EXECUTIVE SUMMARY

In 2003, the Maine Legislature enacted L.D. 53, an Act to Allow Experimentation in the Cultivation of Industrial Hemp. The Act authorized the Director of the Maine Agricultural and Forest Experiment Station (MAFES) to study the cultivation of industrial hemp, including required growing conditions, harvesting methods, marketing opportunities and environmental benefits. In response, MAFES gathered previous studies to evaluate industrial hemp and the results of that effort are summarized in this report to the Legislature.

Our findings indicate the following:

- Maine's soils and climate are adequate to grow industrial hemp. Fertilization with nitrogen, phosphorus and potassium, as well as lime to raise soil pH, would be required. Hemp fiber could be grown in all parts of Maine, but the growing season in northern Maine may to too short for hemp seed production. Supplemental irrigation may also be needed as hemp requires substantial moisture during the growing season for optimum growth.

- The profitability of industrial hemp production depends on many factors that are unknown at this time, including production costs and yields achieved in Maine compared to other places where the crop is grown. It is unlikely that Maine growers would have the lowest costs or the highest yields per acre. Hence, while production may be profitable, growers would face constant pressures to reduce costs/increase yields to remain competitive.

- The current market for industrial hemp is small relative to other major agricultural crops. There are many products that can be produced with hemp and hemp can substitute for other products in the production of other goods and services. It has been estimated that over 25,000 products can be made from hemp. However, it is unknown how much the market for industrial hemp will increase in the future. There is potential for major expansion, but there is very little information on the economic feasibility of the potential market growth. Ultimately, the size of the market for industrial hemp will also influence the feasibility of growing hemp in Maine. Currently, the amount of hemp imported into the US could be produced on a few thousand acres.

- Current harvesting procedures for industrial hemp are generally inefficient. Hemp grown for seed is generally harvested with a combine, while hemp grown for fiber utilizes a baling process. In both instances, existing equipment needs to be modified before being used for hemp harvesting.

- Both hemp fiber and hemp seeds require processing before entering marketing channels. Processing is required to remove the hemp fiber from the other parts of the stem and hemp seed must be crushed to obtain the oil content. Crushing facilities such as those used to crush soybeans can also process hemp seed. At present, however, there are no crushing facilities in Maine. This infrastructure would have to be developed to market any hemp produced in Maine.

- Industrial hemp production is considered to be "environmentally friendly" for several reasons, including its ability to suppress/eliminate weeds, increase organic soil content, increase soil water retention and reduce erosion. Furthermore, pesticide applications are generally unnecessary. Many of the products produced with hemp are considered to be eco-friendly as well.

- There are many barriers to the formation of an industrial hemp industry in Maine and the US. The largest is the fact that it is currently illegal to grow commercial hemp in the US. As long as this is the case, new products and new uses for hemp will not develop; furthermore, the question of whether it can be profitably grown in Maine or other places is irrelevant. Legislation to legalize the production of industrial hemp was introduced in Congress during the summer of 2005, but no action has been taken on the bill to date.

- If it becomes legal to grow hemp in the US, the infrastructure to support the industry will have to be developed. This would include processing plants, modified harvesting equipment and the development of varieties of hemp that optimize yields for local growing conditions. Investment in infrastructure will only be justified if the market for industrial hemp expands substantially once it becomes legal to grow industrial hemp in the US.

- It is recommended that Maine closely monitor the progress of the federal legislation introduced to legalize the production of industrial hemp. If the legislation receives strong support, MAFES should undertake additional studies to determine the feasibility and economic viability of growing industrial hemp in Maine. If the bill is not supported, no further effort should be made to investigate the potential for industrial hemp production in Maine.

AN ASSESSMENT OF INDUSTRIAL HEMP PRODUCTION IN MAINE

I. Introduction

During the 2003 legislative session, the Maine Legislature enacted L.D. 53, an Act to Allow Experimentation in the Cultivation of Industrial Hemp. L.D. 53 defined industrial hemp as any variety of *cannabis sativa* with a tetrahydracannibol (THC) concentration of no more than .3% dry weight that is grown under a federal permit. The act authorized the Director of the Maine Agricultural and Forest Experiment Station (MAFES) to study the cultivation of industrial hemp, including required growing conditions, harvesting methods, marketing opportunities and environmental benefits. The Act also authorized growing trials by MAFES with a federal permit.

In response to the legislation, the Maine Agricultural and Forest Experiment Station made a decision to learn more about the cultivation of industrial hemp by reviewing the literature that is available on the commodity. A few other states in the U.S. and Canada have studied issues related to the growing of industrial hemp. Some of this work has been published and provides a basis for assessing the potential of the crop in Maine.

MAFES collected the available information on industrial hemp and organized it as an initial step in learning more about the crop and its potential for introduction in Maine. A decision was also made to postpone any plans to conduct growing trials until after the initial assessment had been completed. The overall objective of this publication is to present the findings of studies from other states and Canada to provide a basis for determining the potential of industrial hemp as a new crop for Maine agriculture. Specifically, the paper addresses the agronomic and climatic conditions required to produce industrial hemp, current and potential markets for the product, estimates of costs, returns and profitability of industrial hemp production, positive and negative environmental aspects of growing industrial hemp and the current federal regulations under which industrial hemp must be grown.

II. Description and History

The Hemp Plant

Industrial hemp belongs to the plant group *cannabis sativa,* a plant family consisting of long fiber plants with variable concentrations of tetrahydracannibol (THC). It is an annual plant that grows each year from a seed produced by the plant. The hemp plant has a rigid, herbaceous stalk that can grow to heights of 16 feet. There are identified uses for many parts of the plant, including the stalks, seeds and oils (Kraenzel, 1998). Even though industrial hemp is illegal to grow in the United States, it is legal to import (Kraenzal, 1998; Vantreese, 1997). With the exception of a few items, such as textiles woven from imported yarn, most hemp commodities sold in the U.S. are imported.

Hemp Stalk/Fiber Products in the U.S

To use hemp stalks, the stalk's fibers must be separated from the rest of the stalk, and co-products of the separation are the fibers and hurds. The hurds are the coarse parts of the hemp plant that can generally only be used as animal bedding, while the fibers are the principal part of the plant used in the production of several items.

Hemp fiber products in the U.S. include textiles (yarn, fabric, carpet, upholstery, tapestry, clothing, necklaces, bracelets, etc), paper products (specialty papers such as tea bags, toilet paper or stationary), automobile parts (door panels, roofs, headrests, dashboards, filters, etc) and construction materials (mats, linerboard, thermal insulation) (Thompson et al 1998; Kraenzel et al. 1998; USDA 2000; Ehrensing 1998; Cochran et al. 2000; Fortenberry and Bennett 2001;

Small and Marcus 2002; Bosca and Karus 1998). Existing and potential uses of hemp fiber and hurd are discussed in more detail below.

Hemp Seed Products in the U.S.

Hempseed can be used in food and nutrition products similar to the way soybeans or poppy seeds are used. In the U.S., hempseed can be found in snack bars, pretzels, yogurts, cheeses, beer, bodybuilding supplements, and ice cream (Thompson et al 1998; Kraenzel et al. 1998; USDA 2000; Ehrensing 1998; Cochran et al. 2000; Fortenberry and Bennett 2001; Small and Marcus 2002; Bosca and Karus 1998). Actual and potential uses are discussed in more detail below.

It should be noted that the U.S. Drug Enforcement Agency (DEA), which has the responsibility to regulate controlled substances, approved a rule in March 2003 deeming all materials, compounds, mixtures and preparations with any amount of THC in them to be a schedule 1 controlled substance (US Department of Justice 2003). Such substances are not fit for human consumption, and this rule made the sale of all hemp food products illegal in the US. In February 2004, however, the ninth circuit Court of Appeals ruled that the DEA could not regulate hemp products because hemp is not a scheduled drug under the definitions of drugs of the Controlled Substances Act. The Court ruled that the DEA could only ban the presence of marijuana or synthetic THC (United States Court of Appeals 2004). As a result, food products containing industrial hemp seeds and/or oils can be sold legally in the US.

Hemp Oil Products in the U.S.

Several products can be made when hemp seeds are crushed to obtain the oils. In the U.S., hemp oil products include food (cooking oil), personal care items (shampoo, cosmetics, insect repellent, lotions, laundry detergent, etc) and industrial fluids (sealants, lubricants, paints, varnishes, fuel, etc) (Thompson et al 1998; Kraenzel et al. 1998; USDA 2000; Ehrensing 1998; Cochran et al. 2000; Fortenberry and Bennett 2001; Small and Marcus 2002; Bocsa and Karus 1998). Uses of hemp oil are discussed further below.

