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Biofuel and Biotech: A Sustainable Energy Solution

by

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A commitment to renewable energy production can reduce human causes of climate change and provide a stable energy supply if it is matched with a commitment to innovation in biofuel production and agricultural biotechnology. Agriculture will be challenged to meet increasing food demand and free land for energy production.

Just 150 years ago, 90 percent of U.S. energy was supplied by renewable sources. Today, renewables constitute a mere six percent of energy consumption in a U.S. economy that is heavily dependent on a finite supply of fossil fuels. To address this unsustainable situation, science and society are challenged to develop a long-term strategy to return to renewable sources of energy. Such a strategy should also address fuel price instability and contribute to containing climate change.

Because agriculture is a key source of renewable energy, it has a role to play in the development of a sustainable energy supply. A transition to sustainable energy sources can be expected to withdraw resources from the production of foods, and increase food prices. In the short run, it may end chronic oversupply of some commodities. In the longer run, it may impose pressure on agriculture which must not just feed a world population that is expected to grow by three billion people in the next half-century, but also meet some of their energy needs.

In this article, we demonstrate that while current biofuel production and agricultural biotechnology may not be sufficient to replace fossil fuels with renewable energy, they come close, and subsequent generations of these technologies offer greater promise. We make the case that California should invest in research that will improve these technologies and enable agriculture to meet world food demand and provide renewable energy within the next fifty years.

This is a considerable challenge that requires a serious commitment from the research community. World agricultural productivity will have to more than double in the next 50 years, much as it did in the preceding 50 years. We will not be able to capitalize on the same increases in inputs and factor productivity, however. We will rely, in part, on advances in agricultural biotechnology, which promise to increase crop yield and produce staple crops that can grow on marginal land.

The agricultural community has overcome significant challenges in the past. Agriculture met a six-fold increase in the world population from 1800-2000, with a ten-fold increase in agricultural production. Whereas extensive growth—increases in inputs—made possible such significant productivity gains in the past, growth today will be intensive, relying on total factor productivity rather than increases in land and water, two resources in low supply. Biotechnology offers new opportunities for productivity growth that can delay the onset of decreasing marginal returns.

But the growth of agricultural biotechnology is constrained by regulation and bans that may be politically motivated. These constraints reduce productivity and diminish opportunities to develop

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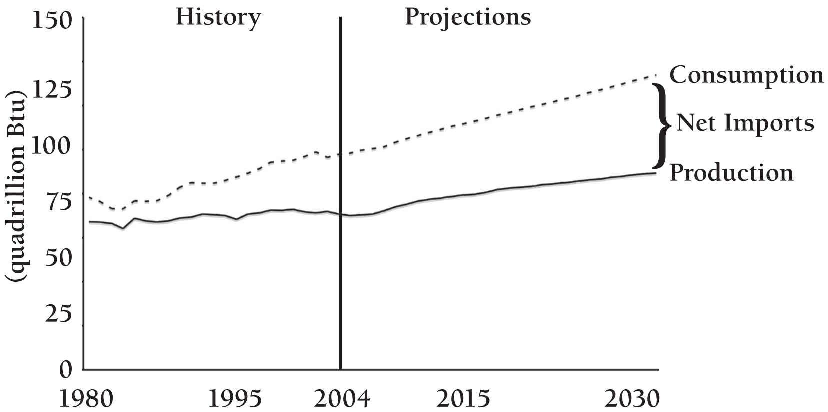
Immigration Reform: What Does it Mean for California Agriculture?

Figure 1: Total U.S. Energy Production and Consumption, 1980-2030



Source: Energy Information Administration

technology. There is evidence that these barriers slow the growth of agricultural biotechnology relative to its potential. They constrain agriculture's ability to address climate change and energy shortages.

In the United States, for instance, the Department of Energy forecasts a growing gap between domestic energy production and consumption, as domestic production lags and demand increases due to a populous that is driving farther and more frequently in bigger cars (See Figure 1). The gap between domestic production and consumption must, of course, be made up by imports. But U.S. oil imports, particularly from the oil-rich Middle East, are becoming increasingly untenable.

Biofuel Offers Hope for Replacing Fossil Fuel

In the field, we see technologies that have the potential to make biofuels a viable replacement of fossil fuels with further refinement of the production process and continued adoption and improvement of agricultural biotechnology. First-generation biofuel technologies can turn corn, sugar cane, and soy into fuel capable of powering cars and trucks. The next generation of these technologies—already being developed in laboratories—are expected to be more efficient.

Already, the technology exists to convert a 56-pound bushel of corn into 2.5-2.8 gallons of ethanol. Sugar is extracted from starchy crops like corn, sugar cane, and sugar beets with enzymes, and then converted into ethanol by yeasts. The ethanol can then be used to power cars that can run on 100 percent ethanol, or a mixture of ethanol and gasoline, or cars that can switch between gasoline and ethanol. Even adding just 15 percent ethanol to gasoline can reduce greenhouse gas emissions by 40 percent. This technology has been widely adopted in Brazil, where 40 percent of automobiles operate on 100 percent ethanol. Not only does ethanol burn cleaner, but it has a higher octane that improves engine performance.

