

# **Pecan Production, Exporting, and Its Future: From a Multi-Country Perspective**

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*The pecan industry, which is dominated by the United States, plays an important role in the multi-billion dollar worldwide tree nut industry. Pecans are currently produced in commercial quantities in countries as diverse as the US, Australia, Mexico, Israel, South Africa, Vietnam and China among others. However, few academic studies have investigated this important agricultural commodity from other than a production perspective. This study contributes to the agricultural, economic, international trade and business literature by providing a review of the current state of the pecan industry in China and its potential for future growth. This study also represents a significant departure from past research in that it is among the first to review both the US and Chinese literature bases.*

## **INTRODUCTION**

The importance of agriculture related trade between the United States and China cannot be overstated. In 2015, US exports of agricultural commodities and related products exceeded \$140 billion with over \$20 billion of those being shipped to China (USDA ERS, 2016). More directly related to this study, in recent years, China has accounted for up to 50 percent of US pecan exports and many in the industry expect that number to continue to increase for the foreseeable future (Hawkes, 2011; Schattenberg, 2010; Blake, 2007; and Smith, 2007). Hence, it is important to develop a richer understanding of the outlook for the Chinese pecan industry as the US seeks to increase exports of all agricultural commodities.

The pecan or *Carya illinoensis* is a species of hickory that is native to the south central and southeastern United States, but which is also grown in countries as diverse as Mexico Argentina, South Africa, Australia, Israel and Vietnam among others (USDA ERS, 2016). While pecans can be grown on many of the world's continents, the US remains the world's largest producer of pecans and accounts for over 85% of global production (Onunkwo and Epperson, 2000). Consequently, pecans and the US pecan industry have been studied from a number of perspectives, which include but not limited to the health benefits associated with pecan consumption (Gobbo, Falk, Feldman, Lewis and Mozaffarian, 2015; Mohammadifard, Salehi-Abargouei, Salas-Salvado, Guasch-Ferre, Humphries and Sarrafzadegan, 2015;

O'Neil, Keast, Fulgoni and Nicklas, 2010) and the effectiveness of government sponsored promotion programs (Moore, Williams, Palma and Lombardini, 2009; Onunkwo and Epperson, 2000). Other research in this area has addressed US consumer demographics and buying preferences (Lombardini, Waliczek and Jajicek, 2008; McKissick, 2008; Wolfe, Daniels, Swickard and McKissick, 2007; Florkowski, You and Huang, 1999) and consumer preferences (Palma, Collart and Chammoun, 2015; Chammoun, 2012). There is also a substantial literature base which focuses on pecan production and variety selection in general (Garcia, Dickey, Johnson and Cowell, 2015; Ares, Reid and Brauer, 2006).

Despite this significant literature base, very little is known about pecan production in other countries or, more importantly, Chinese pecan consumption or production beyond the one study (e.g., Zhang, Peng and Li, 2015) that was published in a US based academic journal. Consequently, the purpose of this study is to provide an initial assessment of the Chinese pecan industry and to develop a better understanding of the export potential of pecans to China. This study utilizes the product lifecycle theory as its foundation because it draws upon the economic theories associated with the laws of supply and demand and because it facilitates the comparison of industries between countries that are in different stages of development. This study contributes to the literature by shedding light onto a largely unstudied area and may be generalizable to other agricultural commodities.

To accomplish the stated objectives this study is laid out as follows. First, the authors will provide a brief overview of the impact that Chinese consumers have on the US pecan market. The authors then provide a review the literature which is used to develop a historical timeline of Chinese pecan production efforts. This will be followed by an analysis of the data (pounds of pecans exported annually and percent of crop exported) which was obtained from the United States Department of Agriculture (USDA) in order to evaluate the potential for future exports which heretofore has not been published. The authors then provide a discussion of study results and study limitations and conclude with a summary of the study findings and suggestions for future research and managerial implications.

