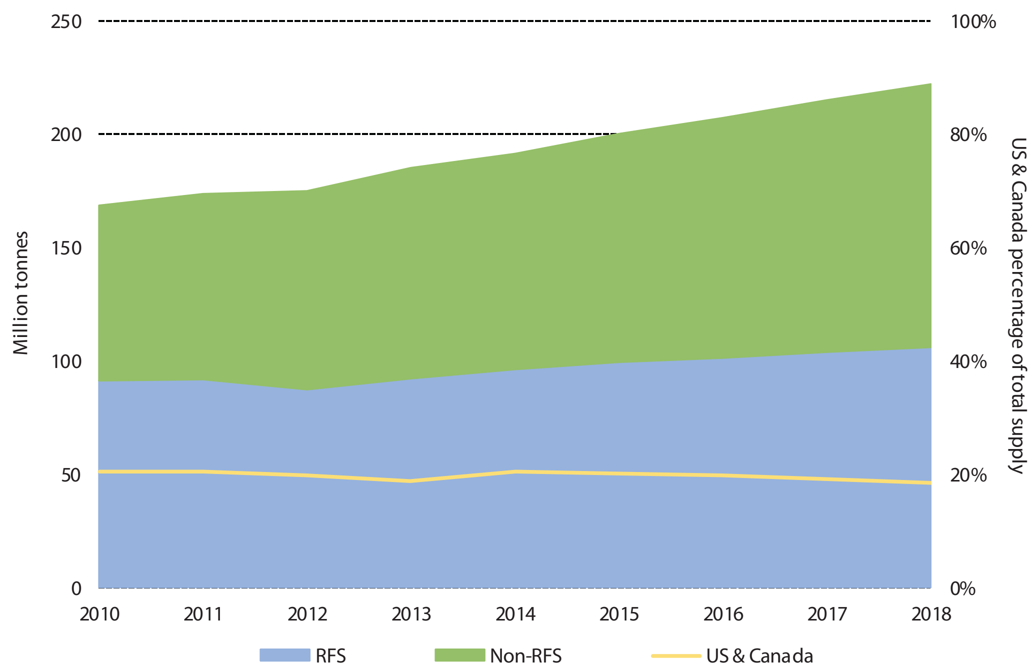


Diagram 3.3 presents the outlook for the total supply of EPA approved biodiesel feedstocks. Supply in the US and Canada is expected to increase rapidly over the next two years, making up for the dip in production seen in 2012 and 2013 but to then remain stable at around 35 million metric tons of oil per year to 2018. On average, the US and Canada will account for around 35% of total world supply of approved feedstocks over the forecast period.

Diagram 3.3: Current (2010-2012) and projected (2013-2018) RFS-approved oil and fat supplies in the USA, Canada and Rest of World

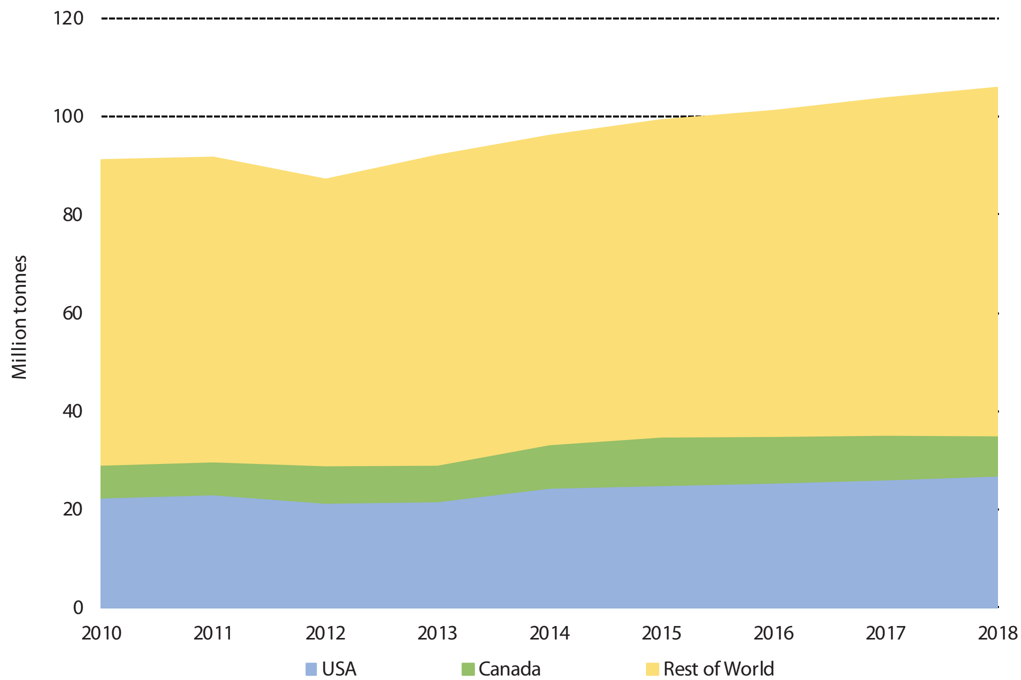
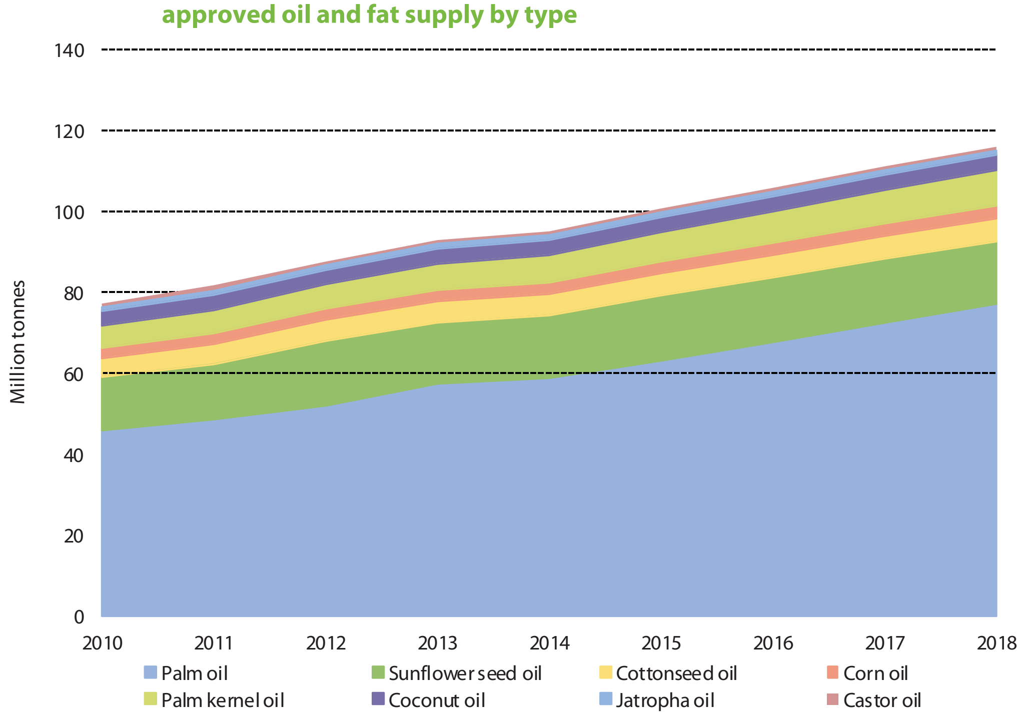


Diagram 3.4 presents an overview of the outlook for non-approved feedstocks over the next five years. The proportion of these feedstocks produced in the US and Canada is just 2%. The majority of supply of these oils comes from palm which makes up a growing proportion of production, increasing from 59% in 2012 to 67% in 2018. Over 85% of the growth in supply over our forecast period is due to increasing palm oil supplies.

Diagram 3.4: Current (2010-2012) and projected (2013-2018) supply of non-RFS approved oil and fat supply by type



Part 4: Discussion Issues

In this section we provide a brief summary of other potential issues that may influence the supply and demand for biodiesel feedstocks.