Hemp vs. Marijuana

Marijuana and hemp are different varieties of the same species, *cannabis sativa l.* By definition, industrial hemp "refers to the strains of *cannabis sativa l.* containing less than 1% THC" (Vantreese, 1998). In most developed countries where industrial hemp is cultivated, production is limited to hemp varieties that contain less than .3% THC. The largest difference between hemp and marijuana is that marijuana usually contains about 4% to 20% THC (Vantreese, 1998; Kraenzel, 1998). A THC concentration in marijuana of approximately .9% has been suggested as a minimum level to achieve the intoxicating effect of the drug, and concentrations of .3% to .9% are considered to have only a very small intoxicating effect (Small, 2002). Thus, the THC concentration level allowed in industrial hemp is set at the minimum level of this threshold effect.

Another difference between the two is that industrial hemp is generally grown in temperate climates while marijuana is usually a tropical plant (West Communication, 2003). It is true that both types of *cannabis sativa* have the ability to adapt to various climatic conditions; nevertheless, the ideal climate for marijuana is somewhat warmer than the ideal climate for industrial hemp.

Similarities in appearance of the two plants are greatest in the early stages of growth. In the field, both marijuana and hemp plants grown for seed production are spaced 8 to 16 inches apart (Vantreese, 2001; West Communication, 2003). As a result, it can be very hard to distinguish between the two. Furthermore, hemp and marijuana plants can cross-fertilize, which can lead to an increase in THC levels of industrial hemp. Current federal regulations require that new certified industrial hemp seed be obtained from the federal government each year, thereby insuring that the THC content of industrial hemp does not exceed .3% THC (Vantreese, 2001). Hemp plants grown for fiber, on the other hand, are planted closer together and do not as closely resemble marijuana plants.

History

Hemp is believed to be one of the oldest and most versatile cultivated plants (Bosca and Karus 1998; Fortenbery 2001). Hemp was first cultivated in China approximately 5000 years ago (Fortenbery 2001; Kraenzel 1998). It was primarily used for textiles due to its durability and waterproof qualities; it was also used for ropes, cordage and flags. There is evidence that the Egyptians used hemp ropes when building the pyramids, and that the Roman Empire was partially responsible for spreading hemp throughout Europe. A sample of paper discovered in China dating back to 140 to 87 B.C. indicates that the world's first paper was made from hemp (Bosca 1998).

Hemp also played a prominent role in the history of the United States. Farmers and landowners, including Thomas Jefferson and George Washington, grew hemp. The first two drafts of the U.S. Declaration of Independence were written on paper made from hemp, and colonial soldiers' uniforms were made of hemp cloth. Benjamin Franklin began his penny printing press with paper made from hemp, and the first U.S. flag was made from hemp. Hemp was even used as legal tender to compensate for the lack of printed money (Kraenzel 1998).

Hemp was first grown in New England in 1645 for fiber, but cultivation later spread to Virginia, Pennsylvania, Kentucky, Missouri, Wisconsin and Illinois. The largest supplier of hemp was Kentucky, and by the mid-1800s more than 160 factories manufactured hemp bagging, cordage and rope in Kentucky. The U.S. navy was one of the largest hemp purchasers due to hemp's ability to withstand saltwater conditions.

Increased production of cotton along with the import of cheaper hemp substitutes eventually led to a decrease in domestic hemp production. The hemp industry in the U.S. declined further in 1937 when Congress passed the Marijuana Tax Act, which placed industrial hemp under regulatory control of the government. Legal restrictions on production of hemp were lifted during World War II, but were reinstated at the end of the war. Commercial production of industrial hemp as a cash crop in the U.S. ended in 1958. (Marinucci 1998; USDA 2000; Ehrensing 1998; Economist 1998; Kraenzel 1998).

Currently, it is illegal to grow industrial hemp in the U.S. unless authorized by the U.S. Drug Enforcement Agency (DEA) for research or police analytical laboratories. *Cannabis sativa l.* is classified as a Schedule 1 Controlled Substance and the DEA contends that the 1937 Marijuana Tax Act applies to both marijuana and industrial hemp, regardless of the THC level (Vantreese, 1998). In the past decade, the legal status of hemp has been questioned and challenged as the popularity of the crop has grown.

Advocates of industrial hemp point to the potential environmental benefits of growing hemp as an alternative crop, such as weed/pest control and the improvement of soil quality. Advocates also note that there are an estimated 25,000 different hemp-related products currently available (Kraenzel, 1998). It is also apparent that consumer demand for environmentally and economically sustainable products has increased, which lends an explanation to the recent interest in such eco-friendly products (Thompson 1998). About 30 countries, including all major industrial nations have legalized the cultivation of industrial hemp.

Those who oppose industrial hemp cite several issues. The first is that it is too difficult to distinguish industrial hemp from marijuana with its higher narcotic (THC) concentration. In the field there is potential for marijuana and industrial hemp crops to cross-fertilize, which could increase the THC levels in federally certified crops. Furthermore, it has been suggested that industrial hemp advocates have a secret agenda of supporting the legalization of marijuana (Vantreese, 1998). Some view the legalization of hemp as a step towards the legalization of marijuana, and there is a fear that marijuana will be illegally grown in fields of industrial hemp crops.

III. Plant Adaptation and Agronomy

Temperature, Moisture and Soil Conditions

As stated above, hemp is well adapted to the temperate zone, with the traditional growing areas located north of 35 degrees parallel (Cochran, 2000; West Communication, 2003). The average temperature range for optimal growth of industrial hemp is between 19 and 25 degrees Celsius, or 66 to 77 degrees Fahrenheit. When the average daily temperature reaches 16 degrees Celsius or 61 degrees Fahrenheit, the plant will enter the rapid growth stage (Bosca and Karus 1998). Hemp can endure colder and warmer conditions than these, however, and can even withstand some frost, although frost can stunt the growth. Recent industrial hemp trials in Hawaii resulted in the successful growth of hemp plants. Some plants grew as high as 8 feet in temperature conditions that are higher than the optimal average (West 2003). Hemp requires a growing season of about 4 months to produce fiber, and about 5.5 months to produce mature seeds (Cochran 2000). Young plants can survive to temperatures of about –5 degrees Celsius or 23 degrees Fahrenheit (Bosca and Karus 1998).

Hemp requires a large amount of moisture, particularly during the first six weeks of growth (Cochran 2000). During the rapid vegetative growth period, approximately 10 to 14 inches of available moisture is ideal, and 20-28 inches of moisture is ideal over the entire growing season (Cochran 2000; Bosca and Karus 1998). After the plants are well rooted, they can endure drier conditions; however, severe drought is damaging. The roots of the hemp plant can adjust somewhat to moisture conditions. The main root can reach extreme depths in some soils, enabling it to retrieve water from deep within the soil (Bosca and Karus 1998).

Hemp can be grown on a variety of soils, but does best on loose, well-drained loam soils with high fertility and abundant organic matter (USDA 2000 Bosca and Karus 1998). Specifically, the most favorable soil textural classes include loamy sand, sandy loam, loam, silt, silt loam, and silty clay or silty clay loam (Bosca and Karus). These soils also have good water retention and permeability characteristics needed by the plant. The ideal soil pH is between 5.8 and 6.0, and significant and constant amounts of nitrogen, phosphorous and potassium are required (Bosca and Karus 1998).

Maine's Climate, Moisture and Soil Characteristics

Table 1 compares the ideal climate, moisture and soil conditions for hemp to the typical conditions that can be found in Maine. The average temperature and precipitation data was available for Caribou, Bangor, Augusta and Portland and is based on averages from 1970 to 2000. It should be noted that the "available moisture" category for hemp is based on numbers that include precipitation during the growing season as well as moisture that is in the ground. The numbers for Maine are just precipitation numbers for the growing season months. The length of the growing season was determined by a frost occurrence chart, which consists of first and last frost date probabilities for various areas across the state. The soil type is based upon information about soils across the state, which tends to be loamy soils that vary from poorly drained to excessively drained.

TABLE 1: **Temperature, Soil and Moisture Characteristics**: **A Comparison Between Ideal Conditions for Industrial Hemp and Typical Conditions in Maine***

	Average Temperature	Available Moisture	Length of Growing Season	Soil Type	Soil pH
Ideal for Industrial Hemp	60-77 degrees during growing season	**Total over growing season**: 20-28 inches **First 6 weeks**: 10-14 inches	**Fiber**: 4 months without killing frost **Oilseed**: 5.5 months without killing frost	Well drained, loamy	5.8-6
Typical of Northern Maine (Caribou, Bangor)	61 degrees during growing season (mid May-end Sept)	**Total over growing season**: 17.16 inches **First 6 weeks**: 6.5 inches	Approximately 4.5/5 months without killing frost	Moderately well drained, loamy	4.8-5.2
Typical of Southern Maine (Augusta, Portland)	63 degrees during growing season (May-beginning Oct)	**Growing Season Total**: 20.52 inches **First 6 weeks**: 7.01 inches	Approximately 5.5 months without killing frost	Moderately well drained, loamy	4.8-5.2

*Information for Table 1 was obtained from the state of Maine government website, the Maine State Climate Office website, Soils of Maine, a report published by the Maine Agricultural and Forest Experiment Station, and the National Weather Service website.