Under current production methods, ethanol costs roughly $0.50 per gallon more than gasoline. The technology is viable when gasoline prices exceed $60 per barrel. There is an element of learning by doing that will improve the profitability of ethanol relative to other fuels. Furthermore, under more aggressive tax regimes, such as a carbon tax, the technology will become profitable. California, for instance, is considering increasing the gasoline tax consumers pay at the pump, moving the effective price of gasoline closer to ethanol.

It has been estimated that if the world community began today to increase ethanol production each year to 34 million barrels in 2056, greenhouse gas emissions could be reduced by one gigaton of carbon. This would require the commitment of one-sixth of the world's farmland to high-yield crops and ethanol production 50 times higher than it is today. In the United States, if all corn crops were devoted to ethanol production, ethanol could replace 20 percent of petroleum consumption. Minnesota, a Corn Belt state, could fully replace fossil fuels with ethanol if it devoted its entire corn production to the effort.

The current biofuel capabilities are encouraging, but they are not good enough. Such crop and land commitments are not feasible. In addition, as demand for biofuel feedstocks grows, food prices are expected to increase, hurting consumers while benefiting producers and reducing farmer subsidies. Agriculture, therefore, has two challenges: develop high-yield feedstocks for biofuel and increase productivity of traditional crops to free land for energy production. The hope is that new technologies will make biofuel production more efficient and improve crop yields, reducing upward pressure on food prices and freeing land for energy production.

The next generation of ethanol production, for instance, will make use of more efficient feedstocks than corn and sugar cane. Corn, in particular, is factor intensive and causes soil erosion. Cellulosic alternatives such as grasses, woody crops, wood waste, and paper, offer several advantages over traditional ethanol feedstocks. They can be grown on marginal land, require little fertilizer or water, and have higher energy content.

Furthermore, because there is considerable land-area potential for cellulosic crops, there is no supply restriction. The United States has 76 million acres dedicated to corn, 12 percent of which is used for ethanol production. Total U.S. cropland exceeds 430 million acres. There is an additional 578 million acres of permanent pasture land that would be ideal for the production of switchgrass, a high-yield crop relatively tolerant to abiotic extremes.

Cellulosic feedstocks are in use in Canada at a demonstration project, but are not commercially produced. The sole barrier to the widespread adoption of cellulosic alternatives is technological, according to members of UC Berkeley's Energy Resources Group. The enzymes needed to convert cellulose are prohibitively expensive and inefficient, but new enzymes that will make this technology viable are said to be forthcoming.

New enzymes that can convert starch to sugar more quickly and efficiently are already in the research pipeline, as well. Scientists are also working to replace yeast with bacteria that are less prone to infection and able to withstand extreme temperatures. Bacteria are less efficient than yeast, but genetic manipulation can resolve that deficiency.

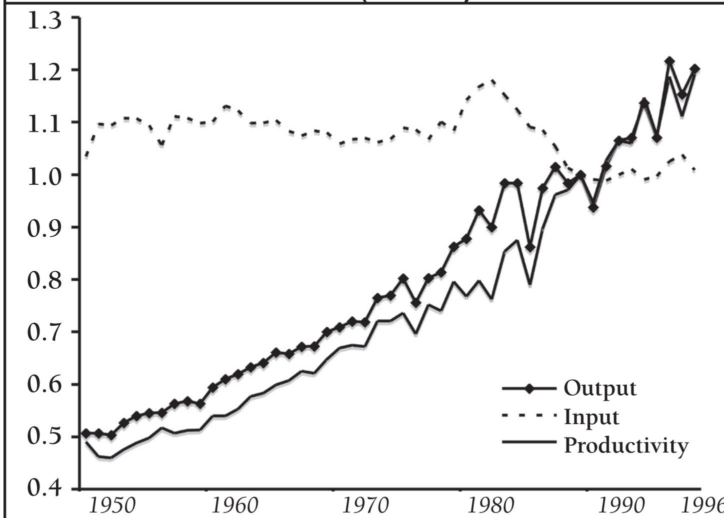
Advancements are also being made to improve biodiesel production, which has traditionally been produced from soy. Once a few technological hurdles are overcome, mustard is expected to serve as a feedstock. Mustard can be grown on land that is worth less than land used to grow corn and soy and can be beneficial to wheat production if used in rotation. Furthermore, mustard is an adaptable crop that can be genetically altered to meet specific needs.

Biodiesel, like ethanol, burns cleaner than its petroleum counterpart and improves engine performance. Through a chemical process that converts vegetable oils, animal fats, and cooking grease to methyl esters, biodiesel has one of the highest energy balances of any renewable energy source. One gallon of liquid fuel yields 3.24 gallons of biodiesel. Petrodiesel, in contrast, produces only 0.83 gallons of diesel per gallon of liquid gas. Biodiesel production is low relative to U.S. consumption. The current generation of biodiesel could only replace 13.3 percent of domestic petrodiesel consumption if all vegetable oils, grease, and animal fats in the United States were employed in biodiesel production, according to a 1998 analysis by the USDA.

Biodiesel does play a key role in greenhouse gas reduction efforts, however. U.S. EPA-mandated reductions in sulfur emissions require petrodiesel to be heavily refined, reducing the lubricity of the fuel. Adding even two percent biodiesel to petrodiesel can compensate for the lost lubricity.