GM seed technology

At present the EU remains opposed to the production of crops from GM seeds. However, opposition to consumption appears to have become less extreme, with imports of oils and seeds from approved GM events increasing. Additionally, the domestic processing of GM produce has expanded, with EU crushers now increasingly also crushing canola seeds.

While not all GM events have been approved, this has not proved a problem for most of the oilseeds where growing is concentrated in a small number of varieties. However, it has proved an issue for US corn, where fears over contamination with unapproved varieties have led to an almost complete moratorium on imports from the US into the EU.

Yield technology

The most important developments are in higher oil content seeds. There have been some developments in this direction. However, attempts to improve the oil content by seed companies have lowered meal content, which can be self-defeating. For example, the widespread adoption of a higher oil content soybean seed would reduce meal output, increasing soymeal prices and creating demand for a higher meal content seed.

Non-tariff trade barriers on animal fats and UCO

The growing use of used cooking oil to produce double counting UCOME in Europe has allowed significant volumes of waste oil to be imported from Asia. However, there are signs that pressure from conventional biofuel producers and concerns over sustainability and traceability may threaten imports.

A major problem is that there is currently no precise definition of 'used' oil. Confusion over the definition of wastes has created significant uncertainty for market participants in determining which feedstocks can be considered for the purposes of double counting.

It is also currently very difficult to track used cooking oil and verify whether the oil is virgin or used. In response, the European Biodiesel Board (EBB) together with the European Commission (EC) intends to set up a world-wide database to track UCO. Attempts to rectify such problems are leading to onerous systems of certification and sustainability which favour European over foreign suppliers.

Additionally, a number of EU member states retain some general restrictions on biodiesel production:

France has one of the most protected biodiesel markets in the EU. The market is protected by production quotas which are allocated mainly to French producers. In addition, all biodiesel sold in the French market must be certified with the French sustainability scheme, 2BSvs. This constitutes a further barrier to foreign suppliers.

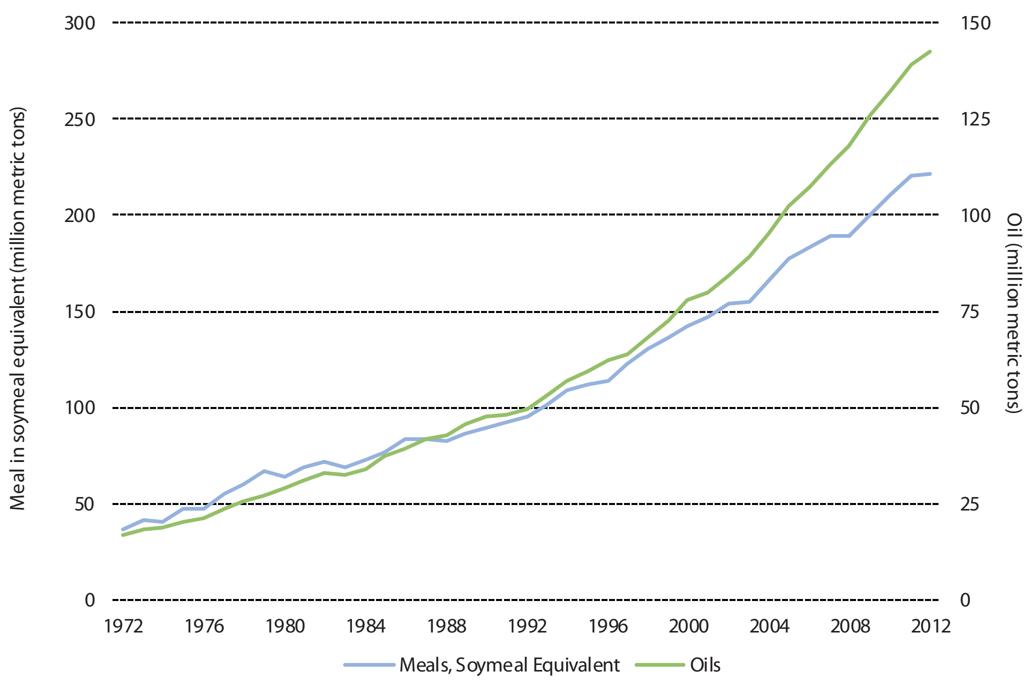
Until recently **Spain** had a relatively open biodiesel market and imported large quantities of biodiesel from Argentina. In April 2012, the Industry Ministry published an order establishing a new allocation mechanism within the Spanish biofuel quota for 2013 and 2014. The order included several retaliatory measures which had the effect of only allowing fuel blenders to use biodiesel sourced from accredited EU producers. This is seen as retaliation for Argentina's nationalisation of YPF, a subsidiary of the Spanish oil company Repsol.

Italy has implemented rules that companies that import biofuels produced outside the EU will have to ask for an authorization at the Ministry for Economic Development. Local sources have said that the authorization should be easy to obtain, although it could constitute a barrier to imports.

Growth in oil and meal demand

On separate axes, Diagram 4.1 plots aggregate global demand for oilseed meal (expressed in soybean meal equivalent terms) and the major vegetable oils. Both oil and meal have enjoyed rapid growth compared with other agricultural commodities. The key to the aggressive growth in oil and meal demand in the longer term is the high income elasticity observed in both sectors, i.e., when incomes increase, the consumption of oilseed products responds well. This dynamic is particularly pronounced at lower-to-middle income ranges. As population and income levels increase, particularly in developing countries, therefore demand for oil and meal has grown rapidly. While the demand for oil is driven by direct consumption, demand for meal is derived from the human consumption of meat via animal feed. Increased meat consumption creates demand for animal feed, which therefore created demand for soybean meal.

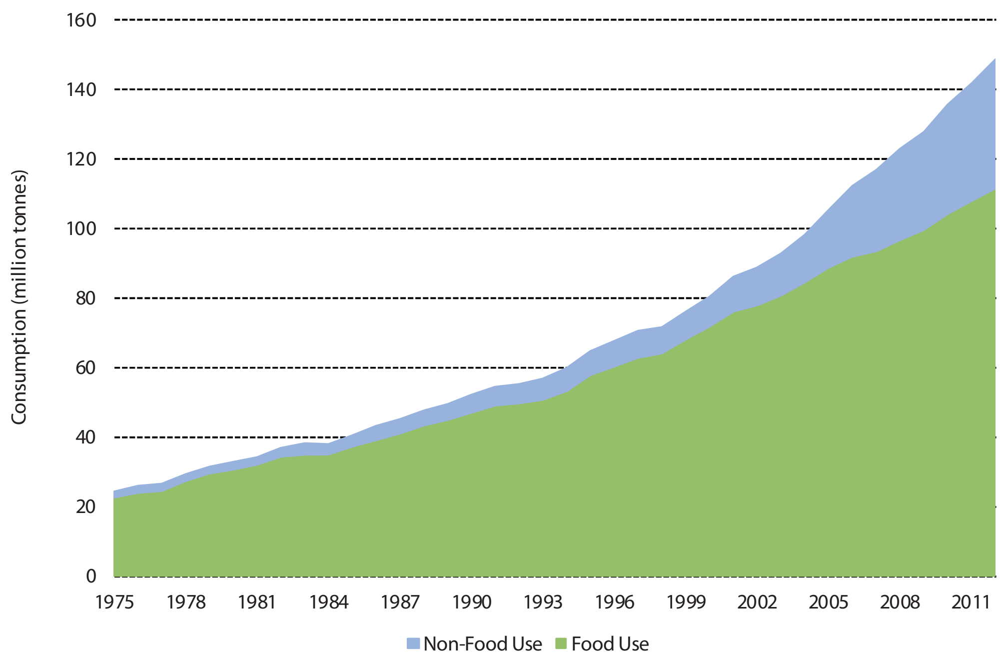
Diagram 4.1: Growth in world consumption of meal and major oils, 1972-2012



The second major observation arising from Diagram 4.1 is that oil and meal growth have recently diverged. The diagram illustrates that, before the turn of the century, consumption growth in meal echoed that of oil. This relationship has broken down over the past decade as oil consumption accelerated beyond that of meal demand. Moreover, the 2008/2009 recession can be seen to have dampened meal demand more than that of oil. This is because oil demand has been supported since 2000 by a new end-user, namely biodiesel.