## **LITERATURE REVIEW**

Before delving too deeply into the literature it is important that readers first understand that pecans are an integral part of the multi-billion dollar tree nut industry which spans the globe (Australian Nut Industry Council, 2014). It is also important that readers understand the extent to which Chinese consumers influence the US pecan market and how this influence has changed and will continue to change over time. Table 1 contains data from Tables F-13 and F-14, USDA, National Agricultural Statistics Service, Noncitrus Fruits and Nuts Summary (2015) provides a clear demonstration of this influence beginning in 2002, the subsequent decline between 2003 and 2006, the rapid growth beginning in 2007 to 2009 and the subsequent decline beginning in 2010. An analysis of Table 1 also indicates that China accounted for an average of 31.53% of US pecan exports between 2010 and 2015.

What Table 1 does not show is that between 2010 and 2015 Chinese pecan imports from Australia and South Africa also increased due to the lower cost of shipping and their ability to more easily meet China's holiday seasonal demand with fresh or new crop pecans due to being located in the Southern Hemisphere (Australian Nut Industry Council, 2014). The increased demand from China has also impacted the US pecan market in terms of the price paid to growers for export quality pecans, the price of pecan trees, the increase in US pecan acreage, the increase in the price for existing pecan orchards and how these price increases have declined as demand from China has also fallen (Wells, 2014). Given the financial significance of these impacts it is also important that readers have a clear understanding of the academic pecan literature.

When comparing the US and Chinese pecan literature bases certain similarities become apparent. The first and most striking similarity is the lack of theory. A detailed review of the literature indicates that only a handful of US based studies and only one Chinese study have a theoretical base (e.g., Luo and Dai, 2014). The second similarity indicates that both countries have rather substantive and similar literature bases (Xi, Xi and Zhang, 2005). However, it must be noted that US based research rarely if ever cites studies conducted in China, whereas Chinese studies almost always cite similar US based research.

Therefore, the remainder of this section will be devoted to providing a brief review of the product life cycle theory and will be followed by a review of the Chinese pecan literature and the development of a historic timeline of pecan production in China.

**TABLE 1**  
**US PECAN EXPORTS (IN SHELL), U.S. TOTAL, CHINA TOTAL, AND PERCENT TO CHINA**

Year	Export Total	China Total	%US
2002	62,354	5,375	8.62%
2003	73,865	631	0.85%
2004	113,959	3,520	3.09%
2005	101,088	2,531	2.50%
2006	160,323	14,044	8.76%
2007	187,605	39,926	21.28%
2008	238,548	62,282	26.11%
2009	213,458	113,294	53.08%
2010	252,191	84,241	33.40%
2011	375,328	107,201	28.56%
2012	487,956	178,237	36.53%
2013	347,353	117,235	33.75%
2014	446,237	122,750	27.51%
2015	468,680	137,849	29.41%

The Product Life Cycle theory (PLC) is a familiar concept in the academic business literature, having first been noted in 1950 (Dean, 1950). The PLC is based on the supposition that all products, similar to living organisms, have a finite life span comprised of four sequential stages (i.e. introduction, growth, maturity and decline) with each stage having different managerial requirements (Lau, 2014). In most cases movement of a product from inception to decline is modeled in some form of an S-shaped curve. Research utilizing PLC theory has also found that different companies within a given industry may have nearly identical products which are in different stages of the PLC compared to the industry as a whole. Alternatively, less developed countries may have industries that are in a different stage of the PLC than similar industries based in more developed countries (Kotler, et al. 1996). Consequently, the PLC provides the necessary theoretical lenses from which to study the Chinese pecan industry which is probably in its growth stage of the PLC, whereas, the US pecan industry is in the maturity stage of the PLC.

A macro level review of the US and Chinese pecan literature bases indicates that the similarities are much greater than the differences. For example, both countries have a history of pecans being among the highest priced tree nuts (Xi, Xi and Zhang, 2005) and both have similar consumer demographics (pecan buyers are typically older, better educated, affluent and generally only purchase pecans during the holiday season) (Zhang et al., 2015). Other similarities include a respective analyses of the overall state of each country's pecan industry (Zhang, Li, Xuan, Jia and Guo, 2014).