These ongoing efforts to improve biofuel technology are encouraging and the next generation of biofuels will offer even greater potential to replace fossil fuels. But the most significant constraint on biofuel production remains the availability of land and the productivity of crops used as feedstocks. Transgenic crops can, however, significantly lessen that constraint with their ability to greatly increase yields and reduce costs. They are expected to permit continued agricultural productivity growth as new genetically modified crops are developed. Advancements in agricultural biotechnology, then, will directly benefit biofuel production.

Figure 2. U.S. Agricultural Productivity: 1948-1996 Index (1987=1)



Source: USDA-ERS: www.usda.gov/nass/pubs/trends/productivity.htm

Biotech Can Relieve Pressures on Agriculture

Devoting all U.S. corn production to making ethanol seems unlikely, as does using one-sixth of world crop land for biofuel production, particularly considering other pressures on agriculture like the increasing demand for food from a growing world population with rising income. But in the United States, agricultural productivity tripled from 1950 to 2000 (See Figure 2). And since the 1960s, while the world population doubled from three to six billion, world agricultural production more than doubled, increasing per capita output by 25 percent. These advancements are owed to new irrigation technology, better pest abatement tools, and crop breeding.

With the continued use of conventional technologies and biotechnology, there is potential to increase productivity by another 200 percent in the next several decades. Such growth could enable the agricultural community to continue meeting world demand for food, while also freeing nearly half of all crop land to energy production.

The current generation of transgenics has infused staple crops like corn and rice with the naturally occurring *Bacillus thuringiensis* (Bt), a relatively innocuous, naturally occurring pesticide. These GM crops have increased yield as much as 80 percent and reduced chemical pesticide applications by 70 percent.

Already, the next generation of GM crops is being developed. It will include crops that infuse additional nutrients into staple food sources like rice and wheat. It will produce less input-intensive crops and crops capable of growing on marginal land. It is expected to drive productivity growth and further reduce environmental externalities. It will also likely improve productivity of livestock systems by enhancing the efficiency of foods. The research community must assess to what extent these technological improvements can change supply and demand in the food system and make resources available for biofuel production.

More Research Could Yield Energy Fix

Although the diffusion of biotechnology has been extraordinarily fast by all accounts, there is strong opposition to it. Despite its proven ability to improve agricultural productivity (with particular benefit to poor and hungry regions of the world) and also mitigate environmental externalities, transgenics are criticized by policymakers and environmentalists who embrace the precautionary principle to stall adoption of GM technology. European leaders, for instance, have heavily regulated GMOs or banned them outright, limiting the market for transgenics and therefore the incentive to conduct additional research and development. Switzerland has called for a five-year moratorium on GMOs. And in California, initiatives have been placed on local ballots to ban GMO production within their jurisdictions.

Critics cite food-safety concerns and environmental hazards as reasons for their opposition to GMOs. However, neither concern has been substantiated in the regions of the world where GM crops are used. GM crops are regulated more heavily than conventional crops and more agencies oversee the safety of their food products. Furthermore, genetically altered food crops have been in use for the better part of a century through selective breeding. The new development is the use of recombinant DNA to more quickly alter genetics.

The environmental benefit of increased agricultural productivity is often downplayed and underemphasized. As Norman Borlaug pointed out in 2002, were the United States still employing the technologies of 1940, we would have needed an additional 575 million acres of agricultural land to meet current production. In other words, conventional technology and biotechnology have spared land for other uses equal to the area of the 25 U.S. states east of the Mississippi River. Furthermore, the current generation of agricultural biotechnology has significantly reduced pesticide applications. Monitoring of environmental impacts can continue without impeding growth of the technology.

The energy crisis and climate change call for policies that remove constraints on the expansion of biotechnology, allow the technology to grow, and invest in improving biofuel technologies.

Whereas the federal government, with its latest energy bill and limited approach to global warming, has yet to form a comprehensive response to these two issues, California is poised to be a pioneer in the development of these technologies and a leader in sustainable growth. With its educational-industrial complex—the interconnectedness of government, public research universities, and private entrepreneurs—California has a capacity for innovation unlike any in the world. The birthplace of many technological breakthroughs in the past half-century, from the Internet and information technology to biomedical advancements, California can be a leader in the response to global warming.

Conservation is certainly important and efforts to modify behavior are admirable, but California's contribution to the world should not emphasize reducing emissions and investing in tree-planting campaigns. California's contribution should be more profound than producing corn or switchgrass for biofuel production. Our contribution should be an investment in research, and we should lead with new technologies that will benefit the world and, once and for all, address the related challenges of global warming and energy security.

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Do Alpacas Represent the Latest Speculative Bubble in Agriculture?

by

Tina L. Saitone and Richard J. Sexton

The benefits of raising alpacas are touted routinely on national television, and alpaca-breeding stock in the United States sells routinely for prices in the range of $25,000 per head, many times higher than prices obtainable in Peru where the world's largest alpaca herd resides. We ask whether current prices for alpaca stock can be justified by fundamental economic conditions governing the industry, or whether alpacas represent the latest speculative bubble in American agriculture.

The alpaca industry in the United States began in 1984 when the first animals were imported from South America. Touted in advertisements on national television (e.g., see exhibit 1) as an alternative to the corporate lifestyle, the U.S. alpaca herd has grown substantially over the past twenty years, with the stock of registered animals exceeding 62,000 at the start of 2004.