Diagram 4.2 shows the share of oil split between the food and non-food sector. In the current era, non-food applications for vegetable oils have become significant: increasing from 10% of total consumption in 2000 to 25% in 2012. This growth is even more noteworthy when we consider it represents over 40% of total oil demand growth since 2000.

Diagram 4.2: Global food and non-food use of vegetable oils, 1975-2012



The Conservation Reserve Program

The Conservation Reserve Program (CRP) is a voluntary scheme in which farmers are paid rent annually if they agree to remove land from production. Enrolment is only possible for environmentally sensitive cropland with a history of cropping. Contracts vary in length from 10-15 years. All 51 states have land in the CRP scheme with the largest seven states accounting for close to half of the total area. The eleven largest states account for over 70% of the total, as shown in Diagram 4.3

Almost all the land that can be cultivated economically in the USA is in production. Despite a rapid increase in commodity prices from 2006 onwards, agriculture was unable to compete land away from other uses. The US has reached its capacity in terms of its total arable crop area, with the majority of remaining arable land placed under conservation.

However, the amount of land that is in conservation has declined since 2007. Increasing returns from cropping have resulted in a decline in the attractiveness of the CRP and enrolment has declined to a historic low of 11 million hectares, as illustrated in Diagram 4.4. As a result, since 2007 the decline in CRP enrolment has released just under four million hectares for cropping.

Diagram 4.4 also shows that the decline in area enrolled in the CRP has occurred despite the fact that the average rent for land in the CRP, measured on the right-hand axis, has increased over the past decade. Until 2007 there was a clear relationship between the level of rents and participation in the scheme. Since 2007, despite rents increasing consistently, participation in the scheme has declined.

Diagram 4.3: Area enrolled in the Conservation Reserve Program by state, 2012

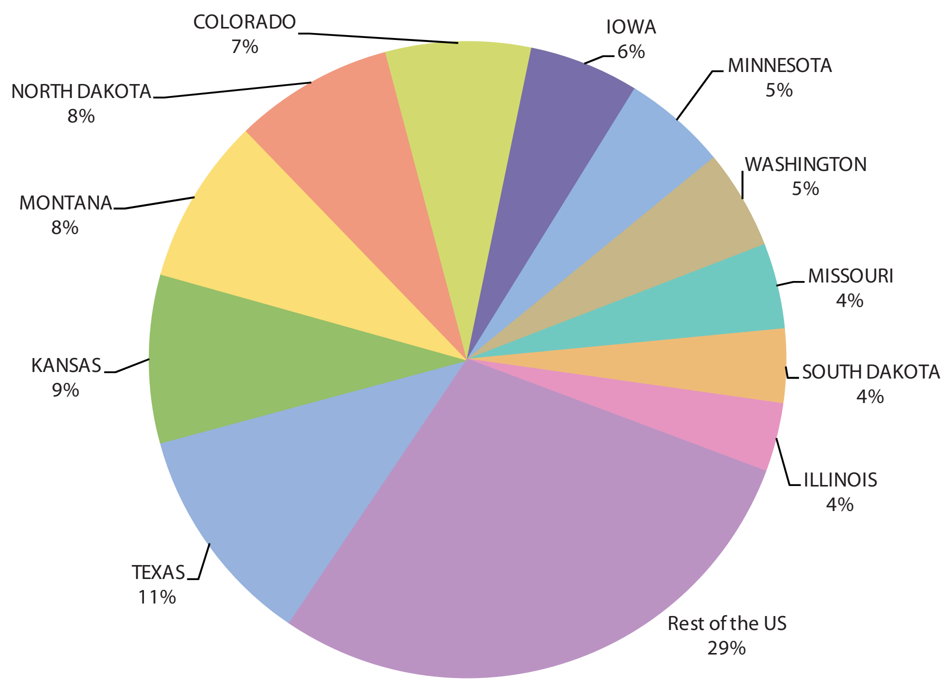
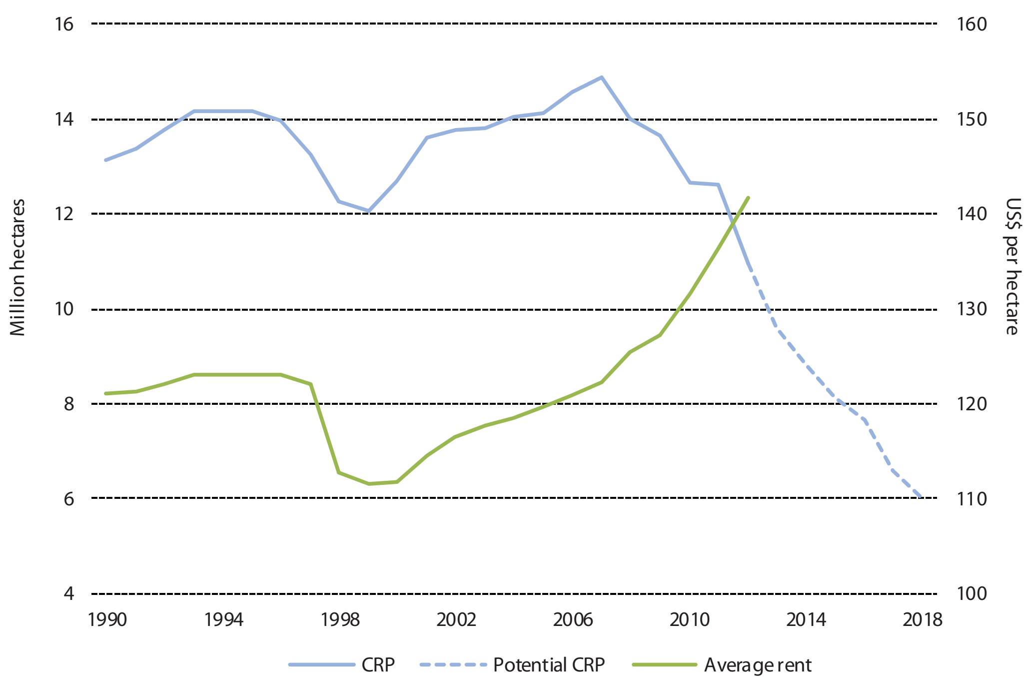


Diagram 4.4: Enrolment in the Conservation Reserve Program



Rents vary greatly between states. Maryland and Wyoming are at either end of the scale. In 2012 in Maryland just over 30,000 hectares were enrolled at an average rent of just below US$350 per hectare. In Wyoming, 86,000 hectares were enrolled at US$66 per hectare. Rents are calculated based on the productivity of the soil and average local rents, explaining the variation.

As farmers are locked into 10-15 year contracts, there is a maximum speed at which the CRP can decline. Diagram 4.4 shows how the area in the CRP could evolve by 2018 assuming that none of the CRP contracts are renewed and that no new land enters the program. This is very unlikely to be the outcome, but does show that the maximum amount of area which could be released from the CRP by 2018 would be five million hectares, leaving six million hectares in the CRP.