Speaking to the Chinese pecan literature base research by Xi (2006) and Zhang, Lv, Zhang, He and Wang (2005) found that pecan production in China is both possible and economically viable, while Lv, Shen, Gao and Huang (2012) noted the importance of pecan production to China's and local farmers' economic well-being. Still other research addresses the problems associated with developing the pecan industry in China (e.g., the lack of supporting government policies, the lack of access to good seed stocks

that are adapted to China, lack of technology to produce pecans (pests and diseases) and the issue of alternate bearing that plagues the industry as a whole (Zhang, Li, Xuan, Jia and Guo, 2014; Lv, Shen, Gao and Huang, 2012; Yang, Li, Xi and Fan, 2010; and Wei, Ma and Wei, 2003). Zhang, Li, Xuan, Jia and Guo (2014) provide suggestions for producing pecans in China (e.g., improved seed collection activities and developing supporting research institutions). Also similar to US based research are studies related to pecan production as a whole (Hou, Liang and Shi, 2007; Dong and Wang, 2003; and Zhu, Lu, and Wei, 1990).

The extensiveness of this literature base would then seem to indicate that pecan production in China has been studied by scholars, government agencies, and business people due to its potential economic impact. Finally, it must be noted that both the US and China are working to significantly increase both acreage and production (Wang, Li, Ning, Zhang and Li, 2009; Zhang, Lv and Ha, 2005; Xi, Fang, and Zhang, 2004). Given these similarities, it is important to understand that the development of the Chinese pecan industry is not a new phenomenon as evidenced by the following timeline (see Table 2) which traces the development of the pecan industry in China.

**TABLE 2**  
**A TIMELINE OF PECAN PRODUCTION IN CHINA**

Time	Content	Reference
1900 & 1901	1901 a missionary, M. Shao, planted a few pecan seeds at the Shucheng Christian Church in Anhui	Yu, 2010
1907	Dr. E.H. Wilson brought a few two-year-old seedlings and planted them in Nanjing, Jiangsu	Zhang et al., 2003a
1916, 1928, and 1944	Pecan seeds from Georgia and South Carolina were planted at Nanjing, Jiangsu in 1916, 1928, and 1944	Zhang et al., 2003b
1950	In the 1950s the Nanhjing Forestry Bureau planted approximately 100 kg (220 lbs) of pecan seeds along city streets to serve as landscape and to a lesser extent for crop production	Li et al., 2009
1957	China introduces its first named pecan varieties (Gulou and Mochou)	Zhang et al., 2015
1965	French pathologist (name unknown) presented China with several specimens of two pecan cultivars (Elliott and Mahan) which were planted in in Guangdong, Fujian and Zhejiang respectively	Li et al., 2009
1974	The Yunnan Academy of Forestry established the first commercial pecan orchard in Yunnan Province. Note: additional plantings were made by Chinese pecan researchers Baipo Wang (1978), Zuijun Sun (1983), Shengke Xi (1991), Riqing Zhang (1998 & 1999) and Jianqing Huang (2011)	Zhang et al., 2015
1978	Graft wood was imported from the US (Apache, Barton, Cherokee, Cheyenne, Choctaw, Kiowa, Major, Peruque, Riverside, Shawnee, Sioux, Shoshoni, Tejas, Western, and Wichita)	Zhang et al., 2001
1983	Graft wood was imported from the US (Kiowa and Shoshoni)	Li 2009
1986	China releases four new named varieties (Changlin 13, Jinhua, Shaoxing, and Shanzhan 2) which were widely planted across China	Zhang et al., 2011