Based on the available information, most of the necessary conditions for growing hemp already exist in Maine. The two noticeable shortcomings occur in the available moisture and pH categories. Moisture can be adjusted through irrigation, and soil pH can be adjusted by the application of lime or a similar agent to raise the pH level. The growing season in Northern Maine does not appear to be long enough for oilseed crops; however fiber crops should not be a problem. Research has shown that hemp can be grown in conditions that are less than ideal; however, it is vital that the crop have good soil, adequate moisture and proper fertilization (West 2003; Niedermann Communication).

IV. Cultural Practices

General agronomic practices for industrial hemp are well known and documented. Several recent publications have summarized the practices for industrial hemp production (Small 2002, USDA 2000, Bocsa and Karus 1998, Kraenzel 1998, Ehrensing 1998). Hemp is similar to other agricultural crops in that the procedures used to grow, cultivate and harvest the crop are highly dependent upon the end product for which the crop will be used. The most notable difference with hemp begins in the planting stage; crops grown for oilseed are planted farther apart while crops grown for fiber are more densely grown. In addition, hemp grown for high quality textile fiber may be handled much differently than hemp that is grown for particleboard or paper. Some suggest that the two crop types are mutually exclusive; the local industry should specialize in either fiber or oilseed production, but not both (Small 2002; Niedermann 2003).

Hemp Varieties

Variety selection plays a large role in hemp cultivation, even more so than with other cultivated plants (Bocsa and Karus, 1998). Each industrial hemp variety has its own unique set of characteristics, based upon the desired end result as well as the location in which the crop is grown. Different varieties produce small or large seeds, various oil levels, different oil compositions, various bast fiber percentages, etc. (Baxter 2000).

Currently, no industrial hemp varieties exist that have been specifically bred for cultivation in the United States. The hemp variety that was the basis of the US hemp industry was known as “Kentucky Hemp”, and it no longer exists (West, 2003). “Kentucky Hemp” had its origin in seed from China, and the USDA developed highly productive varieties until 1933 when hemp breeding operations ceased (West, 2003).

The Hawaiian hemp experiment successfully grew hemp from a variety that had its origins in both Asian and European varieties (West, 2003). Since the legalization of industrial hemp in Canada in 1998, several of the varieties used in the field have been of European origin. There are a few new Canadian-bred varieties that have been developed and used, and research in Manitoba and Saskatchewan regarding hemp seed varieties is still ongoing (Baxter 2000; Niedermann 2003). Recent studies have shown that some of the Canadian hemp varieties may be suitable for US farmers.

Seedbed Preparation and Planting

Hemp should be planted on well-prepared land. Industrial hemp must have good soil, sufficient fertilizer and adequate moisture. The seedbed should be fine, firm and level, and the seeds should be planted as soon as the ground is dry enough to avoid compaction (Baxter 2000). The most productive crops are grown when fall or winter plowing is followed by preparation of a good seedbed in the spring (Cochran 2000). Fertilizer is usually applied broadcast across the entire seedbed before final preparation. Timing for seeding varies, depending on the local climate, but the best time is usually after the last hard frost has occurred. Industrial hemp is normally planted using a seed drill, spacing the seeds about 3 to 7 inches apart for fiber crops (Cochran 2000; Baxter 2000).

Hemp grown for seed or oilseed is normally planted by spacing the seeds about 8 to 16 inches apart (Bocsa and Karus 1998). The seedling depth is usually ¾ to 1¼ inches (Cochran 2000). Seeding rate is specific to each variety. There are generally recommended seeding rates in Europe, however, and those have ranged from 45 to 63 pounds per acre for fiber crops, although numbers can be higher if germination is low and the seeds are large (Baxter 2000). Seeding rates for oilseed crops tend to be lower than the rates for fiber crops. Generally, high plant density will result in high quality fiber hemp crops, while lower plant density will result in a higher seed yield in seed and oilseed crops (Ehrensing 1998; Bocsa and Karus 1998).

Fertilizer

As previously mentioned, industrial hemp requires soil that is high in nutrients, due to the amount of dry matter that is produced. Fertilization is very important to produce a high biomass yield. Several recent studies have indicated that industrial hemp requires liberal fertilization over a wide range of environmental and soil conditions (Ehrensing 1998). Specific amounts will vary upon the quality of the soil and the presence of nutrients in the soil. It is recommended, however, that high levels of nitrogen, phosphorous and potassium be applied to the soil. Typical amounts of nitrogen fertilization are 18-22 pounds per ton of dry matter and current practices include applying half of the nitrogen in the fall prior to sowing and after harvesting the previous crop, and the other half in the spring (Bocsa and Karus 1998). Phosphorous and potassium should both be applied in the fall before plowing (Bocsa and Karus 1998).

Weed Control and Pesticides

One of the characteristics that sets hemp apart from other crops and has contributed to its popularity among environmental advocates is its pest resistant nature. Hemp is a natural weed-suppressant, and herbicide application is usually unnecessary (Cochran 2000; Kraenzel et al 1998). There have been documented cases where hemp crops have completely wiped out Canadian thistle, and caused severe damage to quack grass, bindweed and yellow nutsedge populations (Kraenzel et al 1998, Ehrensing 1998). Hemp's ability to suppress weeds lies in the fact that the plant is so densely grown; it simply chokes out the weed populations during its vegetative growth stage (Bocsa and Karus 1998). The weed control will usually carry over into the next year.

Insect and pest diseases have not been considered significant problems for industrial hemp crops, and pesticides are not commonly used in hemp production (Cochran 2000). While several recognized insect pests do exist for industrial hemp, none of them have been documented to cause economic losses (Bocsa and Karus 1998). Birds feed on hemp seeds and can be a pest. In the recent Hawaiian hemp experiment, birds were found to be the only agriculturally damaging pest (West 2003b). Disease outbreaks in hemp crops are generally not common (Cochran 2000; Bocsa and Karus 1998).

Although hemp is usually a pest-resistant crop, any introduction and increased production of a new crop to a region can result in unforeseen pest problems. Several factors, such as increased fertilizer use, high-density planting and increased irrigation have resulted in increased pest problems in other crops in various regions (Ehrensing 1998). It would be realistic to anticipate a similar outcome with intensive hemp production in a new area such as Maine.

Harvesting

Harvesting is currently the most problematic and least understood aspect of hemp cultivation. One complication is that harvesting is different for fiber and oilseed crops. Another is that machinery for hemp harvesting has a limited capacity per day resulting in high harvesting costs (Bocsa and Karus 1998). When grown for fiber, hemp is usually harvested in the early flowering stage just before the seeds have matured. The harvest system for fiber currently employed in Europe involves six basic steps:

1. Chemical defoliation or an alternative method of removing unnecessary leaves
2. Cutting or reaping the stems of the plant
3. Retting (process in which chemical bonds in the fibers are broken down)
4. Baling

5. Loading
6. Transport to processing facilities

Harvesting in Europe is generally done using tractor drawn harvester-spreaders that cut the hemp stems and lay them in the field for retting. Retting is the process through which the chemical bonds that hold the fibers together are broken down to produce textile-quality fiber. A second machine is used to gather and tie the stems (known as baling) for delivery to the processing facilities (Fortenberry and Bennett 2001). Harvesting can also be done with existing baling equipment that consists of a mower, a rake, a swather and a baler (Kraeznel 1998). A third possible option to harvest unretted hemp stalks is through the use of forage or sugar cane harvesting equipment that has been modified (Cochran, 2000). The overall opinion, however, is that none of these methods are particularly efficient or cost effective, and new technologies need to be developed to lower costs and increase efficiency of harvesting procedures.

Another complication with harvesting is that there are two approaches to retting the crops. The two methods are water retting, during which the plant stems are immersed in water (ponds, rivers or tanks) to break the bonds, and field retting, during which the plants are laid in the field to rot and dry for 2 to 3 weeks. Water retting produces a higher quality fiber, but is very labor and capital intensive. The process also produces large volumes of wastewater that must be treated before being discharged to comply with environmental regulations (Fortenberry and Bennett 2001). Therefore, in most European countries, fiber is field retted. In China and Hungary, however, due to less stringent environmental regulations and lower labor costs, higher quality fiber is produced through water retting (USDA 2000). This results in a comparative advantage for those countries in the hemp market.