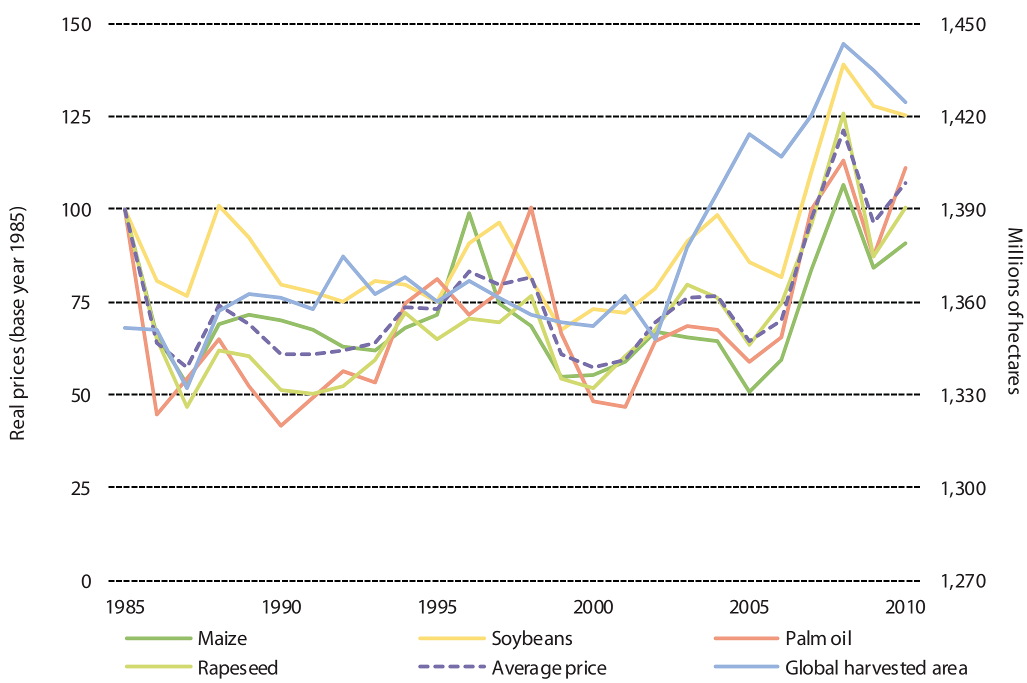
Production response to price signals

Diagram 4.5 shows how harvested area has responded to the unusually high prices of the last decade. Until 2002 most crop prices fell steadily in real terms. During the same period the global harvested area remained static at around 1.36 billion hectares. While the distribution of this land changed, as area contracted in some countries and expanded in others, the world had no need to expand its total crop area.

From 2002 onwards, however, demand for agricultural commodities as food, feed and fuel expanded rapidly outpacing the growth in supply. The inability of supply to meet the increased demand for agricultural products was transmitted through the price mechanism. As Diagram 4.5 shows, prices began a long ascent in 2002. Prices are measured in real (2011) prices and indexed to 100 in 1985 to make them comparable.

Rising crop prices encourage the production of crops which, in the absence of yield improvements, in the short run, had to be met by converting new area to cultivation. Diagram 4.5 also shows how the global harvested area, measured on the right hand axis, increased in tandem with prices.

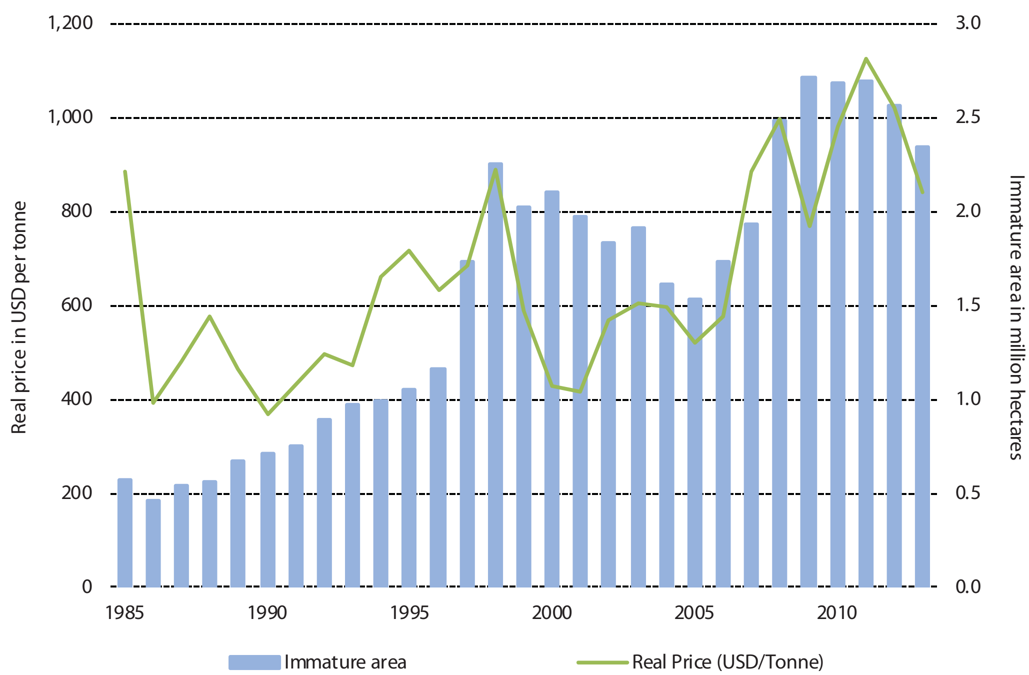
Diagram 4.5: Index of real prices and global harvested area since 1985



Higher prices made it possible to convert new area to farmland and financed ancillary investments in the infrastructure that supports agriculture, such as dams/irrigation, post-harvest logistics and ports. With the advanced agricultural producers, such as the US and EU, unable to expand any further, the expansion has come primarily in the frontier countries, such as Brazil, where large areas of land have been cleared to grow soybeans. Additionally land scarce countries, such as India and China, have managed to expand their harvested area by cropping the same land more frequently.

High prices have also led to investment in perennial crops, such as rubber and oil palm. While arable crops are sown and harvested within one year, permanent crops take several years to start yielding, after which they yield regardless of the level of demand. It takes between three and four years for oil palm and seven years for rubber trees to become mature. Long periods of elevated prices, however, still lead to the establishment of tree crops. Diagram 4.6 shows how the planting of oil palm (measured by the immature area) has reacted to this period of higher prices.

Diagram 4.6: Real palm oil price and immature area under oil palm in South East Asia



Soybean oil demand in the US

Diagram 4.7 shows how soybean oil consumption in the United States expanded rapidly until the middle of the last decade, and then lost share as there was a sharp reaction against Trans-Fatty Acids (TFA). This meant that hydrogenated soybean oil was replaced by omega-9 rapeseed oil and palm oil in baking & frying and margarine uses. The diagram shows how the consumption of these oils increased, as soybean oil declined.

It should be noted that, during the same period, the consumption of soybean oil continued to grow in uses that do not require hydrogenation, such as the salad & cooking sector. However, these uses could not stop the total food oil consumption from declining from 7.7 million metric tons at its peak to 6.3 million by 2012.

Our estimates now suggest that close to 90% of end-users, in sectors where trans-fatty acids are relevant, have already converted from partially hydrogenated soybean oil to a TFA-free format. In some cases, where health concerns are absent or where the market is very price sensitive, they are unlikely to convert at all. As a result, there is limited potential for the further substitution of oils.