1990	In the 1990s Chinese authorities began a land retirement program in which authorities encouraged expansion of nut production in hilly and mountainous regions to alleviate poverty and to replace cultivation of subsistence crops with trees on erodible land	Yang and Gale 2015
1990	The USDA ARS sent a research team to China to study <i>Carya</i> (hickory family). While there this research team observed a number of pilot test plots of pecan trees	Grauke 2000
1991	Graft wood was imported from the US (Osage and Perique)	Zhang et al., 2001
1998	A USDA ARS research delegation observed model pecan orchards and seedling nurseries which were doing well. This delegation also reported that they believed that China represented a short term export opportunity for the US Pecan industry while the Chinese develop their own pecan production capabilities	Grauke 2000
1998 and 1999	Several Chinese scientists contacted the National Clonal Germplasm Repository and requested pecan propagation materials (either graft wood or seed stock). Shipments of graft wood were sent to Hunan (37 cultivars) and Yunnan (6 cultivars) in 1999	Grauke 2000
2000	Four seed stocks were sent to Anhui province through the China National Forestry Seed Company	Grauke 2000
2010-2013	China produced roughly 150 million pecan seedlings which were grafted and will be used to increase pecan acreage	Zhang et al., 2015
2011	Graft wood is imported from the US (Apalachee, Barton, Caddo, Cheyenne, Chickasaw, Colby, Davis, Dependable, Desirable, Elliott, Excel, Farley, Forkert, Giles, Gloria Grande, Kiowa, Lakota, Mandan, Melrose, Mohawk, Moneymaker, Moore, Moreland, Nacono, Owens, Pawnee, Schley, Shawnee, Shoshoni, Stuart, Success, Sumner, Van Deman, Wichita, Wood Roof, Woodard)	Shi et al., 2013
2014	Total pecan acreage in China is believed to be around 8,500 ha (21,003 acres) and production that year was estimated to be roughly 31,000 kg (68,343 lbs). Future production of not yet producing orchards, which make up the majority of total acreage, is estimated to be roughly 1,000 kg (2,200 lbs) per ha (2.47 acres) annually	Zhang et al., 2015
2015	It was reported that China released and distributed 38 named varieties between 1957 and 2014 and that there is a shortage of grafted pecan seedlings resulting in growers having to place their orders a minimum of two years in advance (Zhang et al., 2015). It was also reported that grafted seedlings have been used to establish 600 ha (1,482 acres) of pecan orchards annually for several years. High density planting (13 x 20 or 20 x 26) (400 trees per 2.47 acres) utilizing dwarf stock or very closely pruned grafted stock are the norm due to limited land availability and the need to care for the trees manually	Le et al., 2015

In Table 2, it can be seen that the development of the pecan industry in China effectively follows the PLC (Luo and Dai, 2014). The first or introductory stage began in 1900 when the first recorded pecan seed stock was brought into China and planted by church ministers, diplomats, businessmen, and students who planted the trees for ornamental purposes. Another important participant in this stage was Jin Ling University (located in Nanjin City). Faculty and students from Jin Ling University were responsible for many of the early plantings along the Long River in Jiang Su and Zhe Jiang provinces. Interestingly, these faculty members, who had very little knowledge of pecan production, had the foresight to select seed stock from Georgia and South Carolina because they believed that it was necessary to select seed stock from areas with similar growing conditions. The Great Leap Forward (1958-1961) and the Cultural Revolution (1966-1976) marked the end of the introductory stage of the pecan industry in China and brought with it a period of stagnation when little thought was given to pecan production. During this time China focused its efforts on subsistence agriculture and tabled production of luxury products such as pecans in order to feed a rapidly growing population.

The second or growth stage started in the post-1970s and ran until 2000. During this period there was a renewed interest in pecan production (Zhang, Li, and Su, 2003b) and the industry became commercialized as the government sought to convert marginal hill ground to permanent crops in an effort to control erosion and reduce poverty in rural areas (Zhang, Li, Xuan, Jia and Guo, 2014). Other government policy changes resulted in the easing of price and import restrictions on pecan seed stock and graft wood. These policy changes allowed farmers, researchers and businessmen to seek support from US pecan growers and researchers and ultimately led to U.S. university research delegations visiting Chinese pecan growing areas in 1990 and 1998 (Lv, Shen, Gao and Huan, 2012).

The third or maturity stage appears to have started in 2001. Between 2001 and the present date a number of significant changes have occurred which appear to indicate that the Chinese pecan industry either has or is moving into the maturity stage. Evidence of this movement includes widely published reports from the Central Government which state that it has trained over 7,000 people in the care and operation of pecan orchards and provincial government reports announcing plans to expand pecan production in order to meet environmental and economic development targets (Zhang, Li, Xuan, Jia and Guo, 2014). There have also been commercial developments such as the authorization of the first pecan cooperative, which will enable small pecan producers to collaborate on production and marketing and the announcement that China has produced over 150 million pecan trees to expand Chinese pecan production (Zhang, Li, Xuan, Jia, and Guo, 2014). Having anecdotally established the potential for a successful pecan industry in China, one must also look to the United States for direction in order to gain a glimpse of what the future may hold. Therefore the next section will be devoted to developing a long term forecast for the future demand of pecans from the US.