Harvesting oilseed crops requires a different approach. The seed crops are not harvested until the seeds have matured, which can be about a month after the fiber crops have been harvested. It can be hard to determine when the appropriate time to harvest is, since seeds can mature at a different rate on various parts of the plant. Seeds at the top of the plant can be mature and have already split open, while seeds near the bottom of the plant are not yet mature. When harvested, a combine harvester is used for reaping only on sunny, dry days (Bocsa and Karus 1998). Tall, heavily branched hemp plants, such as those that are grown for seed and oilseed, are sometimes difficult to harvest with conventional combines. As a result, seed harvesting is still done by hand in some areas (Cochran 2000). After the seeds are picked, they are usually washed in the field, dried and then stored in a cool area. The seeds are then sent to a processing plant where they are crushed to recover oil.

V. Industrial Hemp Uses

One of the most important factors when assessing the feasibility of developing a domestic industry such as hemp is the market potential. Several sources have cited the numerous uses and potential uses of hemp fiber, seed and oil (Thompson et al 1998; Kraenzel et al. 1998; USDA 2000; Ehrensing 1998; Cochran et al. 2000; Fortenberry and Bennett 2001; Small and Marcus 2002; Bocsa and Karus 1998). Kraenzel et al estimates that there are 25,000 different hemp related products. The USDA points out in its 2000 study that the many potential uses of hemp need to be competitive with the currently established products for them to turn into concrete market opportunities. Hence, any forecast of potential markets for hemp is highly speculative, because a hemp industry has not existed in the U.S. for 50 years (Vantreese 1997; Fortenberry and Bennett 2001).

Fiber/ Hurd Uses

Figure 1 summarizes the various uses and potential uses of hemp fiber and hurd. The flowchart was adapted from "Industrial Hemp as an Alternative Crop in North Dakota", a report by Kraenzel, Petry, Nelson, Anderson, Mathern and Todd. Additional uses have been added to the original figure. The additional uses came from "Hemp: A New Crop With New Uses for North America", a report by Small and Marcus. As Figure 1 (below) illustrates, several products exist that are produced in the hemp fiber and hurd markets. These products can be broken down into six categories: textiles, paper, plastic composites, building materials, geotextiles, and animal products (Small and Marcus 2002; Bocsa and Karus 1998). In the United States, most of these products are imported.

Figure 1: Hemp Fiber and Hurd Uses

Hemp Fiber and Hurd Uses

Textiles
Clothing
 - shoes
 - shirts
 - pants
Accessories
 - bags
 - jewelry
Household Items
 - carpet
 - tapestries
 - upholstery
Yarn

Paper
Fine
Specialty
 - tea bags
 - coffee filters
 - carbon tissues
 - toilet paper
 - bank notes*

Plastic Composites
Fiberglass Substitutes
Composite Boards
Automobile Parts
 - door panels
 - roofs
 - dashboards
 - filters

Construction Materials
Cement Plaster
Thermal Insulation
Fiberboard
Packaging Materials
 - mats
 - linerboard

Geotextiles
Biodegradable Matting*
Ground Covers*

Animal Products
Bedding
Litter*

* *Items currently not used in the US*

Figure 2 (below) illustrates that the world hemp fiber market is dominated by China and Korea (Vantreese 1998). In 1997, world hemp fiber production was about 55,500 metric tons, and the two countries produced more than 60% of the supply (Vantreese 1998). Hemp has never been illegal to grow in those countries, and they have lower labor and environmental costs than their competitors. Hemp fiber production makes up a small portion of the world bast fiber production. Jute is the largest source of the world's bast fiber, and hemp production is about 8% of jute production (Fortenberry 2001).

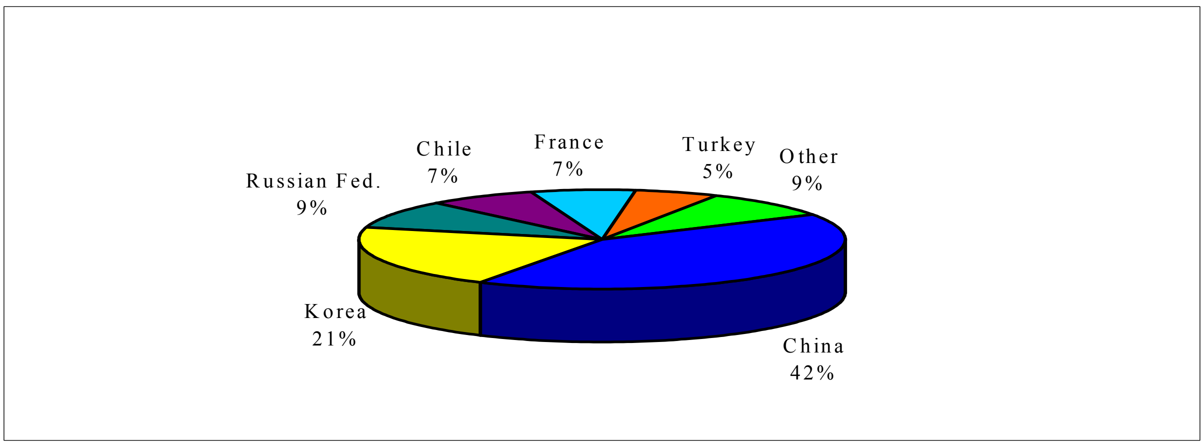
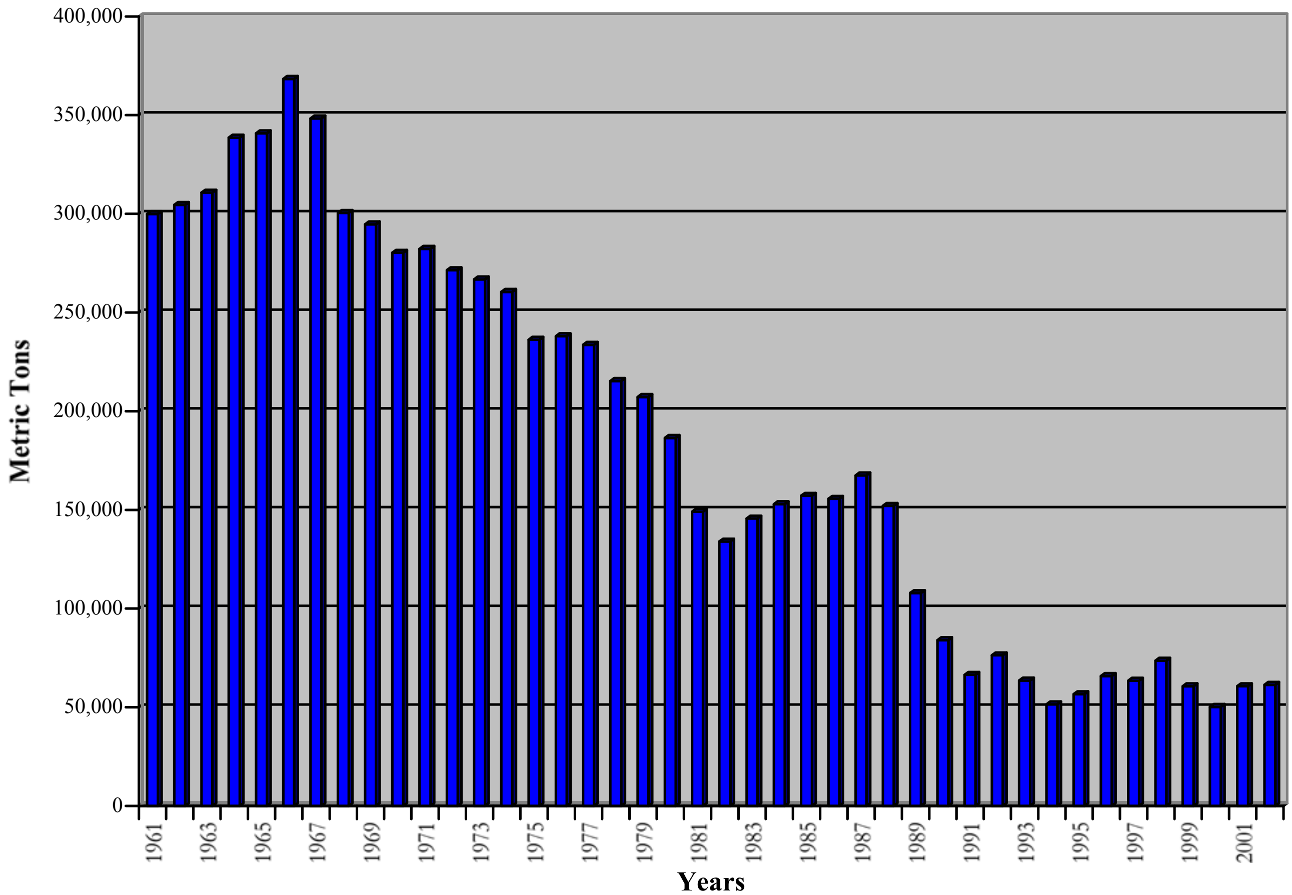


Figure 2: World Market Share: Hemp Fiber and Hurd Production (1997)*

World hemp fiber and hurd production has decreased over the past three decades, to approximately one-fifth of the size that it was (Figure 3). Even though there has been an increased interest in hemp over the past few years, production has remained relatively stable over that time period (Vantreese 1998). US hemp fiber imports have actually increased in the last decade. The US Bureau of the Census documented that from 1995 to 1999 the total amount of hemp fiber, yarn and fabrics imported by the US increased from about 253,000 pounds to 1,890,000 pounds (USDA 2000).