Diagram 4.7: Growth in food oil consumption by major oil in the US

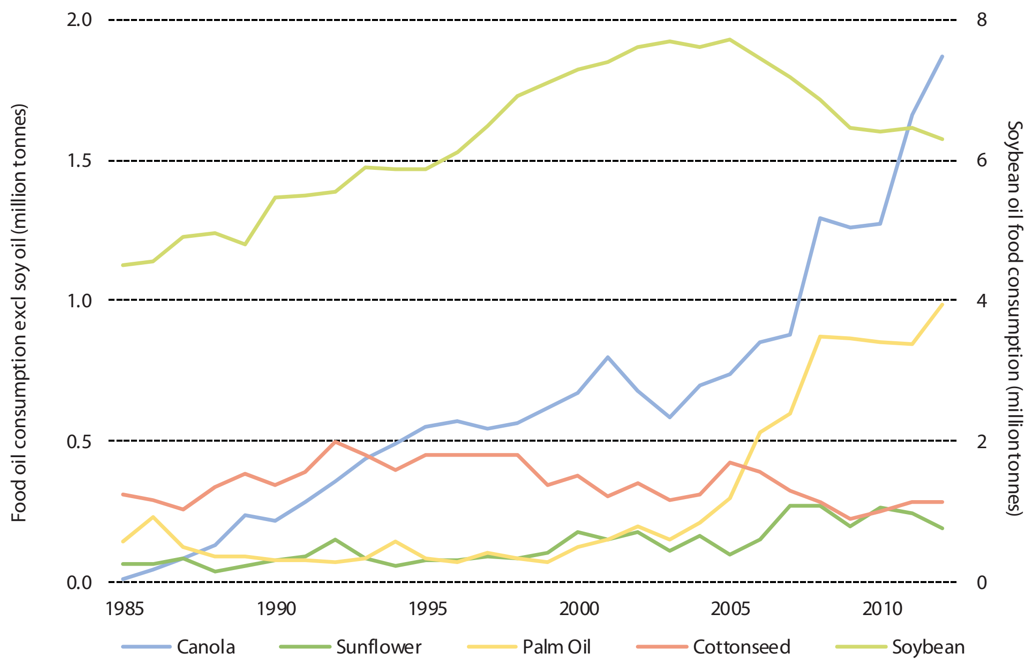
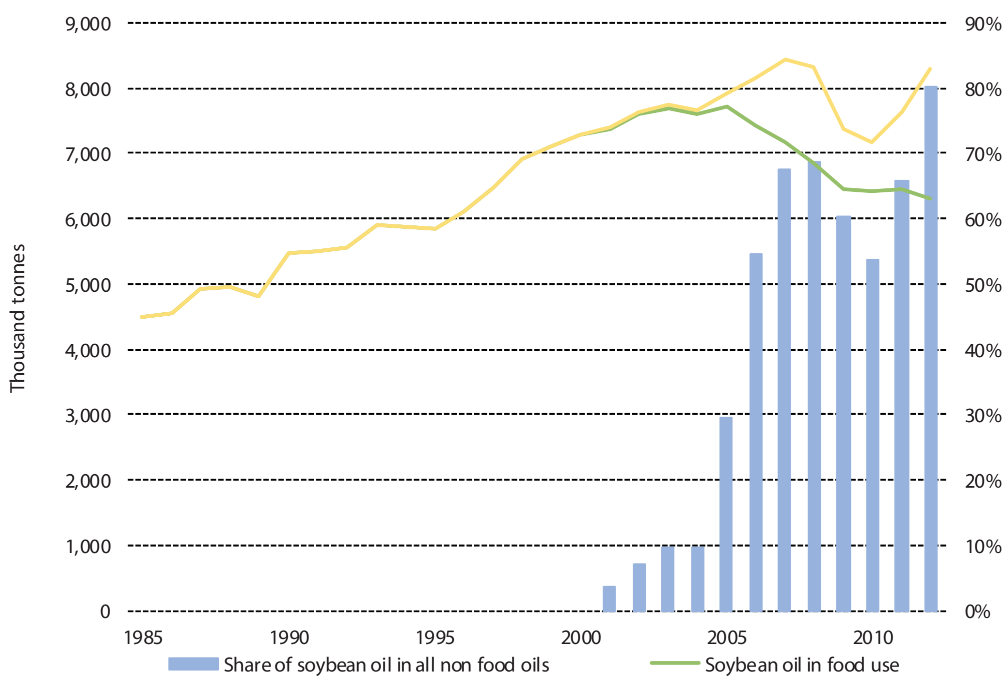


Diagram 4.8: Total and food soybean oil consumption



Excess soybean oil found a market in biodiesel and industrial uses. As Diagram 4.8 demonstrates, the overall consumption of soybean oil has increased, as the total consumption and food oil consumption have diverged. As a result, soybean oil has also come to account for an ever greater share of the non-food oil consumption in the USA (shown in the columns). By 2012 it accounted for 80% of all non-food vegetable oil consumption in the US.

While high oleic soybean oil is now being promoted, reports suggest that it does not have the right taste for the US market. In addition its main competitor, canola, still has a better profile than the new soybean oils and a higher oleic acid content. Given the costs and risks of reformulation therefore soybean oil is unlikely to reclaim the share of food oil consumption it lost due to TFA concerns. As a result, future growth is likely to be dependent on the non-food oil market, in general, and the growth in biodiesel in particular.

Underreporting of UCO and GTO

The availability of used cooking oil (UCO) and grease trap oil (GTO) is harder to estimate than the supply of feedstocks based on crops. This is because unlike crops which need to be planted in advance, the used cooking oil supply can increase very quickly based on higher prices. At the same time, however, as the cost of collecting used cooking oil is the largest expense: when prices are lower the supply of UCO will be lower. There is therefore a distinction between UCO reserves that are economically recoverable and the much larger supply that exists but is not collected.

Competing animal feeds

Animals differ in their feed requirements, with the largest contrast being between ruminants and non-ruminants. Ruminants (such as cattle) have micro-organisms in their guts that enable them to digest large quantities of cellulose from fibrous plants. As a result, feed for ruminants needs to incorporate a certain proportion of roughage that non-ruminants (such as poultry and pigs) cannot digest.

Diagram 4.9: DDG, Soybean- and Rapeseed-meal prices in Europe

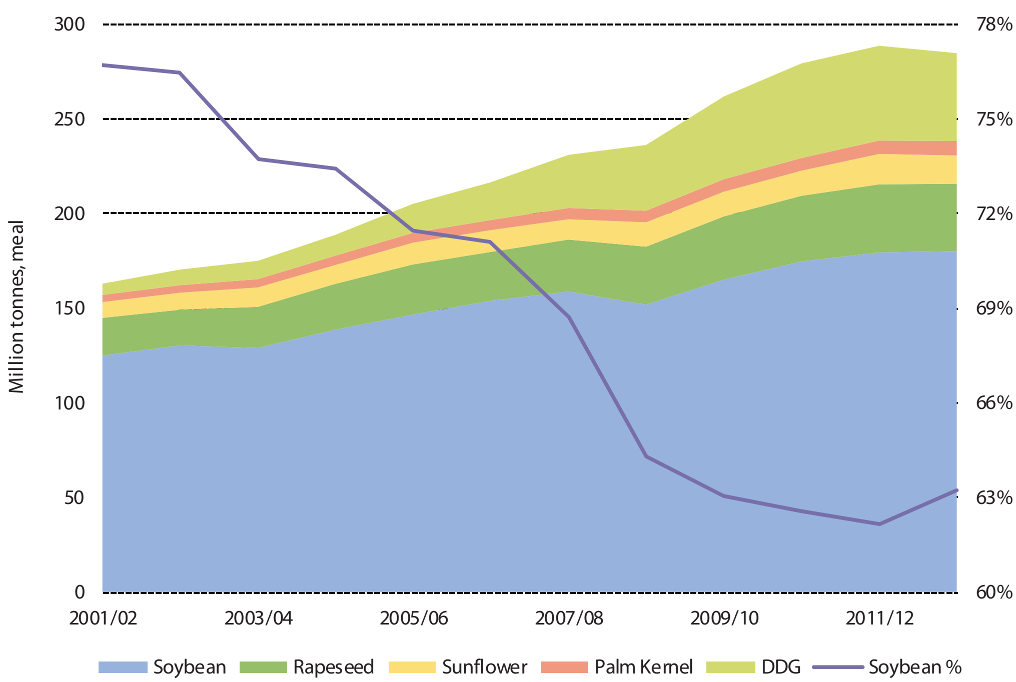
Soymeal is the main source of protein in feed, with its use greatest for poultry and pigs. However, some substitution is possible between soybean meal and other feeds, depending on the animal species and price relativities. As a result, soybean meal's dominance as the major protein feed has come under pressure from the rise in rapeseed meal and DDG generated as by-products in the biofuel sector.

Diagram 4.9 compares EU prices per metric ton of the major protein meals in Europe. Soymeal is the most expensive, due to its high protein content and its low fibre content. Its excellent amino acid composition also boosts its value against other protein meals. The price of wheat DDG (which is the main form of DDG in Europe) is close to that of rapeseed meal, due to their similar protein contents. However, DDG has a higher value than rapeseed meal in metabolisable energy in ruminants and poultry. Hence, DDG is a good alternative to rapeseed meal in the feed sector.