## **ANALYSIS**

In an effort to better understand the US pecan industry's upside potential data (pounds of pecans produced, exported and the percent of the US pecan crop that was exported) was obtained from Tables F-13 and F-14, USDA, National Agricultural Statistics Service, Noncitrus Fruits and Nuts Summary (see Table 3). The data was analyzed and plotted using Microsoft Excel's plotting and linear forecast functions. This method of analysis was selected because it will enable readers to clearly see what is currently happening in the pecan industry and to analyze the numbers themselves and draw their own conclusions. Additional support for this approach is provided by Green and Armstrong (2015) who found that simple forecasting methods when run properly consistently outperform more sophisticated methods in terms of accuracy and limiting forecast error.

**TABLE 3**  
**PECAN PRODUCTION AND EXPORTS (IN 1,000 POUNDS), AND PERCENTAGE EXPORTED**

Year	Production	Exports	% Exported
1995/96	267500	18311	0.07
1996/97	209500	19838	0.09
1997/98	335000	22011	0.07
1998/99	146400	17605	0.12
1999/00	406100	20335	0.05
2000/01	209850	20045	0.10
2001/02	338500	24972	0.07
2002/03	172900	30523	0.18
2003/04	282100	34168	0.12
2004/05	185800	30565	0.16
2005/06	280250	38181	0.14
2006/07	207300	44105	0.21
2007/08	387305	71319	0.18
2008/09	202080	52652	0.26
2009/10	302020	70502	0.23
2010/11	293740	61479	0.21
2011/12	269700	74113	0.27
2012/13	302300	91274	0.30
2013/14	266330	81431	0.31
2014/15	264150	95555	0.36

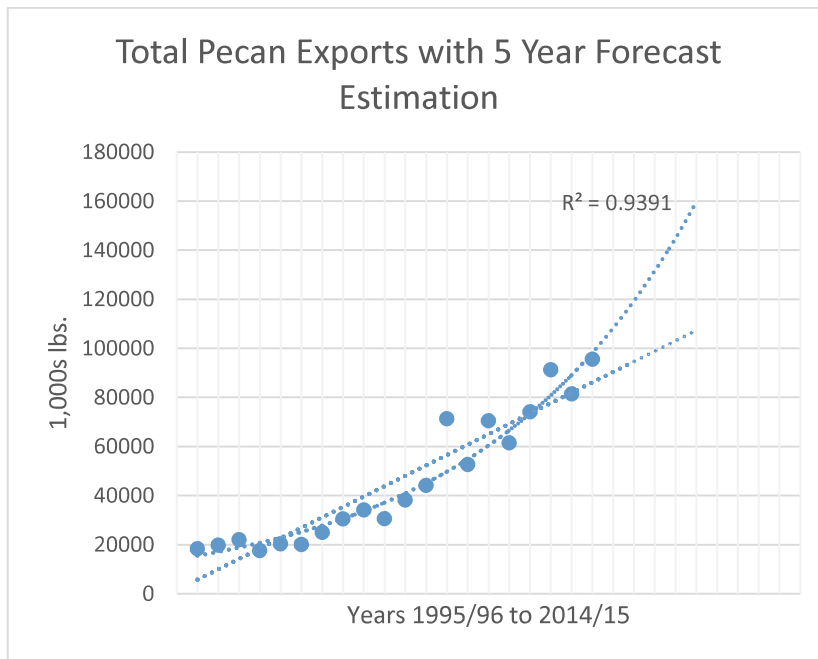
The analysis was run in two stages. In the first stage both total pounds of pecans exported and the percent of the US pecan crop exported were plotted and a polynomial best fit line was plotted in order to establish a pattern of growth. Line fit was assessed using  $R^2$  (a standard statistical assessment of reliability to determine how well the line fits the data based on Nunnally (1979) who calls for a minimum acceptable cutoff of .7). Both plots demonstrated acceptable fits with  $R^2$  values of .939 and .906 respectively.