The average auction price of alpaca-breeding stock in the United States may exceed $25,000, while in Peru, home to over three million alpacas and the world's only viable alpaca textile industry, alpacas sell for a small fraction of this price. The pricing dichotomy between the United States and Peru is especially striking considering that U.S. alpacas are of recent South American origin and boast few, if any, distinguishing characteristics from their ancestors.

This paper asks whether current alpaca prices in the United States are supportable by market fundamentals or, instead, likely reflect a speculative bubble that is destined to burst to the ultimate dismay of investors swayed by the pervasive advertising campaigns and the animals' appealing appearance.

Evolution of the U.S. Alpaca Industry

The Alpaca Owners and Breeders Association (AOBA) was established in 1988 and, upon inception, created the Alpaca Registry, Inc. (ARI) to undertake blood typing, DNA testing, and the registering of animals being imported into the United States. Although originally any alpaca could be registered with the ARI regardless of its country of origin, screening processes were instated eventually and became increasingly stringent over time until the ultimate closure of the registry in 1998 when registration became restricted to only those offspring (cria) of a registered sire and dam. Currently, nearly 99 percent of all alpacas in the United States are registered, and animals in the United States without this distinction have minimal value.

Although the registration requirements and the closure of ARI themselves represent a form of supply restriction and a barrier to the importation of alpacas, additional import restrictions are in place due to disease concerns. Peru is not classified by the USDA as a foot-and-mouth disease (FMD)-free country, which precludes the importation of any ruminant from Peru into the United States. Chile is the only South American country with an alpaca population that is eligible currently to export ruminants to the United States. Nonetheless, Chilean alpaca exports to the United States have not been a factor due to the substantial costs, quarantine time, and risks associated with intercontinental trade in live animals, and, since 1998, their preclusion from the ARI.

Table 1 provides an indication, based upon a survey of over 900 auction prices collected by the authors, of the U.S. alpaca prices. Although the table evinces considerable variation in the sales prices of alpacas, even the lowest prices recorded at the auctions surveyed were several thousand dollars, with average prices in most cases exceeding $25,000, and with prices exhibiting a clear tendency to rise during the four-year period surveyed. These prices are broadly consistent with the information that AOBA provides to potential investors.

Exhibit 1: Alpaca Television Advertisement Transcript

Actor/Alpaca Rancher: *I love alpacas because back in 1993, I was getting burned out in a high-stress medical practice. I discovered that raising alpacas allowed me to live a comfortable rural lifestyle and to spend more time with my family. Now, 10 years later, I can still say that it was a great decision.*

Announcer: *Alpacas are gentle and easy to raise. To get the full story, visit an alpaca farm or ranch. To locate one near you, go to www.Ilovealpacas.com.*

Table 1. Alpaca Auction Price Statistics

	2001	2002	2003	2004
	(All prices are in U.S. dollars)			
	Total Huacayaa			
Average	16,910	23,465	28,195	26,080
Observations	43	171	157	160
High	57,750	165,000	102,000	83,000
Low	3,900	6,500	6,000	6,000
	Total Suria			
Average	16,867	26,4437	27,497	30,7967
Observations	27	111	86	79
High	34,100	265,000	84,000	103,000
Low	7,200	6,500	9,500	11,500

[a]Huacaya and Suri are the two major types of alpacas in the U.S. See the main text for further discussion.
The following auctions were surveyed to compile the data in this table: 2004—America's Choice Alpaca Sale (ACAS) , Breeder's Showcase Alpaca Sale (BCAS), Mapaca Jubilee Alpaca Sale, AOBA Alpaca Sale (AOBA-AS); 2003-- ACAS, Celebrity Alpaca Sale (CAS), AOBA-AS, Parade of Champions Alpaca Sale, Breeder's Choice Alpaca Sale (BCAS); 2002- ACAS, CAS, AOBA-AS, Accoyo Alpaca Sale (AAS), BCAS, 2001—Spring Celebration Alpaca Sale, AOBA-AS, BCAS, AAS.

The Domestic and International Alpaca Fiber Industry

Sheared annually, the average alpaca produces between six and eight pounds of raw fiber per year. Alpaca fiber prices are determined primarily by two specific criteria: micron count and the type of alpaca (huacaya or suri) producing the fiber. Processors pay a premium for fiber with lower micron count. Huacaya alpacas comprise over 80 percent of the alpaca population in the United States while suri alpacas are rarer and earn a premium for their fiber.

The market for alpaca fiber in North America is limited due to lack of large-scale processing facilities. Revenue generated from the sale of alpaca fiber in North America emanates primarily from two sources: small-scale (cottage), independent textile producers or the Alpaca Fiber Cooperative of North America (AFCNA). Although reputable producers with established contacts in the niche textile markets are reportedly able to obtain upwards of $44/lb. for raw fiber of highest quality, it is not possible to sell any significant volumes of fiber at these prices, forcing most producers to market their fiber through AFCNA, where members receive anywhere from $5.00/lb. for top-quality fiber to 0.50/lb. for short or coarse/strong fiber. A premium of nearly $2.50/lb. has been paid for high-quality fiber produced by suri alpacas. The AFCNA prices are above the prices paid for raw fiber in the world market, which as recently as 2002 reflected no premium for suri fiber, and the maximum price paid for any quality fiber was $US 3.80/lb.

The AFCNA estimates that the feeding, vaccination and general health requirements of the average alpaca raised in the United States are approximately $169 annually (about $26/lb. of fiber harvested annually). Our independent estimate of food and nutrition costs is somewhat higher—on the order of $308 per year ($47/lb. of fiber harvested).