As a result, of its large availability DDG has emerged as a major feed ingredient. Since 2001/02 the worldwide output of DDG, notably from maize (corn) in the US and wheat in Europe, has surged to almost 50 million metric tons. Diagram 4.10 shows this trend and reveals that, soymeal's share among the leading sources of vegetable protein has slumped from 77% in 2001/02 to just over 60% in 2011/12.

Additionally, around 70% of dry milling corn ethanol plants in the US have introduced corn oil extraction systems. This is likely to rise to around 80% by the end of the year. In 2012 around 540,000 metric tons of corn oil was extracted from the dry milling of DDG. Of these almost 260,000 metric tons went into biodiesel. The remaining 280,000 metric tons of corn oil were remixed with DDG. At first this appears counterintuitive. However, the removal of corn oil alters the nutritional profile of the DDG by reducing the energy content and increasing the protein concentration. As we have seen some animals, such as poultry and pigs, benefit from feed with a higher protein content. As a result, corn oil extraction allows the feed compounders to tailor their feed more closely to the requirements of individual livestock sectors.

Diagram 4.10: Soymeal as a proportion of protein meal supply



The impact of global biofuels and agricultural policy on trade

The oilseed and oils industry has been subject to less government intervention than many other agricultural sectors. That is not to say that national policies are not in place — most sectors have elements of government support — but when taking a broader view of the global vegetable oil industry, national policies have not been the driving force behind most sectors.

Increasingly, however, biofuels policy has driven much of the recent development in the oilseeds-complex. Biodiesel consumption is driven largely by official initiatives in many countries worldwide, with incentive structures employing either blending mandates or fiscal incentives (or a combination of the two) to stimulate demand.

The most active biodiesel blending mandates have been in the ***EU member states*** where the Renewable Energy Directive (RED) intends to ensure that 'alternatives' supply 20% of total EU energy demand by 2020 and 10% of the energy used in the transport sector. The EU has met this demand through three sources:

- The direct import of biodiesel. Imports equated to 200,000 metric tons from 2010 to 2012 and were dominated by Argentina and Indonesia. Around 55% of these imports came from Argentina (soybean oil) and around 37% from Indonesia (palm oil).

- Imports of vegetable oils. However, the direct imports of biodiesel only accounted for a small fraction of the approximately 11.6 million metric tons of biodiesel that were consumed on average per year from 2010 to 2012. Instead the EU has imported the feedstocks directly — such as palm oil from Indonesia, soybean oil from Argentina and canola from Canada —to create its own biodiesel.

- Indirect soybean oil imports. The EU also import soybean oil indirectly, as it imports large volumes of soybeans for crushing to create soybean meal. As the soybeans are imported from Brazil and the US, the oil that is created as a byproduct is GM and therefore mostly finds its way into biodiesel.

The introduction of the biodiesel blending mandates therefore has created a large demand for imports of oils into the EU. Two sources have been particularly apparent soybeans and soybean oil have been imported from the Americas and palm oil from South East Asia. Additionally, imports of canola oil and seeds from Canada have emerged over the past five years.

As we have, seen most imports into the EU have been in the form of crude oils rather than as biodiesel. In response a number of exporting countries have introduced differential export tax policies to encourage downstream processing.

- **Malaysia** and **Indonesia** have introduced DET incentives to encourage both the refining and the further processing of palm oil into biodiesel. As a result of these incentives, Indonesia has become a major exporter of biodiesel to the EU.

- **Argentina** has become the world's leading soybean oil and biodiesel exporter as a result of generous export tax relief for biodiesel processors. However, its biodiesel export status is currently in turmoil. The majority of biodiesel exports were traditionally destined for the EU, but since Argentina's nationalisation of the Spanish Repsol oil company's subsidiary YPF, the Spanish government has ruled that only EU-produced biodiesel is eligible to meet Spanish biodiesel quotas.

Over the past three years EU biodiesel demand has stalled at around 12 million metric tons. In part this is because double counting has in fact reduced the total volume of feedstock required, by allowing one tonne of waste oil to count as two metric tons for consumption. Additionally, enthusiasm for first generation biofuels that employ crops as raw materials, such as biodiesel appears to be waning. There is a proposal to modify the 10% target for blending biofuels into transport fuels to a combination of 5% first generation and 5% novel biofuels and have drafted a law to this effect. As this is close to the level currently met by first generation biofuels, this would effectively cap any further growth.

As a result, the growth in biodiesel consumption is likely to be driven by the introduction of new mandates. Many of these mandates are in countries that are major producers of vegetable oils.

- The ***US*** EPA has recently given extra support to biodiesel by raising the mandate reserved specifically for biodiesel for 2013 beyond the million gallon mark. Initially this is unlikely to affect trade as domestic soyoil is the predominant feedstock in terms of virgin oils. Much of this soyoil was previously used in food, for which there is now little demand following trans fatty acid (TFA) regulations. The EPA envisages that corn oil and other recycled oils will also become increasingly significant.

- ***Brazil*** introduced a biodiesel mandate in 2005 and raised its mandate to 5% by volume in January 2010. The government is considering gradually moving to 20% blends in big cities by 2015 with a 10% mandate for the nation as a whole. Such a move would raise annual biodiesel consumption above four million metric tons. However, to date Brazil has not met its 5% mandate, though the government is introducing tax relief to support the sector. This has meant that increasing volumes of soybeans are crushed domestically in Brazil to satisfy the expanded local oil demand.

- ***Argentina*** has also boosted its domestic oil consumption with a biodiesel mandate, but its most important intervention remains the imposition of export taxes.

- While ***China*** gives official support to biofuels, the government stipulates biofuel mandates should not use food crops as raw materials. Thus, its two million metric ton 2020 target biodiesel programme is focused upon recycled waste oils with increasing efforts to develop non-food oils, notably jatropha. Additionally China has, in recent years, adopted programmes of direct support for domestic oilseed producers, and has backed these up with temporary embargoes on Canadian canola and Argentine soy oil. A complex system of import licensing, price interventions, direct purchases for stockpiles and stock releases shapes the oilseed and oils sector within China.

- ***Colombia*** has a 10% mandate and high capacity utilisation rates are favouring an increase above B10 as well as attracting new plants. This uses exclusively domestic palm oil.

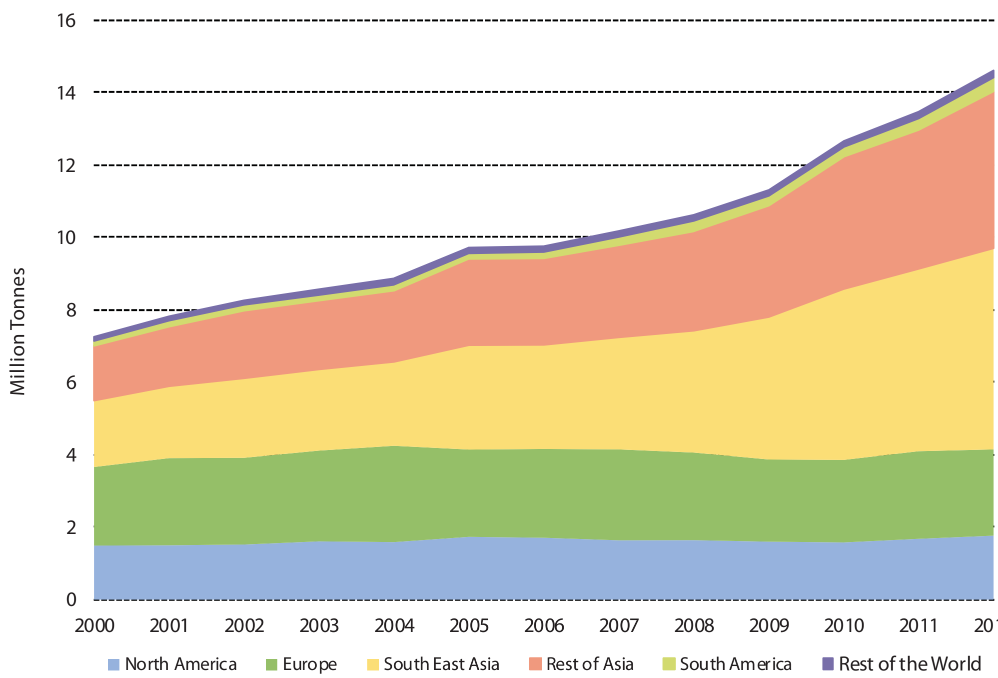
- ***Canada*** introduced a national 2% biodiesel mandate from July 2011. Peru, Paraguay, Uruguay, Cost Rica, Chile, Australia, Fiji, Thailand, Philippines, South Korea and Taiwan are among the other countries to have biodiesel mandates in place.