Figure 3: World Hemp Fiber and Hurd Production (Metric Tons) 1961-2002*



**Data for Figure 4 is from the Food and Agricultural Organization of the United Nation's FAOSTAT website (www.apps.fao.org.)*

Hemp fiber has the potential to replace other biological fibers in several products, and even has the potential to replace other materials such as steel and glass fiber. Also, as forests continue to diminish, the cultivation of annual plants is likely to increase as alternative sources of fiber are needed (Small and Marcus 2002). There has also been an increased demand in the past decade for environmentally friendly products, which is a part of hemp's marketability.

The following six sections discuss hemp fiber products and potential products. It is apparent that there is a demand in the U.S. for many of these products, yet there are several barriers to a hemp fiber industry in Maine. The most prominent problem is that specialized harvesting, spinning and weaving equipment are necessary when using hemp fibers in fine textiles apparel. This type of equipment is not currently available in the US. In addition, the infrastructure required for the processing of hemp for textiles, geotextiles, paper, plastic composites, and building construction materials is not available (Small and Marcus 2002).

A second issue is that of competition with other producers in the market. The European Union currently offers subsidies to hemp growers, averaging about $346 per acre as of 1997 (Vantreese 1998). As a result, farmers in the EU hold an advantage in the world market. In addition, the current textile market leaders (China, Korea, etc.) have significantly lower labor and environmental costs than the U.S., creating a competitive advantage. Any hemp fiber industry in Maine would require new technology and necessary infrastructure investment.

Textiles

Textiles made from hemp fibers include clothing, fine linen, yarn, upholstery, bags, sacks, tarpaulins, carpets and other home furnishings. Although many of these products are sold at high prices, hemp textiles have an appeal to a certain part of the population who are willing to pay for the products (USDA 2000). Much of the hemp apparel that is found in the U.S. comes from yarns, fiber and fabrics that are imported from Europe or China (Small and Marcus 2002). In addition to hemp apparel, home furnishings are also in demand, particularly in the "eco"-friendly market. Environmentally friendly carpets and upholstery can be found in the private sector as well as the industrial sector.

Current fine textile production takes place primarily in China and it seems likely that China will continue to dominate that market (Small and Marcus 2002). Coarser woven cloth, used in other textiles, such as carpets do not require specialized equipment; however, there has been very little effort in the U.S. to produce such woven cloth from yarn imports (Small and Marcus 2002).

Pulp and Paper

Much of the world pulp and paper industry relies on wood pulp, and industry leaders have looked into the use of hemp pulp only on an experimental basis. Historically, hemp based pulp has been used when producing conventional paper, however recent analyses have concluded that this method of use is not profitable (Small and Marcus 2002). Current research in European countries, however, has determined that hemp can be used as a fiber supplement to recycled paper pulp due to its long fibers. Also, the European market has shown that there is a small niche for specialty pulp products made from hemp, and several of these products have been sold in the U.S. (USDA 2000; Thompson et al 1998; Small and Marcus 2002). These include products such as cigarette papers, hygiene products, toilet paper, art paper, tea bags and filters.

Paper made from hemp pulp is more costly to produce than paper made from other sources, however, resulting in a much higher price for hemp specialty paper. The higher cost is a result of hemp paper being produced on a much smaller scale, requiring non-wood-based processing facilities, processing techniques that result in the loss of half of the fiber mass, and the high costs of transportation and storage (Bocsa and Karus 1998; Small and Marcus 2002). There is currently not a large market for hemp paper; however demand is likely to grow as fiber substitutes for wood-based pulp and paper products increases.

Plastic Composites

There are several products that can be made from hemp plastic composites, including fiberglass substitutes, injection molding, and press molded parts. Hemp fibers have proven to be very successful in the production of plastic composites for use in automobiles, and this use is the second most important part of the hemp industry in the E.U. (Small and Marcus 2002). In Europe, hemp fibers have been used to reinforce trunk linings, rear decks, dashboards, headrests and door panels. Even small companies in the U.S. have been outfitting vehicles such as buses with hemp-reinforced parts (USDA 2000).

There are several benefits associated with using hemp fibers in plastic composites: low density and weight reduction, positive results in crash tests, higher stability, the possibility of producing more components from one raw material and in one step, occupational health benefits compared to glass fibers, and favorable mechanical, acoustical, and processing properties (Small and Marcus 2002; Bocsa and Karus 1998). This market is expected to grow as technology improves and the use of hemp in plastic composites expands to other transportation vehicles such as bicycles and airplanes.

Building Construction Products

Hemp- based construction products include thermal insulation, fiberboard, and cement plaster. Hemp thermal insulation materials are in very high demand because of high energy costs, concerns about conservation of non-renewable resources and dependence on current sources of oil (Small and Marcus 2002). As a result, the area of environmental insulation materials is experiencing phenomenal growth rates (Bocsa and Karus 1998). In Europe it is predicted that by 2005, tens of thousands of tons of hemp and flax thermal insulation materials will be sold (Small and Marcus 2002). Hemp is also being added to concrete to increase strength while reducing cracking and shrinkage, and has even been chemically combined with materials to make drywall. Even in the US, whole houses have been constructed from hemp building products, and it appears that demand for these products will increase. This aspect of the market is relatively undeveloped; however, there is potential for it as hemp fiber produces extremely strong material (Small and Marcus 2002).

Animal Bedding

Hemp hurds, the woody core of the plant, are obtained during the mechanical processing of the plant. The hurds make very good animal bedding, particularly for large animals such as horses. Hemp hurds can also be used as bedding for smaller animals and as cat litter. The hurds are very easily composted and can absorb up to 5 times their weight in moisture (Small and Marcus 2002; Bocsa and Karus 1998). Hemp hurds used for bedding are a suitable substitute for wheat straw and provide similar insulation and softness. Hemp bedding is particularly useful in situations where animals have allergies or sensitivity to wheat straw. In Europe, hemp hurd bedding has been very successful, especially in areas where straw is scarce and costly to dispose of. The hemp hurd bedding market is anticipated to grow, but might not be as successful in areas that have ample quantities of straw available (Bocsa and Karus 1998; Small and Marcus 2002).

Geotextiles

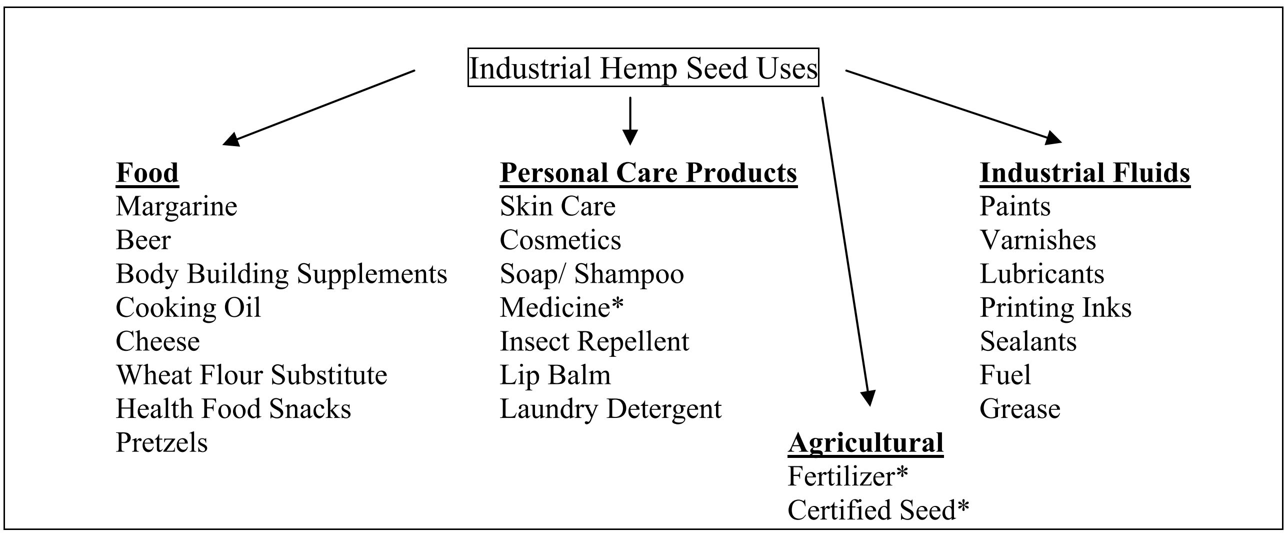
Large quantities of textiles are used for erosion control (geotextiles), and historically these have been made from synthetic fibers. Recent interest has risen around the idea of using natural fibers to produce biodegradable geotextiles. Experiments conducted replacing synthetic fibers with natural fibers in geotextiles have proven very successful. Hemp seems an excellent choice for geotextiles because it has a high tensile strength, minimal stretching, slow biodegradability and outstanding water-absorption qualities (Bocsa and Karus 1998).