Based on AFCNA's conservative estimate of production costs, the price of unprocessed fiber would have to be nearly $26/lb. for alpaca breeders to cover variable production costs from fiber revenues. Even those raising suri alpacas and producing the highest-quality fibers are receiving only on the order of $7.50/lb. from AFCNA. Based upon our cost estimates, raw fiber prices would have to be about $47/lb. for breeders to cover the variable costs associated with maintaining their herds.

However, based upon the estimated price paid by cottage-industry textile producers of $44/lb. for raw fiber, a producer would earn a variable profit per animal (net of harvest costs) from fiber sale of $92 based upon AFCNA's estimates of costs. Thus, it is possible to generate isolated scenarios where fiber sales generate per-animal revenues in excess of per-animal variable production and fiber-harvest costs. This analysis, however, is too optimistic because the revenue estimates assume that all fiber produced is of highest quality and that other costs such as shipping and insurance are insignificant.

Table 2 summarizes the cost and revenue analysis, including the optimistic scenario involving sale to independent textile producers and more realistic scenarios involving a mix of fiber quality and sales at the prices paid by the AFCNA. Notably under the more realistic scenario, the value of a huacaya's fiber does not cover the variable costs associated with harvesting it.

Are U.S. Alpaca Prices the Product of a Speculative Bubble?

The expected value at time t, derived from ownership of a male alpaca not used for breeding, can be expressed as the discounted sum over the animal's expected productive lifetime of the variable profits generated from its fleece production, less the husbandry costs incurred prior to its fiber-bearing life. The valuation equation for female alpacas includes the same terms as the valuation for fiber males, plus an additional term to reflect the revenue derived from the female alpaca's ability to also produce cria. In general, a typical female alpaca bears her first cria at two to three years of age and has the ability to have six to seven offspring over her lifetime.

At current fiber prices and input cost levels, an alpaca in the United States whose sole economic purpose is to produce fiber, e.g., a gelded male, has no economic value under any of the scenarios depicted in table 2 that involve sale of fiber through AFCNA. Of course, proponents of the industry would argue that: (i) many alpacas (most females and some males) have considerable economic value as breeding stock, (ii) alpacas produce a desirable, luxury fiber that is likely to experience increasing demand as its properties become better understood by consumers, and (iii) as the U.S. alpaca herd grows, various costs of maintaining alpacas and processing fiber will fall.

Table 2. Revenue and Cost of Fiber Production in U.S. Dollars

	Independent Producer	AFCNA Member	
		Suri	Huacaya
	6.5 lbs. Micron<20	5 lbs Micron<22.9 1.5 lbs Micron<31.9	5 lbs Micron<22.9 1.5 lbs Micron<31.9
Net Revenue From Fiber	261	0.52	-9.48
Variable Cost (authors)	307.85	307.85	307.85
Variable Cost (AFCNA)	169	169	169
Profit From Fiber (authors)	**-46.85**	**-307.33**	**-317.33**
Profit From Fiber (AFCNA)	**92**	**-168.48**	**-178.48**

These seemingly independent arguments about value as breeding stock and future profitability of fiber production and sale actually collapse to only one argument that hinges on the future profitability of producing and selling fiber. The economic value of a cria produced by a female alpaca whose valuation is at issue is determined by the value of the product(s) the cria is expected to produce in the future, namely fiber and still more cria. Thus, the capital-asset framework leads ultimately to a valuation process that requires forecasts of the market conditions for fiber and alpaca stock over the long term, in the limit to infinity. Of course, discounting applies to this valuation process, so events forecasted to occur further and further into the future become less and less important to the evaluation and ultimately can be ignored.

It is fundamental to the valuation process for an alpaca that its economic value, whether expressed directly through the animal's own production or indirectly through the production of its progeny, must be based exclusively upon forecasts of the value of producing and selling fiber—the only widely marketable product alpacas produce. Alpacas sold today as breeding stock have values wildly in excess of even the most optimistic scenarios based upon current fiber prices and production costs. Thus, these stock prices can be justified by economic fundamentals only if investors can rationally forecast substantially better conditions in the fiber market in terms of higher fiber prices, lower production costs, or both that will make fiber production and sale a much more profitable proposition in the future.

What can a rational economic assessment tell us about the prospects for fiber production in North America? On the supply side, the stock of registered alpacas in the United States is rising rapidly. The population more than doubled between 1998 and 2002, rising from 19,384 registered animals to 46,105. The population rose further, to nearly 62,000, by the start of 2004.

Table 3 indicates the time in years required for the U.S. alpaca population to reach various levels based upon two scenarios and a simple, exponential growth model. Even under the more conservative growth rate, the U.S. alpaca herd size is projected to reach one million, 16 times its size in 2004, in just over 16 years. This rapid growth may enable the industry to capture economies of

Table 3. Size of the U.S. Alpaca Herd for Alternative Growth Rates

	Growth Rate	
	0.17	0.28
Population	Years Necessary to Reach Population	
1,000,000	16.37	9.94
1,500,000	18.75	11.39
2,000,000	20.45	12.41
2,500,000	21.76	13.21
3,000,000	22.83	13.86
3,500,000	23.74	14.41
4,000,000	24.52	14.89

size but also implies a roughly proportional expansion of domestic fiber supply, meaning that the lucrative niche cottage industries will become even less relevant as a market outlet for U.S. producers.