Greater domestic consumption of oils in biodiesel in countries that are adopting or expanding their biofuels programs will therefore reduce the availability of exports.

Trend in US oleochemicals industry and demand for tallow

At present fatty acid consumption remains concentrated in the developed countries with Europe and North America accounting for half of global demand. However, demand growth in these regions has stalled over the last decade, as their regional markets have become saturated. By contrast, demand has been growing rapidly in the developing world and in particular in South East Asia, China and India.

Diagram 4.11: Global Consumption of Oleochemicals



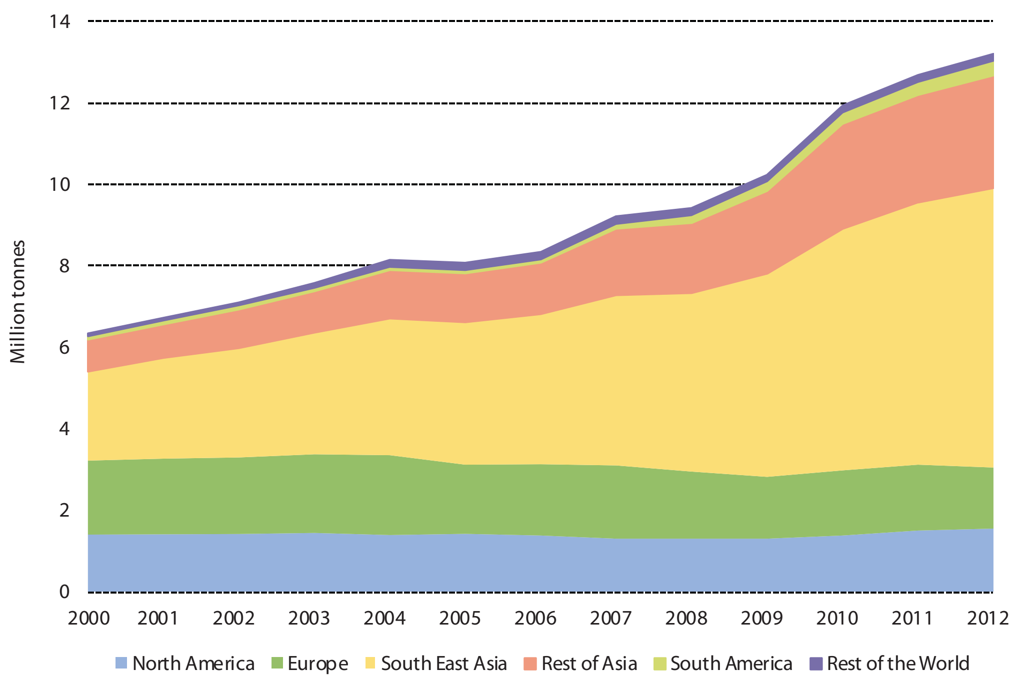
In the developing countries, such as South East Asia, China and India, higher income levels have led to changes in lifestyles and greater consumption of products which are derived from oleochemicals (such as washing powders and detergents). Diagram 4.11 shows how oleochemical consumption has evolved over the recent past.

There has also been a rapid change in the composition of production with Asia now responsible for just under two-thirds of total oleochemical production worldwide. This is illustrated in Diagram 4.12. Of this production, 60% is based in South East Asia. As a result, the traditional North American and European producers have seen their influence dwindle. This shift has been driven by the emergence of palm and palm kernel oil as an abundant and cheap source of fatty acids. Increasingly plantation groups in South East Asia have integrated downstream to take advantage of this cheap feedstock for oleochemicals.

In Indonesia it has also been supported by an export tax regime that taxes exports of crude palm oil but levies no tax on oleochemicals. This provides a sizeable stimulus to oleochemical investment in Indonesia. This is because local prices reflect the revenue available from making exports, i.e., the FOB price *minus* the export tax. Thus, the presence of the export tax artificially holds down the internal price of the feedstocks used for oleochemical manufacture.

The shifting centre of oleochemical production towards Asia and the upsurge in domestic consumption has therefore restricted the availability for fatty acid exports to the US. This is unlikely to change, as South East Asia has planned and built significant capacity for fatty alcohols. As its traditional export markets of China (and to a lesser extent India) move towards becoming less import dependent, South East Asia will need to target North America more to utilise its additional capacity. All of this will place extra pressure on the supply of animal fats, such as tallow, which are an alternative source of fatty acids for the US oleochemicals industry, causing price inflation.

Diagram 4.12: Global production of oleochemicals



Other feedstocks: free fatty acids

The removal of Free Fatty Acids (FFA) during the refining of soft oils, such as soybean, rapeseed and palm oil creates by-products which contain high levels of FFA. Inedible oils, which are not refined, therefore do not create FFA by-products. This includes waste greases, corn oil extracted from dry-milling and animal fats. There are two means or refining: chemical and physical.

- Chemical refining produces two by-products: Acid Oils (AO) and Fatty Acid Distillates (FAD). The use of sodium hydroxide to neutralise the free fatty acids in crude oils produces a "waste" stream of soapstock. This is then further refined creating the acid oils. Additionally, the condensation of distillates during the final deodorisation process yields fatty acid distillates. Acid oils are created in much greater volumes than fatty acid distillates.

- The physical refining of oils, by contrast, does not use sodium hydroxide to remove the FFA from the crude oil. As a result, the refining process does not produce soapstock and therefore does not create acid oils as a by-product. Instead vacuum steam distillation is used to strip the FFA from the crude oil, producing FAD as a by-product. This is analogous to the final deodorisation stage of the chemical refining process. As steam distillation is the only process used to remove the FFA from the oil, physical refining yields much greater volumes of FAD than chemical refining.

FAD, therefore, are created by both physical and chemical refining, while acid oils are only created by chemical refining. The feedstocks covered in this study that produce FFA by-products through refining are soybean, canola and palm oil. Animal fats, inedible oils and grease are not refined and therefore do not produce FFA by-products. While soybean and canola oil are usually refined chemically, palm oil predominantly uses physical refining. In our calculations we assume that:

- 80% of crude canola and soybean oil is refined chemically and 2% refined physically. The remainder is consumed as crude oil.
- All palm oil is refined physically.

The volume of FAD and acid oils created by both refining processes depends on the FFA content of the oil and the refining factor. We assume that:

- The FFA content and refining factor are the same for both soybean and canola oil. On average the chemical refining of crude soybean and canola oil yields around 0.15% FAD and 1.7% acid oils. The physical refining yields 1.2% FAD.
- By contrast, the physical refining of crude palm oil based on its higher FFA content, yields 4.18% FAD output.

Based on these assumptions, we can calculate the volumes of FAD and AO for soybean, canola and palm oil out to 2018. Table 4.1 reveals that Palm FAD (PFAD) is by far the most important single source of free fatty acids accounting for around three quarters of the total supply. This reflects both the large volumes of palm oil that are being refined and the high yield of fatty acid distillate.