In the second step of the analysis the linear forecast function was employed to determine the long term growth of the industry with a five year forecast. Anecdotal evidence from the agricultural commodity markets suggests that the long term linear growth line represents the maximum sustainable rate of growth for a given commodity. Deviations either above or below this line are not uncommon because the market historically corrects itself based on the amount of time required to either increase or decrease capacity for a given commodity. In the case of pecans this time period ranges between seven to twelve years as this the time required to bring a new tree into production.

## DISCUSSION

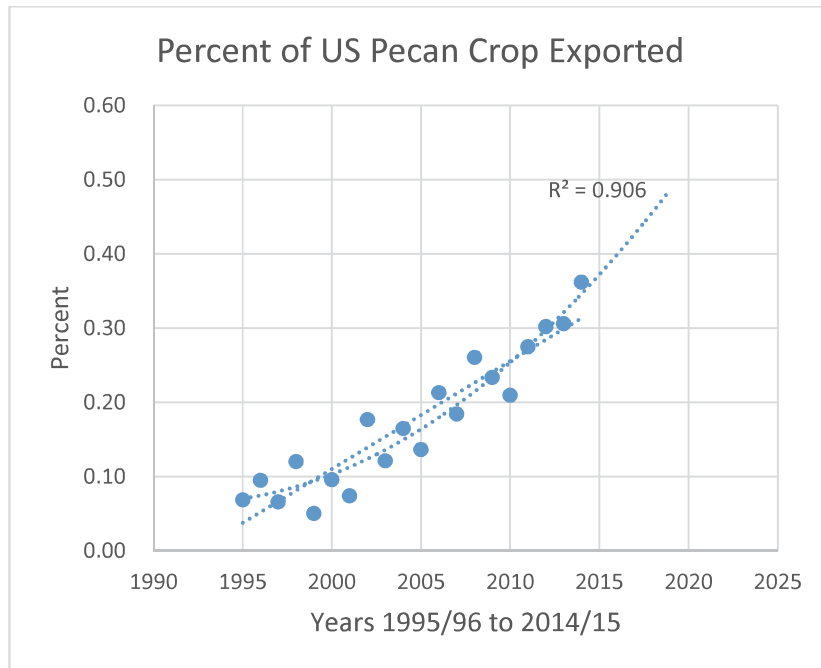
The results of this analysis produced both interesting and unexpected results that should be of interest to readers. The first thing that can be seen in Figures 1 and 2 is that both pounds of pecans exported and the percent of the US pecan crop exported have increased exponentially with the last four data points accounting for the majority of the change. It can also be seen that during this period the slope of both lines exceeded the straight-line long-term growth line at an increasing rate indicating excessive unsustainable growth in accordance with the product lifecycle (Kotler, et al. 1996). This unexpected finding was confirmed using the exponential line function which produced nearly identical results. Additional comparisons using the logarithmic and power functions indicate the potential for a major market correction within the next four to five years, which is consistent with the point in time in which both pounds exported and the percent of the pecan crop exported began their increase above the long term growth line.

FIGURE 1





**FIGURE 2**



Another unexpected finding identified in Figure 1 and 2 and cause for concern is the number of consecutive data points that are either on or above the long term linear trend line. As a general rule of thumb 4 consecutive data points (either on, above or below the trend line) indicate the need to pay attention, 5-6 points in a row indicate the need to proceed with caution while the 7<sup>th</sup> is the tipping point and indicates that the 8<sup>th</sup> data point will make a major move in the opposite direction which is again consistent with the laws of supply and demand (Webber and Wallace, 2007). In this case both plots have 4 consecutive data points that are either on or above the line. What is not shown are the results of the 2015/2016 season which USDA has not yet formally published. However, preliminary estimates put this number above the long term growth line but below the 2014/2015 numbers due to China's economic decline.