In contrast to the trade barriers for live alpacas, trade barriers for alpaca fiber have been virtually eliminated due to the passage of the Andean Trade Promotion and Drug Eradication Act (ATPDEA). Indeed, the Peruvian government estimated that the increased access to U.S. markets could cause alpaca fiber and textile exports to the United States to grow from 30 to 50 percent in one year.

Is it possible that a United States-Peru price differential of perhaps 800 percent or higher for live alpacas can be sustained when there are no barriers to arbitrage in the single marketable product these animals produce, namely fiber? The answer clearly would seem to be no. The economic value of alpacas, wherever they reside, is based upon the value of the fiber they and their progeny produce. If the fiber market is subject to free trade and arbitrage, then fiber prices across producing countries for a similar level of quality will converge with due allowances for transportation and other arbitrage costs, meaning that prices for the capital asset must converge also.

Inputs into alpaca production are less readily arbitraged across national borders, and this fact may lead to a sustainable equilibrium with some transnational differences in the value of alpacas. However, inputs to raising alpacas are cheaper in Latin America than in the United States, making animals there more valuable, other factors constant.

We designed a simple simulation analysis to answer the question of how rapidly fiber prices must increase over time as a consequence of demand growth, holding all costs constant at today's levels, to justify the types of prices we observe today for alpaca stock. The framework begins with a single juvenile alpaca female (age two) that might be purchased at auction today for a price in the $15,000-25,000 range. This female was assumed to bear fiber annually from the time of her purchase over a 15-year life span. This female was assumed to bear a cria on average every 18 months, seven in total over her lifetime with a reproduction rate of 100 percent. Additionally, we assumed that 50 percent of all cria born are female. These cria also eventually bear fiber and, if female, bear additional cria, and so on as the generations unfold. All of this activity is attributable ultimately to the purchase of the original female and determines her value according to the capital-asset formula. Although the process in principle continues indefinitely, we truncated the simulation at 20 years, assuming that this represents a maximum time horizon over which any rational investor would seek to recoup his investment.

Moderate growth in prices in the range of one, three, or five percent, sustained over the entire 20-year horizon, does not generate a positive economic value for the original female. For example, at a 10 percent discount rate, even sustained five percent annual growth in fiber prices leads to a discounted loss ranging from $22,000-45,000, depending upon the alpaca type and maintenance-cost estimate utilized. Even a 10 percent growth in fiber prices does not produce a positive valuation. Indeed, an annual growth rate in prices in excess of 20 percent is needed to justify alpaca prices in the range of $15,000 or higher.

However, it is far from clear that even substantial demand growth for fiber can translate into the substantial growth in prices that the simulation analysis demonstrates are needed to justify the current price levels for alpacas. As noted, the U.S. fiber supply is itself poised to grow rapidly and offset the price impacts of demand growth. The large Peruvian herd is also poised to grow rapidly, if fiber and textile prices rise, providing a further supply response to mitigate fiber and textile price increases caused by demand-side growth.

Conclusion

Dramatic improvements over time in the alpaca fiber market are thus required to justify today's price levels for alpaca stock based upon their investment value. Such improvements in the market are extremely unlikely to occur. Thus, the evidence seems to be rather overwhelming that the current prices are not supportable by economic fundamentals and, thus, are not sustainable.

Our conclusion that today's prices for alpaca-breeding stock are the outcome of an unsustainable speculative bubble is not surprising, given the warning signs surrounding this industry. Advertising that focuses on attracting additional producers, limited information on the investment, control of the available information by industry representatives, investment appeals directed to small-scale investors, and commonly held misconceptions perpetuating unreasonable prices are telltale signs that have been prominent throughout the history of speculative bubbles in agriculture.

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Bee-conomics and the Leap in Pollination Fees

by

Daniel A. Sumner and Hayley Boriss

Commercial pollination services are mostly provided by honeybees through a long-standing and well-organized market. Recently, honeybee pests and other problems have reduced available supplies, while expansion of almond acreage has increased peak-season demand. The resulting leap in pollination fees follows from these market fundamentals.

According to entomologists and other experts, over the past decade populations of pollinators available to service California agriculture have fallen steadily. At the same time, demand for pollination services, especially during the peak period of February and early March, has risen and seems poised to rise even further. One reflection of this situation and outlook is that, from 2004 to 2006, the price of honeybees to pollinate California almonds has jumped from about $54 per colony to about $136 per colony (Figure 1). This article examines the forces behind these market adjustments and some of the consequences for California agriculture.

Much of California agriculture depends on pollination services. While some pollination is by wild insects and other feral pollinators (including some birds and even bats) a major share of pollination services to agriculture is provided by bees, especially commercial honeybee colonies.

The status of pollinators in California and the rest of the United States has attracted national attention. Observers have questioned the future availability of pollination services for important agricultural crops and whether government policy should be marshaled to enhance or ensure the supply of pollination services. As a reflection of these concerns, the National Academy of Sciences created a multidisciplinary committee on the Status of Pollinators in North America to determine the outlook for pollinators and potential policy implications.