Table 4.1: World supply of Fatty Acid Distillates (FAD) and Acid Oils from soybean, canola and palm ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Canola FAD	8	7	7	7	9	10	10	9	8
Soybean FAD	72	73	65	71	74	75	78	81	83
Canola Acid Oil	71	75	81	77	105	119	113	106	92
Soybean Acid Oil	680	686	612	670	694	713	733	761	789
Palm FAD	1,918	2,004	2,099	2,243	2,320	2,486	2,666	2,852	3,031
Total FAD	**1,997**	**2,083**	**2,171**	**2,321**	**2,402**	**2,572**	**2,753**	**2,942**	**3,123**
Total Acid Oil	**751**	**761**	**693**	**748**	**800**	**831**	**846**	**867**	**881**
Total (FAD and Acid Oil)	**2,748**	**2,844**	**2,864**	**3,069**	**3,202**	**3,404**	**3,599**	**3,809**	**4,003**

Table 4.2: US supply of Fatty Acid Distillate (FAD) and Acid Oil from canola and soybean ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Canola FAD	0.4	0.7	0.4	0.7	0.6	0.6	0.7	0.7	0.7
Soybean FAD	25	25	23	20	25	26	26	27	27
Canola Acid Oil	4	6	4	6	6	6	6	6	7
Soybean Acid Oil	232	235	219	185	240	244	248	252	256
Total FAD	**25**	**26**	**24**	**20**	**26**	**26**	**27**	**27**	**28**
Total Acid Oil	**236**	**242**	**223**	**192**	**246**	**250**	**254**	**259**	**263**
Total (FAD and Acid Oil)	**261**	**267**	**247**	**212**	**272**	**276**	**281**	**286**	**291**

Soybean acid oil is the second most important feedstock accounting for just over a fifth of total FFA supply. Soybean oil accounts for over 90% of the total acid oil supply in our calculations based on the much smaller supply of canola oil.

Table 4.2 shows the supply of FAD and acid oil in the US based on the domestic production of soybean and canola oil. As there is no production of palm oil, this has been omitted. However, as there are imports of crude palm oil which are subsequently refined, in practice this does create some domestic production of PFAD. Owing to its higher yields, acid oil is the largest source of FFA in the US with soybean oil providing around 98% of the total supply.

World demand for fats and oils by end use

In this final section we examine the break down by end use of world consumption of fats and oils, making a distinction between food, biodiesel and other uses (mainly animal feed). The results of this exercise are given in Tables 4.3-6. Our forecasts of the use of oils and fats in biodiesel (Tables 4.5) are based on the current breakdown of biodiesel production by feedstock. These proportions were then forecast out to 2018 based on our assumptions of growth for each feedstock and applied to forecasts of total biodiesel demand. For example, we expect the use of waste oils to remain relatively constant due to the lack of potential for growth in supply, therefore the proportion of overall supply from waste oils declines over the forecast period. On the other hand both soy and palm oil are expected to make up a growing percentage of total supply. Demand for biodiesel made from soybean oil is expected to increase with demand for domestic supply in the US and imports into the EU from South America driven by mandates. On the other hand biodiesel from palm oil is driven more from demand for cheap fuel in Asia. Total biodiesel supply is expected to grow by an average of 7% per year over the forecast period, reaching 32.6 million metric tons in 2018.

Table 4.3: World supply of fats and oils ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Soybean Oil	49,993	50,451	44,998	49,298	51,043	52,400	53,880	55,946	57,979
Rapeseed Oil	28,964	29,089	29,645	29,078	32,762	34,980	34,268	33,480	31,633
Animal Fats	23,752	23,586	23,671	23,410	25,005	26,244	25,974	25,672	24,852
Corn Oil from DDG	213	377	538	961	1,419	1,536	1,617	1,686	1,755
Waste Grease	3,941	4,128	4,253	4,364	4,520	4,704	4,902	5,112	5,329
Camelina Oil	5	1	2	4	32	83	202	449	846
Palm Oil	45,873	47,923	50,199	53,659	55,478	59,470	63,763	68,215	72,493
Sunflower seed Oil	13,193	13,718	16,519	14,841	15,501	16,184	16,035	15,869	15,417
Cottonseed Oil	4,623	4,988	5,324	5,241	5,407	5,482	5,557	5,632	5,707
Corn Oil	2,563	2,691	2,738	2,785	2,857	2,930	3,002	3,105	3,182
Palm Kernel Oil	5,501	5,563	5,765	6,091	6,226	6,668	7,148	7,644	8,119
Coconut Oil	3,628	3,828	3,737	3,789	3,647	3,682	3,717	3,751	3,787
Jatropha Oil	952	1,027	1,243	1,279	1,278	1,270	1,246	1,164	1,049
Castor Oil	884	1,392	865	882	899	916	932	949	966

Table 4.4: World food use of oils and fats ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Soybean Oil	44,063	42,073	36,864	41,619	43,075	43,180	43,624	44,605	45,751
Rapeseed Oil	21,306	21,816	22,705	21,493	25,092	27,048	26,318	25,590	23,978
Animal Fat	-	-	-	-	-	-	-	-	-
Corn Oil from DDG	-	-	-	-	-	-	-	-	-
Waste Grease	-	-	-	-	-	-	-	-	-
Camelina Oil	-	-	-	-	-	-	-	-	-
Palm Oil	32,962	34,271	35,500	37,308	38,270	41,225	44,594	48,083	51,528
Sunflower seed Oil	10,837	10,802	12,292	12,529	13,141	13,763	13,566	13,353	12,865
Cottonseed Oil	4,379	4,504	4,869	4,924	5,085	5,156	5,227	5,298	5,370
Corn Oil	2,507	2,529	2,439	2,613	2,671	2,726	2,785	2,876	2,946
Palm Kernel Oil	1,281	1,387	1,493	1,530	1,545	1,789	2,064	2,357	2,621
Coconut Oil	3,250	3,104	2,835	2,991	2,756	2,746	2,736	2,726	2,715
Jatropha Oil	-	-	-	-	-	-	-	-	-
Castor Oil	-	-	-	-	-	-	-	-	-

Table 4.5: Biodiesel use of fats and oils ('000 metric tons)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Soybean Oil	5,930	8,378	8,134	7,680	7,968	9,221	10,255	11,341	12,229
Rapeseed Oil	7,659	7,273	6,940	7,585	7,670	7,932	7,949	7,890	7,655
Animal Fat	1,220	1,649	1,678	1,557	1,679	1,858	1,934	2,001	2,024
Corn Oil from DDG	51	138	259	470	654	702	734	761	788
Waste Grease	1,535	1,766	1,969	1,811	1,927	2,056	2,119	2,170	2,173
Camelina Oil	0	0	0	0	0	0	0	0	0
Palm Oil	3,001	3,158	3,447	3,311	3,777	4,410	4,920	5,454	5,848
Sunflower seed Oil	354	391	360	382	410	452	480	507	523
Cottonseed Oil	12	13	14	14	15	16	17	18	19
Corn Oil	56	162	299	172	185	204	217	229	236
Palm Kernel Oil	0	0	0	0	0	0	0	0	0
Coconut Oil	43	49	52	50	57	66	75	84	92
Jatropha Oil	952	1,027	1,243	1,279	1,278	1,270	1,246	1,164	1,049
Castor Oil	8	9	8	8	9	10	11	11	12

Table 4.6: Non-food and Non-Biofuel use of fats and oils

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Soybean Oil	-	-	-	-	-	-	-	-	-
Rapeseed Oil	-	-	-	-	-	-	-	-	-
Animal Fats	22,532	21,937	21,993	21,852	23,326	24,386	24,040	23,671	22,828
Corn Oil from DDG	163	239	279	491	765	834	883	925	967
Waste Grease	2,406	2,362	2,284	2,554	2,593	2,648	2,783	2,942	3,157
Camelina Oil	5	1	2	4	32	83	202	449	846
Palm Oil	9,910	10,494	11,252	13,040	13,431	13,834	14,249	14,677	15,117
Sunflower seed Oil	2,002	2,524	3,867	1,930	1,950	1,969	1,989	2,009	2,029
Cottonseed Oil	232	471	441	303	306	310	313	316	319
Corn Oil	-	-	-	-	-	-	-	-	-
Palm Kernel Oil	4,220	4,176	4,272	4,561	4,681	4,879	5,084	5,287	5,499
Coconut Oil	334	675	849	748	834	869	906	942	980
Jatropha Oil	-	-	-	-	-	-	-	-	-
Castor Oil	876	1,383	857	874	890	905	922	938	954