Unfortunately this portion of the analysis only considers US pecan exports and does not address China's productive capacity, which cannot be ignored. With this in mind many believe that demand for pecans in China should stay relatively constant at 68,000,000 lbs (Zhang et al., 2015). Then drawing on the data contained in the Timeline of Pecan Production in China there are certain facts that need to be considered. These facts include but are not limited to: 1) in 1998 model pecan orchards were observed in China, 2) in 2014 China had approximately 21,000 acres of pecans, (Zhang et al., 2015) 3) future production is conservatively estimated to be 890 lbs. per acre, 4) between 2010-2013 over 150,000,000 pecan seedlings were grafted, (Zhang et al., 2015) 5) current pecan planting density in China is 162 trees per acre and 6) acreage has increased by at least 1482 acres annually for the last several years (Le et al., 2015).

Based on this information it appears that China will require 76,404 acres of pecan trees to meet current demand (68,000,000 / 890 lbs. per acre) (Zhang et al., 2015). Assuming that the Chinese began planting their pecan orchards in about 2000 and planted an average of 1482 acres pecans annually the required 76,404 acres will be reached in 2037. Alternatively, if one looks at productive capacity and we assume that only 10% of the 150,000,000 pecan seedlings reach maturity, 890 lbs. of production per acre and 162 trees per acre China should be able to 82,406,880 lbs. of pecan annually and will exceed domestic demand by 14,406,880 lbs. which will make it a net exporter of pecans by 2030 at the latest (Zhang et al., 2015).

Another potential scenario that the US pecan industry ought to consider is if China had 21,000 acres of pecan trees in 2014 and they have the potential to plant an additional 92,592 acres (150,000,000\*.1/162) this would give them roughly 113,592 acres of pecan trees that will be nearing full production as early as 2032. At 890 pounds of production per acre this equates to 101,096,880 pounds of production annually leaving China with roughly 33,096,880 pounds of excess capacity. Assuming that any of these possible scenarios comes to fruition China has the potential to become a very formidable adversary to the US pecan industry on world markets.

## **STUDY LIMITATIONS**

This study like all others is not without its limitations. The most difficult of these to overcome stems from the difficulty to obtain information about agricultural production in China. The second limitation of this study is the result of the strong industry bias based on the belief that China is not capable of producing sufficient quantities pecans to meet domestic demand and that the market in China is simply too large to be satisfied and will only increase in the long term as the Chinese people become more familiar with pecans. These limitations notwithstanding, this study makes an important contribution in that it is the first to assess the market potential of this important market using USDA published data. The results of this discussion also provide the basis for a number of important managerial recommendations which are provided in the next section.

## **MANAGERIAL RECOMMENDATIONS**

Assuming that the information gleaned from these academic studies is accurate, as it should be as these articles have gone through a rigorous peer review process, there are three important managerial implications that can be drawn from this study. First, given China's proven ability to produce other types of tree nuts, it is highly probable that they will overcome those problems (disease, pests and low producing varieties) which currently limit their ability to produce sufficient quantities of pecans to meet their domestic demand in the near future. Second, assuming that China is able to meet its pecan production goals in accordance with the Central Government's policy of food self-sufficiency, they will ultimately become a net exporter of pecans, which will put them in direct competition with US growers within a few years. This implication is especially troubling given China's significantly lower cost of production. Third, US based pecan growers through the Pecan Board need to shift their focus from exporting pecans as a commodity to premium US branded pecan based or ingredient products such as candy, ice cream, pecan flour and oil. We must also begin taking steps to increase domestic demand as a buttress against fluctuating international demand and economic downturns.

## **CONCLUSIONS AND FUTURE RESEARCH**

While this study's results are not, by themselves, definitive, they do indicate the need for caution in regard to the long-term potential of the Chinese pecan market. Furthermore, if pecan prices and production follow the same pattern as other commodities such as oil, natural gas, cattle and corn, it is safe to say that significant increases in prices and production will once again result in a corresponding decrease in price due to oversupply.

The results of this study also point to the need for a global research agenda in two primary areas. First, the academic community needs to study the differences between stated and actual trade policies around the world so that more effective and equitable trade policies can be developed. Second, given the growing body of evidence supporting climate change, new research streams will need to be developed in order to assess the potential impacts on food growing areas and the supply chains that support them.

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