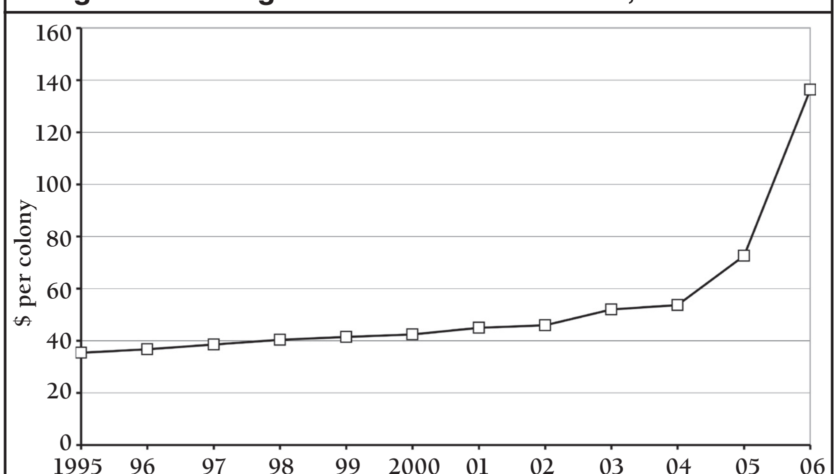
Industry participants and observers express concerns over the spread of pests and diseases and loss of habitat that affect the role of pollinators in the ecosystem generally. Here we will leave aside these broader public-good or externality issues and focus on the services that the commercial pollination industry provides to crop agriculture.

Despite the common metaphor of an unpriced benefit that spills over between pollination and production of honey, in fact, the commercial market for pollination services has been well established for many decades. For example, economists have explained the creation of the market for pollination services in the California alfalfa industry between 1949 and 1951 and the efficiency of the market for pollination of apples in Washington State. Econometric work has also documented the linkages between the honey and pollination markets.

The Supply and Demand Issues and Operation of the Pollination Market

Many honeybees used for pollination in California arrive from other states and often pollinate more than one crop—either here or in other states. Most of these bees also produce commercial honey, either while they are in California or in their home states. Some crops, such as clover, provide nectar for honey while others, such as almonds, are not valuable as sources for commercial honey production. Data from bees based in the Pacific Northwest, indicate that the average fee for pollination services on valuable honey crops is about

Figure 1. Average Almond Pollination Fee, 1995-2006



Source: California State Beekeeping Association Pollination Surveys
Note: 2006 is a forecast.

Table 1. Honeybee Pollination Months for Representative Crops

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alfalfa Seed									
Almonds									
Apples									
Avocados									
Cherries (late)									
Cherries (early)									
Plums									
Sunflower									

Sources: Traynor, J., "Tree Crop Pollination in California," available at: http://aoi.com.au/acotanc/Papers/Traynor-1/index.htm
Joe Traynor and Eric Mussen: personal communication
UC Davis ARE Department cost and return studies available at: http://coststudies.ucdavis.edu
UC ANR 1999 alfalfa symposium proceedings available at:http://ucanr.org/alf_symp/1999/99-76.pdf

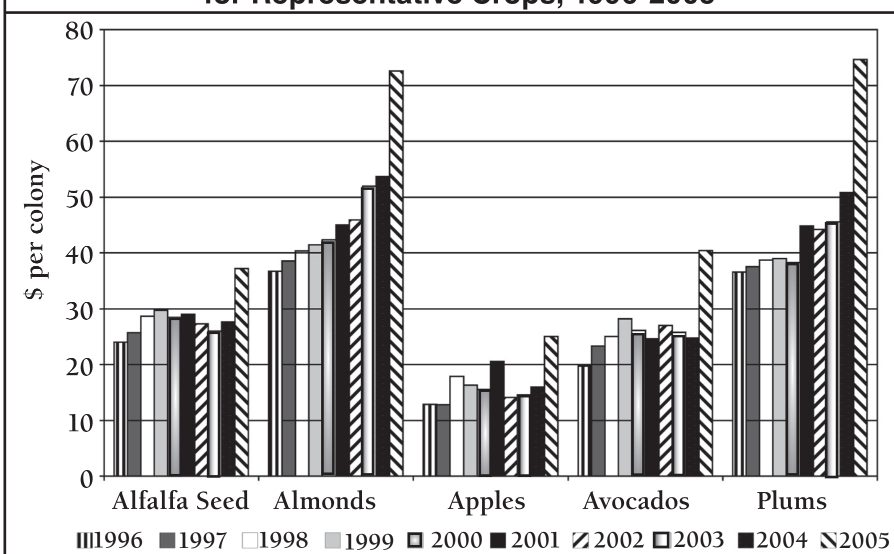
50 percent below the fee for crops that do not provide nectar valuable for honey.

While data are limited, it appears that prices and quantities of pollination services have been reasonably responsive to supply and demand drivers in recent years. The USDA National Agricultural Statistics Service estimates that the number of U.S honey-producing colonies has decreased from 3.4 million in 1989 to about 2.5 million colonies in 2004. Several factors have affected the supply of commercial honeybee colonies recently. First, a jump in the price of honey in 2002 and 2003, and a subsequent drop back to earlier levels, likely affected honeybee populations and the availability of bees for pollination services. Second, the Varroa mite has been spreading with severe effects on winterkill and colony health and vigor. The California State Beekeepers survey estimated that the winter mortality rate doubled from 15 percent in 2003/2004 to 29.6 percent in 2004/2005. (The Varroa mite is also thought to have destroyed most of the feral bee populations, increasing producer dependence on commercial rental of colonies for pollination.) Furthermore, mites have developed resistance to the most common pesticides used for treatment. Finally, in recent months relaxation of restrictions on live-bee imports from New Zealand and Australia have offset some of these negative supply impacts.