This market is expected to grow as concern for the environment grows, and more stringent environmental regulations are put into place.

Oilseed Uses

Figure 4 summarizes the various uses and potential uses of hempseed. The flowchart was adapted from “Industrial Hemp as an Alternative Crop in North Dakota”, a report by Kraenzel, Petry, Nelson, Anderson, Mathern and Todd. Additional uses have been added to the original figure. The additional uses came from “Hemp: A New Crop With New Uses for North America”, a report by Small and Marcus.

Figure 4: Industrial Hemp Seed Uses

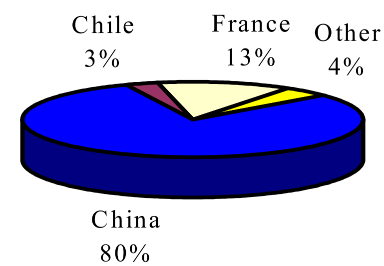


* *Items currently not used in the US*

As Figure 4 illustrates, several products exist that are produced in the hemp seed and oilseed markets. These products can be broken down into four categories: food, personal care products, agricultural products and industrial fluids (Small and Marcus 2002; Bocsa and Karus 1998). In the United States, most of these products are imported or are made in the U.S. using imported hemp products. As with hemp fiber production, China holds a competitive advantage over other countries because labor and environmental costs are lower there.

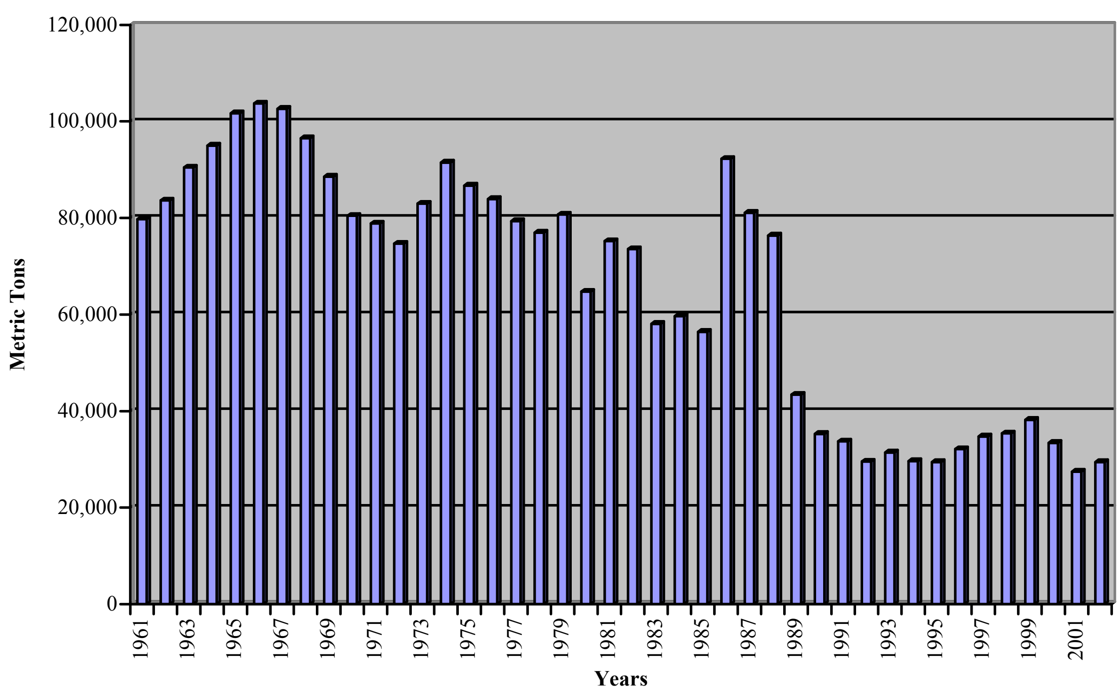
Figure 5 (below) illustrates how the world seed market is dominated by China, which produced 80% of the total world hemp seed production in 1997 (Vantreese 1998). World hemp seed production has decreased over the past three decades to about one half of its original output. As with hemp fiber, even with an increased interest in hemp seed over the past few years, production has remained relatively stable over that time period (Vantreese 1998).

FIGURE 5: World Market Share: Hempseed Production (1997)*



** Data for Figure 5 is from the Food and Agricultural Organization of the United Nation's FAOSTAT website (www.apps.fao.org.)*

FIGURE 6: World Hempseed Production (Metric Tons) 1961-2002*



Recent research indicates that hemp oilseed crops have more potential for North American, and thus U.S., farmers than fiber crops. Hemp seed and oil generally get higher prices than fiber crops, and hemp seed can be processed with existing equipment while fiber requires new equipment and facilities. In addition, European countries tend to focus on fiber crops as opposed to oilseed (Small and Marcus 2002). It should be noted that hemp seed export prices have historically been very volatile, and that it is very difficult for farmers to deal with such drastic price fluctuations (Vantreese 1998).

In Canada, where hemp cultivation was only recently legalized, farmers have chosen to specialize in oilseed production. In the past few years, Canada has made advances in growing, harvesting and processing hempseed, and has moved ahead in the development of raw materials and products for the nutraceuticals, natural foods and cosmetics industries (Small and Marcus 2002, Niedermann Communication 2003). This may be a logical path for an emerging hemp oilseed industry in Maine; however, available infrastructure poses a problem. The largest obstacle to any oilseed market in Maine is that there are currently no oil processing or seed crushing facilities available. The closest oilseed processing facilities are located in New York and New Jersey (Soyatech, 2003).

Food (Hempseed)

Hempseed is now incorporated into many food preparations and is often used to mimic familiar foods (Small and Marcus 2002). Hemp seeds have a nutty flavor and are used in many foods, including snack bars, pretzels, yogurts, salad dressings, pancakes, ice cream and cheese (Bocsa and Karus 1998; Small and Marcus 2002). Also, at least two breweries in the United States make hemp beer (USDA 2000). These products are currently found in niche markets, such as natural food and specialty foods outlets. The overall market potential for hempseed as an ingredient in food is unknown; however it is probable that it will remain a small market such as sesame and poppy seed markets (USDA 2000). Some consumers will be willing to pay for the novelty of hemp seed foods, but the seeds will have to compete with more common ingredients on taste and functionality.

Food (edible oil)

The use of hemp for edible oil dates back at least three thousand years, and has gained current popularity because of its nutritional benefits. Hemp oil has high levels of tocopherals (anti-oxidants), unsaturated fatty acids and protein (Small and Marcus 2002). Hemp oil contains both linolenic and linoleic acids, both of which are essential fatty acids required in a nutritionally balanced diet (USDA 2000). The market for hemp oil is somewhat limited, however. Because hemp oil is high in unsaturated fats, it is unsuitable for frying and baking, has a limited shelf life and must be kept in dark colored bottles. Also, hemp oil does not undergo degumming and bleaching as do other edible oils, which can lead to a taste and color that might not be pleasing to some (USDA 2000).

Personal Care Products

European companies first introduced hemp oil-based personal care products in the 1990's. These products now consist of creams, lotions, lip balms, shampoos, soaps, laundry detergents, and cosmetics. Hemp-based cosmetics and personal care products account for about half of the world market for hemp oil (Small and Marcus 2002). The Body Shop, a British-based international skin products company, began selling hemp-based products in the U.S. in 1998 (USDA 2000). In 2000, the company reported gross sales of about a billion dollars, 4% of which were from the hemp products (Small and Marcus 1998).

Industrial Fluids

Although hempseed oil is more suited to edible than industrial purposes, hemp oil has been used in paints, varnishes, sealants, printing inks, fuel, grease and lubricants. However, wide use of the oil in industrial fluids is not economically feasible today. The oil is currently too expensive in these applications to compete with more traditional oils such as linseed and soybean oils (Small and Marcus 2002). Also, the economic future of these products is unknown, as the use of plant oils and fats in industrial applications has fluctuated over the last two decades with no apparent upward or downward trend (USDA 2000).