On the demand side, the main driver has been the expansion of acreage of almonds, the crop most dependent on honeybee pollination. This increase in bearing acreage requiring commercial pollination services has increased the demand for honeybee services during the late winter months in California.

Table 1 presents the pollination periods for several crops pollinated by honeybees. Plums, some avocado orchards, and early blooming cherries compete with almonds for pollination in February and early March. Apples bloom in the spring directly after almonds, and alfalfa seed and sunflowers require pollination services during the summer months.

Figure 2. Average California Pollination Fees for Representative Crops, 1996-2005

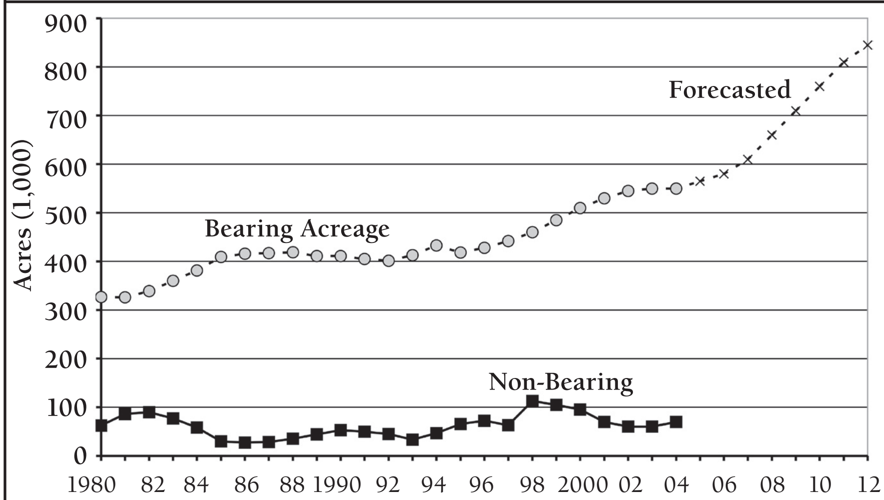


Source: California State Beekeeping Association Pollination Surveys

Figure 2, shows pollination fees from 1996 through 2005 for five important crops, and illustrates both the rise in peak-season pollination fees over the past ten years and the seasonal pattern across crops. Prices are highest and have risen most for almonds and plums, which compete for pollination. Almond production is fully dependent on pollination by honeybees during a six-week blooming period. With an average of about 2.5 hives per acre, pollination costs in 2005 were about $175 per acre. In

2006, using price projections from Figure 1, these pollination costs are expected be about $340 per acre, or about 15 percent of almond operating costs estimated by UC Davis almond budgets. These budgets are available on the Internet at http://coststudies.ucdavis.edu. At this level, pollination may become a significant curb on almond profitability and the expansion of almond acreage in California.

Figure 3. California Almond Acreage Bearing, Non-Bearing and Forecasted



Sources: USDA National Agricultural Statistics Service. Forecasts from California Almond Board.

Figure 3 shows that almond acreage increased by 25 percent—from about 430 thousand acres in 1996 to about 550 thousand acres in 2004. The Almond Board of California projects that acreage will increase to more than 800 thousand acres by 2012. Using an estimate of 2.5 colonies per acre, almond acreage required roughly 1.4 million colonies in 2004. Therefore, if all the colonies used for almonds also produced honey sometime during the year, almost 60 percent of the 2.5 million colonies in the United States were required to pollinate almond orchards in 2004 and 2005. Given the growth in almond acreage projected for the next six years, we would expect California to require about two million colonies for almond pollination alone by 2012. This shift in demand, in the face of declining supply trends, has raised alarm among almond producers, pollinators and outside observers.

Analysis of Longer Run Prospects

With almond acreage expanding rapidly relative to the other uses of pollinators, more and more honeybees will likely be "unemployed" for much of the rest of the pollination season. If most of the honeybees in the country are required in almond orchards in February and early March, many bees will face no further demand for their pollination services during the year. Since almonds do not provide nectar for commercial honey (the honey from almonds is unpalatable to humans), the honey revenue for these bees is also reduced when more of their effort is geared towards almonds. The result is that rather than receiving half or one third of their annual revenue from almonds, many commercial pollinators may now require almonds to cover most of their annual cost of colony maintenance. If this scenario develops as described, we may expect the pollination fee for almonds to remain high. The extreme pollination fee for almonds projected for 2006 seems very high relative to the long term cost of supplying honey bees for pollination during the peak season. Nonetheless with continuing mite problems and the almond crop demanding more than 60 percent of the national honeybee stock, we can expect fees to settle well above those of just a few years ago.Further, under this scenario, with more total bees in the system than otherwise, pollination fees for crops blooming in other seasons would fall, as would the price of honey.

In general, the increase in demand for pollination services during the peak season, together with the increase in costs for pollination services have implied higher pollination fees. This fee increase indicates a pollination market responding as expected to supply and demand signals and does not suggest a role for any particular government interventions, except perhaps additional price and quantity data to allow participants to better track the market.

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