VI. Estimated Production Costs, Returns and Profitability

When evaluating industrial hemp as an alternative crop in Maine, potential yields, costs, returns and profitability are important considerations. Without actual observations on U.S. production, processing and profitability, it is difficult to estimate these numbers. Previous studies have relied on cost estimates for comparable crops (such as corn) as well as on Canadian and European experiences. Estimates for fiber and oilseed crops can be found in Tables 2 and 3. The estimates vary greatly across the studies, and the authors acknowledge their limitations when estimating profitability (Thompson et al., 1998; Baxter and Schiefele, 2000; Ehrensing 1998; Moes, 1998; BCMAC, 1999). Baxter and Scheifele (2000) note that there are no reliable price indicators in North America at the current time.

Industrial Hemp Fiber Crops

Table 2 summarizes the estimated costs, revenues and profits for industrial hemp fiber production per acre for the U.S. (Thompson et al., 1998; Ehrensing, 1998) and Canada (Baxter and Scheifele, 2000). The total cost per acre estimates range from around $364 to $616.

The cost differences are a result of the exclusion of items such as land rent, irrigation equipment and monitoring/licensing costs in the lower estimates.

TABLE 2: Profit Estimates for Industrial Hemp Fiber Production (Per Acre)

	STUDY AND STATE/REGION		
OPERATING COST CATEGORIES	Thompson et al (1998) Kentucky	Ehrensing (1998) Pacific Northwest (Oregon)	Baxter & Schiefele (2000) Ontario, Canada*
Seed (lbs)	$125.00 (50 lbs)	$34.00 (25 lbs)	$138.39 (40 lbs)
Total Fertilizer	$45.01	$85.00	$81.49
Herbicides	$0.00	$0.00	$0.00
Pesticides	$0.00	$0.00	$0.00
Lime	$12.12	-------	-------
Fuel (Oil)	$18.43	-------	$12.30
Repairs, Maintenance	$16.14	-------	$15.38
Operating Interest	$8.38	$29.78	$22.30
Pick Up	-------	$7.68	-------
Farm Truck	-------	$6.34	-------
General Overhead	-------	$20.00	-------
Operator Labor/ Acre			
Tillage and Planting	-------	$40.00	-------
Irrigation	-------	$62.00	-------
Forage Chopper	-------	$15.00	-------
Raking	-------	$7.50	$15.38
Cutting/Swathing	-------	-------	$11.53
Retting	-------	-------	-------
Baling	-------	$49.00	$40.75
Total Labor Cost/ Acre	$56.00	$173.50	$67.66
Trucking/Transport	$27.20	$15.00	$39.21
Storage	$5.00	-------	$34.60
Land Rent	-------	$150.00	-------
Insurance – Machinery	-------	$3.00	-------
Irrigation System	-------	$44.00	-------
Machinery/ Equipment	-------	$48.00	-------
Crop Insurance Premiums	-------	-------	$15.38
Police Security Check	-------	-------	$3.84
Global Positioning**	-------	-------	$7.69
THC Sampling and Testing	-------	-------	$30.75
Fixed Costs ***	$50.27	-------	-------
Total Enterprise Costs	**$363.55**	**$616.30**	**$478.99**
PROFITABILITY			
Yield (ton per acre)	3.4	5.0	3.0
Price (per ton)	$200.00	$75.00	$130.70
Total Revenue/Acre	**$680.00**	**$375**	**$392.10**
PROFIT/ACRE	**$316.45**	**- $241.30**	**$86.89**

NOTE: *Assumptions, definitions of costs, and estimates vary considerably across the three studies, and should be viewed accordingly.*

* All values for the Canadian studies have been converted to US dollars from Canadian dollars using the exchange rate, as of Jan 14, 2004, of 0.7688 US $ to Canadian $.
** Satellite coordinates for the hemp crops, as required by the Canadian government.
***Fixed costs include depreciation, taxes, and insurance typical yields associated with irrigated field corn

The Kentucky and Canadian studies do not include land rent, lime or irrigation estimates. Also, both the Kentucky and Oregon studies exclude costs associated with monitoring, licensing or regulating hemp production. For any cost estimates in Maine, irrigation and lime would both need to be included as the precipitation and soil pH levels in Maine are not ideal for hemp cultivation. Monitoring, licensing and regulating costs would also need to be incorporated.

In addition to differences in costs, there are discrepancies in the yield per acre and the market prices that were selected by the authors. Yield per acre estimates range from 3 tons to 5 tons. The market price estimates for hemp fiber range from $75.00 per ton to $200 per ton. Thompson et al. (1998) used yield estimates from German agricultural data (nova Institute) and based the price for fiber on US imports for 1998. Ehrensing (1998) based his yield estimates on the Pacific Northwest, and based the fiber price on discussions with an Oregon hemp composite manufacturer. Baxter and Schiefele (2000) based their yield and price estimates on recent Canadian industrial hemp data. Overall profits per acre range from - $241 to $317.

Industrial Hemp Oilseed Crops

Table 3 summarizes the costs, revenues and profits for industrial hemp seed production per acre for the U.S. (Thompson et al., 1998) and Canada (Baxter and Scheifele, 2000; BCMAC, 1999). The total cost per acre estimates range from around $139 to $320. Again, cost differences for these estimates are related to the exclusion of monitoring, licensing and/ or regulating costs. It should also be noted that none of the studies include cost estimates for irrigation.

TABLE 3: Profit Estimates for Industrial Hemp Seed Production (Per Acre)

	STUDY AND STATE/REGION			
OPERATING COST CATEGORIES	Thompson et al (1998) Kentucky GRAIN	Thompson et al (1998) Kentucky CERTIFIED SEED	Baxter & Schiefele (2000) Ontario, Canada*	BCMAF (1999) British Columbia, Canada*
Seed (lbs)	$25.00 (10 lbs)	$25.00 (50 lbs)	$69.20 (20 lbs)	$17.04 (21 lbs)
Fertilizer	$45.01	$45.01	$81.49	$16.62
Herbicides	$10.95	$10.95	-------	-------
Lime (tons)	$12.12	$12.12	-------	-------
Fuel	$14.06	$14.06	$12.30	-------
Repairs/ Maintenance	$30.38	$30.38	$15.38	-------
Operating Interest	$5.24	$5.24	$15.38	-------
Operator Labor /Acre				
Tillage & Planting	-------	-------	-------	$13.96
Combining	-------	-------	$46.13	-------
Stalk Shredding	-------	-------	$7.69	-------
Grain Cleaning	-------	-------	-------	$13.30
Grain Drying	-------	-------	$18.45	-------
Harvest and Haul	-------	-------	-------	$75.14
Total Labor Cost/Acre	$56.00	$70.00	$72.27	$102.40
Trucking/Transport	$8.00	$5.60	$3.08	-------
Storage	$5.00	$5.00	-------	$3.32
Crop Insurance Premium	-------	-------	$9.23	-------
Police Security Check	-------	-------	$3.84	-------
Global Positioning**	-------	-------	$7.69	-------
THC Sampling and Testing	-------	-------	$30.75	-------
Fixed Costs ***	$45.00	$70.73	-------	-------
Total Enterprise Costs	**$256.76**	**$294.09**	**$320.61**	**$139.40**
PROFITABILITY				
Yield (ton per acre)	1,069 lbs/acre	700 lbs/acre	800 lbs/acre	800 lbs/acre
Price (per ton)	$.39/lb	$1.20/lb	$.38	-------
Total Revenue/Acre	**$476.91**	**$840.00**	**$307.52**	-------
PROFIT/ACRE	**$220.15**	**$605.91**	**- $13.09**	-------

NOTE: *Assumptions, definitions of costs, and estimates vary considerably across the four studies, and should be viewed accordingly.*

* All values for the Canadian studies have been converted to US dollars from Canadian dollars by the current rate, as of Jan 14, 2004, of 0.7688 US $ to Canadian $.

** Satellite coordinates for the hemp crops, as required by the Canadian government.

***Fixed costs include depreciation, taxes, and insurance.

Yield per acre estimates range from 700 lbs to 1069 lbs. The market price estimate for hemp seed is about $.38, and $1.20 for certified seed. Thompson et al. (1998) used yield estimates from German agricultural data (the nova Institute) and based the price for seeds on U.S. imports for 1998. Baxter and Schiefele (2000) based their yield and price estimates on Canadian industrial hemp experience. It is unclear what data BCMAF (1999) based their yield estimate on, but it is to be assumed that they also used Canadian commercial experience as well as experimental trials. BCMAF did not provide price estimates, and therefore there is no revenue information available for the study. Across the studies, profits per acre for hemp seed production ranged from about $600 for certified seed production to $-13 for oil seed production based on the Canadian experience.

Relative Profitability

Since relative profitability (hemp's profitability compared to the profitability of other crops) is also an important consideration, some of the authors chose to include comparisons between hemp and other crops grown in the area. Vantreese (1998) estimated that the returns on hemp were, on average, $73.49 per acre, and that this is generally comparable to other crops grown in Kentucky. Vantreese did note, though, that hemp was not as profitable as tomatoes or tobacco. Thompson et al (1998) also concluded that estimated returns on hemp were comparable with other crops in Kentucky, but were still well below tobacco returns. Finally, Kraeznel et al. (1998) used data from both the Vantreese and Thompson studies, and concluded that only irrigated potatoes compare favorably with industrial hemp returns.

Profitability Conclusions

Profit estimates range from -$200 to positive $600 per acre. Since much of the data on which the estimates are based is speculative, it is difficult to say which of the estimates is most reliable. While production costs in Maine will vary somewhat from those calculated for the other regions, profitability of industrial hemp production will be influenced more by fiber/oil seed prices and the level of hemp yields that can be achieved in Maine.

VII. Positive and Negative Aspects of Industrial Hemp Cultivation in Maine

Positive Aspects of Industrial Hemp as an Alternative Crop

Agricultural/Environmental

Some of the popularity of hemp as an alternative crop is related to its agricultural and environmental benefits. Several sources describe hemp's unique ability to resist most pests, resulting in the use of virtually no pesticides (Bosca and Karus 1998; West 2003a; Rosenthal 1994; Vantreese 1997; USDA 2000). It has been shown to successfully suppress weeds. As a result, hemp is a very good candidate for sustainable agriculture and organic crop rotation. (West 2003b). Hemp has also been shown to improve soil quality, and reduce soil erosion and agricultural runoff problems (Bosca and Karus 1998; Small and Marcus 2002). When hemp is used as an alternative source of paper, forest conservation increases. Also, hemp can be processed into paper with the use of fewer chemicals than wood processing requires. This can result in a decrease in paper mill emissions. Finally, hemp fiber can be used to make bio-based plastics and construction materials, which are more recyclable than the traditional materials (Bosca and Karus 1998; Small and Marcus 2002; Kerr 2001; Rosenthal 1994).

Markets/Economy

Several sources indicate that the demand for "ecologically-friendly" products is increasing (Wall Street Journal 1998; Economist 1998; USDA 2000; Vantreese 1997). Because of its long fibers, rapid growth and versatile oil, hemp can be manufactured into many products. It has also been estimated that there are several potential hemp products that could be developed, including alternative fuel (Nova Institute 2000; Kraenzel et al. 1998; Small and Marcus 2000).

Negative Aspects of Industrial Hemp in Maine

Markets

A large barrier to establishing a hemp market in Maine is the competition with other hemp suppliers. Industrial hemp already has an established international market, in which China, France, Korea and Russia dominate. These countries have advantages such as lower labor costs, established infrastructure and subsidies to help farmers (Vantreese 1997; Thompson et al. 1998; USDA 2000; Fortenberry 2000). One Canadian specialist speculates that the only viable market for the U.S. would be a domestic market (Niedermann 2003). This poses problems because studies indicate that there is not high demand in the U.S. for hemp products. It is estimated that a few farmers would be able to supply the amount of hemp imports each year (USDA 2000; Vantreese 1997).

Recent Canadian experience indicates the difficulties that new hemp producers can experience. The total acres of hemp grown in Canada decreased from over 35,000 acres in 1999 to only 3,250 in 2001 due to an oversupply problem. Canadian firms and growers stepped up production based on the belief that there would be a large expansion in the use of hemp. This expansion did not occur. Also, one of the largest hemp companies in Canada, Consolidated Growers and Processors, went out of business not long after it started (Niedermann 2003). This could also be an issue in the U.S. as the USDA estimates that it would only take a few 500 acre farms to produce the hemp fiber equivalent of 1999 import levels. Also, hemp seed and oil import estimates for North America in 1998 could have been supplied by approximately 2,600 acres (Cochran et al., 2000).

Production

Other barriers to industrial hemp in Maine are the fact that there are no hemp varieties specifically bred for North American use, profit estimates are inconsistent and the infrastructure for processing hemp does not exist. Although some new varieties are being developed, there have not been North American hemp varieties available since Kentucky hemp (West 2003b). In addition to this, estimates that have been done regarding the profitability of hemp in North America are speculative and inconsistent. The estimates range from a loss of a couple hundred dollars to a gain of several hundred dollars. Finally, the infrastructure for processing does not exist in Maine. Hemp fiber production cannot use facilities for other crops, and even though oil production can, the facilities do not exist. One specialist estimates that it would cost a minimum of $5 million in start-up capital to grow and process 500 acres of fiber for industrial applications (Niedermann 2003).

VIII. Licensing and Regulations

Since it is illegal to grow industrial hemp in the US, any trials conducted in Maine would have to meet federal regulations. CFR 1301 contains the regulations for working with Controlled Substances. It outlines the process to apply for research permits to grow a Schedule 1 Substance. It also explains how and when a certificate of registration (DEA-225 Controlled Substance license) will be issued. CFR 1301 also explains general security requirements, such as safe or vault specifications, building requirements, security systems and employee regulations.

The rule indicates that the specific security regulations are at the discretion of the administrator in charge of the licensing (US Department of Justice CFR 1301). Only one permit has been granted to grow industrial hemp to date. One state applied for a permit to grow hemp for research purposes in 1998 and DEA still has not acted on it.

An example of the security measures and regulations required to grow hemp is illustrated by the recent Hawaiian hemp experiment. In the experiment, the principal investigator initially had a security system that included infrared beams surrounding a ten-foot perimeter fence with barbed wire at the top and a large safe where all of the Schedule 1 Substance (seed) was stored. The investigator was issued licenses from the federal government as well as the Hawaiian government, both of which had to be renewed every year. For the licenses to be renewed each year, the site had to pass an inspection. In addition, certified seed (shown to have legal THC levels) was the only seed used for planting. The site was broken into and before a new license could be issued, new security requirements had to be added. It is the investigator's belief that actual security measures needed to renew the permit included 24 hour armed surveillance and watchdogs in addition to the security already in place (West 2003b). The research was terminated due to the added security costs required to renew the permit. The costs of securing the fields, obtaining the necessary licenses, testing the THC levels and regulating the crops are all additional considerations for growing industrial hemp in Maine. These procedures can prove to be time consuming and expensive.

In June of 2005 a bill was introduced in Congress that would legalize the commercial production of industrial hemp in the US. The Industrial Hemp Farming Act of 2005 would amend the Controlled Substances Act by specifying that marijuana does not include industrial hemp. This bill would allow states to decide whether the production of industrial hemp would be allowed and the security conditions that would be required. Congress has not acted on this bill to date. However, if approved by Congress, a major barrier to the production of industrial hemp and the development of potentially new markets for the crop would disappear.

IX. Conclusions

When evaluating the development of industrial hemp production in Maine, available literature suggests that the agronomic considerations are of relatively minor concern. In fact, recent studies such as the Hawaiian hemp experiment indicate that industrial hemp can be grown in areas where the conditions are less than ideal for hemp cultivation. Based on the available data regarding agronomic conditions in Maine, it appears that hemp could be grown with soil pH adjustments and supplemented irrigation. The largest barrier to the economic feasibility of industrial hemp in Maine and the U.S. is the lack of innovation in harvesting and processing technology, as well as the lack of available infrastructure. In addition, the major world suppliers are generally countries with access to government subsidies and/or low labor and resource costs.

Previous U.S. and Canadian studies indicate that hemp production may be profitable in the U.S. When compared to other crops, hemp is slightly more profitable than traditional crops, but less profitable than other specialty crops. The Canadian experience indicates that in a young hemp industry, farmers do not appear to earn a substantial profit on the crop. Furthermore, it is apparent that it only takes a small number of farmers to supply the current demand.

A strong argument in favor of industrial hemp is the positive impact it has on the environment. It has been found to be a very good rotational crop, and the environmental benefits are numerous. There are thousands of current and potential products made from hemp, and several of them are “eco-friendly”. The demand for such products appears to be increasing as society becomes more environmentally conscious.

Clearly, industrial hemp has a lot of potential as an alternative crop in the U.S. and Maine. However, this potential will never be realized unless the production of industrial hemp is legalized. If legalized, investments in infrastructure, harvesting innovations and new products using hemp will be more likely to occur. Until then, it is difficult to predict the future importance of industrial hemp as an agricultural crop. Maine should take a closer look at industrial hemp production only if Congress passes legislation to legalize its production.